

# Book of Abstracts

# inter.noise 2014

43<sup>rd</sup> International Congress on Noise Control Engineering

Improving the World through Noise Control



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## PEER REVIEWED PAPERS

The 98 papers with the following paper numbers were peer reviewed at the request of the author(s) before being accepted for the Internoise 2014 conference. The paper number of each paper is shown in the abstract section of this Book of Abstracts. These papers were peer reviewed by a review panel composed of the topic organizers, the session organisers and the peer reviewers. The identities of the peer reviewers were not disclosed to the authors. The peer reviewers reviewed these papers to ensure that they were of a high standard for the conference, and provided written feedback on the quality of the manuscripts. The review criteria included technical content, originality, English expression and technical significance. Papers were matched where possible to peer reviewers in the same field with similar interests and areas of expertise as the authors.

1, 8, 10, 11, 34, 46, 50, 51, 52, 54, 74, 78, 81, 83, 84, 85, 89, 91, 96, 97, 100, 103, 112, 115, 120, 122, 124, 133, 141, 145, 151, 155, 173, 174, 180, 182, 184, 207, 208, 235, 237, 251, 264, 275, 296, 302, 308, 321, 324, 351, 354, 377, 386, 389, 400, 439, 443, 456, 477, 525, 582, 590, 596, 601, 606, 623, 655, 661, 670, 672, 680, 684, 691, 695, 700, 710, 723, 724, 726, 730, 771, 774, 787, 788, 790, 801, 813, 817, 829, 841, 869, 886, 887, 894, 904, 912, 971, 1000

## INVITED PAPERS

The 250 papers with the following paper numbers were invited for presentation at the Internoise 2014 conference by the session organisers. The paper number of each paper is shown in the abstract section of this Book of Abstracts.

2, 9, 10, 13, 15, 17, 23, 26, 30, 31, 32, 34, 40, 52, 53, 55, 58, 60, 65, 69, 71, 73, 76, 78, 80, 82, 85, 89, 92, 95, 97, 98, 101, 102, 106, 109, 111, 112, 113, 114, 135, 138, 143, 151, 154, 157, 159, 160, 162, 164, 167, 168, 171, 172, 174, 176, 177, 189, 194, 199, 201, 202, 206, 207, 208, 213, 214, 215, 216, 217, 224, 234, 235, 242, 249, 251, 252, 257, 261, 263, 270, 275, 276, 277, 279, 284, 285, 286, 287, 289, 290, 292, 294, 297, 298, 303, 307, 319, 321, 324, 331, 333, 343, 349, 358, 362, 368, 371, 375, 378, 381, 389, 395, 397, 401, 402, 410, 412, 427, 433, 446, 454, 458, 462, 467, 468, 469, 473, 479, 481, 483, 486, 498, 505, 506, 507, 508, 515, 516, 523, 529, 543, 544, 545, 548, 549, 550, 556, 557, 558, 564, 571, 577, 581, 589, 594, 595, 596, 597, 599, 605, 608, 611, 614, 627, 642, 647, 648, 651, 658, 664, 665, 667, 668, 671, 673, 674, 675, 680, 685, 692, 697, 704, 708, 712, 718, 719, 724, 731, 739, 743, 747, 752, 758, 760, 765, 770, 771, 780, 781, 785, 793, 802, 810, 812, 813, 817, 819, 825, 833, 836, 839, 841, 852, 858, 860, 864, 865, 866, 871, 878, 880, 883, 884, 886, 887, 888, 908, 913, 919, 930, 935, 939, 941, 943, 949, 951, 955, 958, 968, 971, 974, 978, 989, 996, 998, 1001, 1009, 1010, 1026

## Contents

### Sunday 17:00-18:00 Room Plenary

#### Plenary 1

**Chair: Joachim Scheuren** **41**

17:00 Sound Sketch: Shaping sound in space and time using loudspeaker arrays  
Choi, Jung-Woo 41

### Monday 08:20-09:20 Room Plenary

#### Keynote 1

**Chair: Marion Burgess** **41**

08:20 Can technology deliver acceptable levels of aircraft noise?  
Astley, R Jeremy 41

### Monday 08:20-9:20 Rooms 219 & 220

#### Keynote 2

**Chair: Charles Don** **41**

08:20 A new era for applications of active noise control  
Qiu, Xiaojun; Lu, Jing; Pan, Jie 41

### Monday 09:20-10:40 Room 218

#### L1a Active control of sound

**Chair: Bosun Xie, Kean Chen** **42**

09:20 Analysis on the timbre of Ambisonics recording by circular and spherical microphone array using a binaural loudness model  
Xie, Bosun; Liu, Yang 42

09:40 Reduction of air space behind piezoelectric absorbing panel using negative stiffness  
Yamada, Keisuke; Yamagata, Kenta; Utsuno, Hideo 42

10:00	A stability analysis of cluster active control system of sinusoidal sound in free space Yu, Haoxin; Chen, Kean; Sang, Zhiming; Tang, Dakai	42
10:20	Generation of localized sound using speaker array Fukaya, Kigen; Iwamoto, Hiroyuki; Sanada, Akira; Tanaka, Nobuo	42

**Monday 09:20-11:00 Room 217**

**T8a Sound Quality**

**Chair: Klaus Genuit, Roland Sottek**

09:20	Improving sound quality measures through the multifaceted soundscape approach Schulte-Fortkamp, Brigitte	43
09:40	Contribution of single sounds to sound quality assessments of multi-source environments Skoda, Sabrina; Steffens, Jochen; Becker-Schweitzer, Jörg	43
10:00	Perception of sound quality of product sounds A subjective study using a semantic differential Hülsmeier, David; Schell-Majoer, Lena; Rennies, Jan; Van De Par, Steven	43
10:20	Psychoacoustic analysis of HVAC noise with equal loudness Hohls, Silke; Biermeier, Thomas; Blaschke, Ralf; Becker, Stefan	43
10:40	Study on evaluation method of the pure tone for small fan Yamaguchi, Takao; Minorikawa, Gaku; Kihara, Masayuki	44

**Monday 09:40-10:40 Room 216**

**C1a Aeroacoustics**

**Chair: Con Doolan**

09:40	Study on modeling of flow induced noise using Lighthill's analogy and boundary element method Mori, Masaaki; Masumoto, Takayuki; Ishihara, Kunihiko; Oshima, Takuya; Yasuda, Yosuke; Sakuma, Tetsuya	44
10:00	Direct numerical simulation of flow and acoustic fields around an air-reed instrument with tone holes Yokoyama, Hiroshi; Kobayashi, Masaki; Onitsuka, Hirofumi; Miki, Akira; Iida, Akiyoshi	44
10:20	Aerodynamic noise produced in flow around an automobile bonnet Yokoyama, Hiroshi; Nakajima, Takahiro; Shinohara, Taishi; Miyazawa, Masashi; Iida, Akiyoshi	44

**Monday 09:20-10:40 Room 215**

**A1a Education - outreach to community**

**Chair: Courtney Burroughs, Marion Burgess**

09:20	Education and Outreach: I-INCE Publications Burroughs, Courtney B; Thompson, James	45
09:40	Role for an Acoustical Society Journal Burgess, Marion	45
10:00	Public participation at measures to reduce noise in Germany Zeisler, Annett	45
10:20	Communicating the noise message Parnell, Jeffrey; Wassermann, John	45

**Monday 09:40-11:00 Room 214**

**H1a Urban sound propagation**

**Chair: Timothy Van Renterghem**

09:40	Comparison of acoustic pulse propagation between scale-model measurements and three-dimensional simulation over real-life urban topography Oshima, Takuya; Ishizuka, Takashi; Kamijo, Takahide	45
10:00	Calculation of sound propagation with highly reflective environments Probst, Wolfgang	46
10:20	Experimental analysis of the noise shielding by a green roof in response to rainfall Van Renterghem, Timothy; Despriet, Mathias; Botteldooren, Dick	46
10:40	Model based monitoring of traffic noise in an urban district Van Der Eerden, Frits; Graafland, Freek; Wessels, Peter W; Segers, Arjo; Salomons, Erik M	46

**Monday 09:20-11:00 Room 213**

**Q2a Numerical methods in vibro-acoustics**

**Chair: Steffen Marburg, Herwig Peters**

09:20	Enhancing the low frequency vibration reduction performance of plates with embedded acoustic black holes Conlon, Stephen; Fahline, John; Feurtada, Phil; Semperlotti, Fabio	46
09:40	FE based measures for structure borne sound radiation Klaerner, Matthias; Marburg, Steffen; Kroll, Lothar	46

10:00	Analytical and numerical approaches to predict radiated sound power of fluid-loaded cylindrical shells Zhang, Yilin; Jiang, Weikang; Peters, Herwig; Kessissoglou, Nicole	47
10:20	Experimentally uncertainty quantification in numerical and analytical beam models Langer, P; Sepahvand, K; Krause, M; Marburg, Steffen	47
10:40	Prediction of airborne and structure borne sound transmission through hearing protectors using FEM Sgard, Franck; Brummund, Martin; Viallet, Guilhem; Boyer, Sylvain; Doutres, Olivier; Nelisse, Hugues; Laville, Frederic; Petit, Yvan; Boutin, Jerome	47

**Monday 10:00-11:00 Room 212**

**B4a Machinery N&V - Plant**

**Chair: Zhuang Li, Colin Tickell**

**48**

10:00	Analysis of Sound Propagation in Finned Tube Bundle of HRSG in Power Plant Ahn, Sungjong; Lee, Sanghyuck; Ha, Jinwoong; Shin, Eontak	48
10:20	Numerical and Experimental Study on Mechanism of Low Frequency Noise from Heat Recovery Steam Generator Tang, Hongyun; Jiang, Weikang; Zhong, Zhenmao; Zhao, Yingjiu	48
10:40	Fatigue Life Estimation of Piping System for Evaluation of Acoustically Induced Vibration (AIV) Izuchi, Hisao; Nishiguchi, Masato; Lee, Gary Y H	48

**Monday 09:20-11:00 Room 211**

**N1 Speech privacy in buildings**

**Chair: Jorge Patricio, Kenric Van Wyk**

**48**

09:20	Speech Privacy and Intelligibility in Open-Plan Offices as an Impact of Sound-Field Diffuseness Utami, Sentagi Sesotya; Sarwono, Joko; Al Rochmadi, Nurwachid; Suheri, Nanan	48
09:40	Preliminary study of the acoustic behavior concerning an innovative prototype for indoor modular partitioning Simões, Gonçalo; Patricio, Jorge; Faria, Paulina	49
10:00	The Influence of Abfuser Configuration to the Speech Privacy and Intelligibility in an Open Plan Office Sarwono, Joko; Rachman, Arinda Puspita; Azzahra, Iva R Nisa; Utami, Sentagi Sesotya	49
10:20	An electronic database of speech sound levels Nash, Anthony	49
10:40	Improvement of body-conducted speech recognition using model estimation Nakayama, Masashi; Ishimitsu, Shunsuke; Nakatani, Satoshi	49

**Monday 09:20-11:00 Room 210**

**N8a Room acoustics**

**Chair: Toru Otsuru, Nazli Bin Che Din**

**50**

09:20	Psychoacoustic analysis of preference reverberation time for Gamelan Bali Concert Hall Nitidara, Ni Putu Amanda; Sarwono, Joko; Merthayasa, I G Nyoman	50
09:40	Withdrawn3 Withdrawn3,	50
10:00	Micro-perforated sheets as day-light ceilings Nocke, Christian; Hilge, Catja; Scherrer, Jean-Marc	50
10:20	The Design of MPP and its Application to Enhance the Acoustics of a Real Auditorium Sarwono, Joko; Prasetyo, I; Andreas, S; William, A	50
10:40	Application of an in-situ measurement method using ensemble averaging technique to material development Okamoto, Noriko; Otsuru, Toru; Tomiku, Reiji; Kamimizu, Takaaki; Yamaguchi, Makoto; Okuzono, Takeshi	50

**Monday 09:20-10:40 Room 209**

**D1 Road vehicle noise**

**Chair: James McIntosh**

**51**

09:20	Road traffic facade treatment in Israel Epstein, David	51
09:40	Selection of state highway bridge expansion joints in noise sensitive areas Chiles, Stephen	51
10:00	Towards a reduction of noise emission of powered two-wheels – Part 1 Lelong, Joel; Chatagnon, Roger; Clerc, Christian; Jamin, David; Seigner, Maxime; Thivant, Michael	51
10:20	Towards a reduction of noise emission of powered two-wheels - Part 2. Thivant, Michael; Clerc, Christian; Jamin, David; Gauthier, Quentin; Lelong, Joel; Chatagnon, Roger	51

**Monday 09:20-11:00 Room 208**

**D4a Pavement modelling and measurement techniques**

**Chair: Paul Donovan, Gaetano Licitra**

**52**

- 09:20 Comparison of road and laboratory measurements of tyre/road noise  
Swieczko-Zurek, Beata; Ejsmont, Jerzy; Ronowski, Grzegorz; Taryma, Stanisław 52
- 09:40 Investigating lateral porosity effect on air pumping noise from connected road cavities with CFD simulations  
Conte, Frédéric; Klein, Philippe; Bérangier, Michel 52
- 10:00 Reduction of vehicle noise at lower speeds due to a porous open-graded asphalt pavement  
Donovan, Paul 52
- 10:20 Test sections to study the acoustical quality and durability of thin noise reducing asphalt layers  
Bergiers, Anneleen; De Visscher, Joëlle; Denolf, Katleen; Destrée, Alexandra; Vanhooreweder, Barbara; Vuye, Cedric 52
- 10:40 A study on comparison of noise reduction effect of single-layer drainage asphalt pavement and double-layer drainage asphalt pavement : Part 1 sound power level and frequency characteristic in initial construction  
Mori, Hisho; Ishikawa, Kenichi; Ueta, Tomotaka; Noguchi, Eiji; Yoshida, Motoomi; Kokusho, Masami; Nagaoka, Hironori 53

**Monday 09:20-10:40 Room 207**

**R1 Underwater acoustics**

**Chair: Alec Duncan**

**53**

- 09:20 AQUO Project – Modelling of ships as noise source for use in an underwater noise footprint assessment tool  
Audoly, Christian; Rousset, Céline; Leissing, Thomas 53
- 09:40 Ambient noise forward prediction from measured characteristics and high resolution modeling  
Eller, Anthony I; Heaney, Kevin D 53
- 10:00 Shipping noise impacts on marine life  
Cato, Douglas H 53
- 10:20 Directionality and coherence of underwater noise and their impact on sonar array performance  
Zhang, Zhi Yong 53

**Monday 09:40-11:00 Room 206**

**T4a Noise and health- overall effects and susceptible groups**

**Chair: Irene van Kamp, Stephen Stansfeld**

**54**

- 09:40 Daytime and night-time aircraft noise and cardiovascular disease near Heathrow airport in London  
Hansell, Anna; Blangiardo, Marta; Fortunato, Lea; Floud, Sarah; De Hoogh, Kees; Fecht, Daniela; Ghosh, Rebecca E; Lazlo, Helga E; Pearson, Claire; Beale, Linda; Beevers, Sean; Gulliver, John; Best, Nicky; Richardson, Sylvia; Elliott, Paul 54
- 10:00 Traffic noise in relation to self-reported mental health  
Turunen, Anu W; Yli-Tuomi, Tarja; Tiittanen, Pekka; Halonen, Jaana; Männistö, Satu; Lanki, Timo 54
- 10:20 Noise sensitivity modulates the auditory-cortex discrimination of sound feature changes  
Heinonen-Guzejev, Marja; Klyuchko, Marina; Heikkilä, Kauko; Spinosa, Vittoria; Tervaniemi, Mari; Brattico, Elvira 54
- 10:40 Four electrophysiological studies into noise sensitivity  
Shepherd, Daniel; Hautus, Michael J; Lee, Jenny; Mulgrave, Joe 55

**Monday 11:00-12:20 Room 220**

**E1 Railway noise and vibration**

**Chair: James Nelson**

**55**

- 11:00 Considering the perception of combined railway noise and vibration as a multidimensional phenomenon  
Sharp, Calum; Woodcock, James; Waddington, David 55
- 11:20 Railway vibration reduction using impact dampers  
Yang, Wonseok; Ahn, Sangkeun; Koh, Hyo-In; Park, Junhong 55
- 11:40 Exhaust noise control case study for 2800 class locomotive  
Croft, Briony; Brown, Stephen; Miller, Aaron; Parker, Andrew 55
- 12:00 Railway-noise reduction effect and aged deterioration properties of softer rail pad  
Saito, Hidetoshi; Ninomiya, Masaki; Shimizu, Kenta; Takeda, Yoji; Sato, Daigo 55

**Monday 11:20-12:40 Room 219**

**P1a Vibration and Shock**

**Chair: Len Koss, Vincent Rouillard**

**56**

- 11:20 Vibration of a curved subsea pipeline due to internal slug flow  
Reda, Ahmed M; Forbes, Gareth L; McKee, Kristoffer K; Howard, Ian M 56
- 11:40 Analysis on propulsion shafting coupled torsional-longitudinal vibration under different applied loads  
Huang, Qianwen; Liu, Jia; Zhang, Cong; Yan, Xinping 56

12:00	Investigations of eddy current vibration damping Ruber, Karel; Kanapathipillai, Sangarapillai; Randall, Robert Bond	56
12:20	Footfall vibration analysis of a high precision manufacturing facility Gaekwad, Jason; Lee, Yong Keat; Mackenzie, Neil	56

**Monday 11:00-12:40 Room 218**

**L1b Active control of sound**

**Chair: Bosun Xie, Kean Chen** **56**

11:00	Individual Error Signal Design in Narrowband Active Noise Control Systems Chang, Cheng-Yuan; Kuo, Sen M	56
11:20	Mitigation of indoor low-frequency noise using single channel active noise control system Kaneuchi, Ken; Nishimura, Koichi; Matsui, Toshihito	57
11:40	Noise reduction through active noise control using stereophonic sound for increasing quiet zone Min, Dongki; Kim, Junejong; Nam, Sangwon; Park, Junhong	57
12:00	Hybrid active noise barrier with sound masking Wang, Xun; Koba, Yosuke; Ishikawa, Satoshi; Kijimoto, Shinya	57
12:20	A power constrained algorithm for multi-zone sound reproduction Liao, Xiangning; Zheng, Sifa; Peng, Bo; Lian, Xiaomin	57

**Monday 11:20-12:40 Room 217**

**V1a Metrology - calibration and realisation of standards**

**Chair: Doug Manvell, Longbiao He** **58**

11:20	Influence of ground-shield configuration in reciprocity calibration of laboratory standard microphones Olsen, Erling Sandermann; Carlsen, Henrik	58
11:40	Realization of Air-borne Sound pressure unit with LDA technique by Spectrum and autocorrelation method in a travelling wave tube He, Longbiao; Feng, Xiujuan; Yang, Ping; Niu, Feng; Zhong, Bo	58
12:00	Noise dosimeter microphones: an evaluation of the measurement reliability Bondarenko, David Bello	58
12:20	Experimental determination of the difference between free-field and pressure sensitivity levels of half inch laboratory standard microphones Bacelar Milhomem, Thiago Antônio; Martins Defilippo Soares, Zemar; Machado Da Rosa Albuquerque, Lucas	58

**Monday 11:00-12:20 Room 216**

**C1b Aeroacoustics**

**Chair: Con Doolan** **59**

11:00	Benchmark study of numerical solvers for the prediction of interior noise transmission excited by A-pillar vortex Cho, Munhwan; Kim, Hyoung Gun; Oh, Chisung; Ih, Kang Duck; Khondge, Ashok; Mendonça, Fred; Lim, Jongyun; Choi, Eui-Sung; Ganty, Bastien; Hallez, Raphael	59
11:20	Characterization of an Aeroacoustic Wind Tunnel Facility Pascioni, Kyle; Reger, Robert; Edstrand, Adam; Cattafesta, Louis	59
11:40	Characteristics of turbulent noise from backward-curved centrifugal fan with rectangular casing Hayashi, Hidechito; Aramaki, Takuma; Shirahama, Seiji; Oda, Ippei; Okumura, Tetsuya	59
12:00	On the reduction of the engine and aerodynamic noise of aircraft Campos, L M B C	59

**Monday 11:00-11:40 Room 215**

**A1b Education - outreach to community**

**Chair: Courtney Burroughs, Marion Burgess** **60**

11:00	Common failings of inter-disciplinary studies on noise and the potential solutions McLaren, Stuart J; Page, Wyatt H	60
11:20	Web-based calculators for transportation noise and vibration Smith, Michael; Chiles, Stephen	60

**Monday 11:40-12:40 Room 215**

**A2a Education- to the profession**

**Chair: Courtney Burroughs, Marion Burgess** **60**

11:40	Post baccalaureate professional development in noise control engineering Holger, David K	60
12:00	Expanding the horizon of machinery noise source control via a dedicated short course on gear dynamics and noise Singh, Rajendra	60

12:20	Extending the scope of urban sound planning by education and research Scheuren, Joachim; Kropp, Wolfgang; Forssen, Jens	61
<b>Monday 11:20-12:00 Room 214</b>		
<b>H1b Urban sound propagation</b>		
<b>Chair: Timothy Van Renterghem</b>		<b>61</b>
11:20	Use of traffic modeling and geographic information systems to evaluate noise reduction policies in urban environments: case study in Bogota - Colombia Paez, Daniel; Caviedes, Alvaro	61
11:40	Assessment of noise pollution sourced from entertainment places in Antalya, Turkey Sari, Deniz; Ozkurt, Nesimi; Hamamci, Samet Feyyaz; Ece, Mustafa; Yalcindag, Nazli; Akdag, Ali; Akdag, Nese	61
<b>Monday 11:20-12:40 Room 213</b>		
<b>Q2b Numerical methods in vibro-acoustics</b>		
<b>Chair: Franck Sgard, Matthias Klaerner</b>		<b>61</b>
11:20	A review of the coupling parameter of the Burton and Miller boundary element method Marburg, Steffen	61
11:40	A comparison of numerical methods for the large-scale modelling of acoustic coupled fluid-structure interactions of double-walled cylindrical shells Peters, Herwig; Wilkes, Daniel Ryan	62
12:00	Prediction of the radiated sound power from a fluid-loaded finite cylinder using the surface contribution method Liu, Daipei; Peters, Herwig; Kessissoglou, Nicole; Marburg, Steffen	62
12:20	Implementation aspects of the Boundary Element Method including viscous and thermal losses Cutanda Henriquez, Vicente; Juhl, Peter	62
<b>Monday 11:20-12:20 Room 212</b>		
<b>B4b Machinery N&amp;V - Plant</b>		
<b>Chair: Zhuang Li, Colin Tickell</b>		<b>62</b>
11:20	Noise Control for Fluid Power Systems Li, Binghui; Moore, Simon	62
11:40	Acoustic and Vibration Stability Analysis of Furnace System in Supercritical Boiler Kwon, Hyuk-Min; Cho, Chi-Hoon; Kim, Heui-Won	62
12:00	Minimising the cost of noise control in the coal seam gas industry by selection of noise treatments for gas wells using engineering optimisation Davis, David James	63
<b>Monday 11:20-12:20 Room 211</b>		
<b>N3 Green sustainable buildings</b>		
<b>Chair: Jeffrey Fullerton</b>		<b>63</b>
11:20	The challenge of meeting both acoustic and thermal comfort in 21st century school classrooms Campbell, Colin; Svensson, Carsten; Nilsson, Erling	63
11:40	Noise associated with the ground water systems serving residential geothermal heat pumps Fullerton, Jeffrey L	63
12:00	Acoustical investigation of open-plan offices in green building: Simulation experiment Nazli, Che Din; Nurul Amira, Abd Jalil; Nila Inangda, Keumala; Asrul Sani, Razak	63
<b>Monday 11:20-12:40 Room 210</b>		
<b>N8b Room acoustics</b>		
<b>Chair: Toru Otsuru, Takeshi Okuzono</b>		<b>64</b>
11:20	Room impulse response measurement with a spherical microphone array, application to room and building acoustics Barré, Sébastien; Döbler, Dirk; Meyer, Andy	64
11:40	Influence of time-varying talker directivity on the calculation of speech transmission index from speech in a room acoustical context Opsata, Adam; Cabrera, Densil; Yadav, Manuj	64
12:00	Validation of lateral fraction results in room acoustic measurements Protheroe, Daniel; Day, Christopher	64
12:20	Sound source localization accuracy of ambisonic microphone in anechoic conditions Malecki, Pawel	64



**Monday 11:00-12:40 Room 209**

**D2a Vehicle noise vibration and harshness (NVH)**

**Chair: Joseph Lai, Zhichao Hou**

**64**

- 11:00 Structural transfer path analysis of automobile tire/road noise  
Yu, Xiongying; Pang, Jian; Min, Fujiang; Wen, Wei; Gong, Shichao 64
- 11:20 Measurement of the distributed dynamic stiffness of seats under compression to analyze dynamic characteristic of seats  
Kim, Deokman; Min, Kyongwon; Park, Hyunkyu; Park, Junhong 65
- 11:40 Development of an adaptive composite leaf spring  
John, Sebastian; Dannemann, Martin; Kostka, Pawel; Ehlig, Jana; Modler, Niels 65
- 12:00 Study on the vertical vibration of an occupant - seat cushion system  
Hou, Zhichao 65
- 12:20 Tire/road contact modeling for the in-vehicle noise prediction  
Vuj, Trong Dai; Yin, Hai Ping; Duhamel, Denis; Gaudin, Arnaud; Abbadi, Zouhir 65

**Monday 11:20-12:40 Room 208**

**D4b Pavement modelling and measurement techniques**

**Chair: Paul Donovan, Gaetano Licitra**

**66**

- 11:20 A study on comparison of noise reduction effect of single-layer drainage asphalt pavement and double-layer drainage asphalt pavement: Part 2 long-term change of sound power level and frequency characteristic  
Ueta, Tomotaka; Ishikawa, Kenichi; Mori, Hisho; Noguchi, Eiji; Yoshida, Motoomi; Kokusho, Masami; Nagaoka, Hironori 66
- 11:40 Effect of road surfaces on road traffic noise on the public roads of Japan - An investigation based on tyre/road noise measurement  
Koike, Hiroshi; Ito, Akiyoshi 66
- 12:00 Project ROSANNE: Rolling resistance, Skid resistance, and Noise Emission measurement standards for road surfaces  
Haider, Manfred; Conter, Marco; Wehr, Reinhard; Sandberg, Ulf; Anfosso, Fabienne 66
- 12:20 SPB and CPX results of rubberized surfaces in the Italian urban and extra-urban context  
Licitra, Gaetano; Teti, Luca; Cerchiai, Mauro; Ascari, Elena; Chetoni, Marco 66

**Monday 11:20-13:00 Room 207**

**R3a Underwater noise and its control**

**Chair: Paul Croaker**

**67**

- 11:20 LES-based Numerical Analysis of Surface-Pressure Fluctuations and Unsteady Thrust of a Marine Propeller  
Tian, Jin; Yang, Haosen; Zhang, Zhenguo; Yuan, Guoqing; Rao, Zhiqiang; Hua, Hongxing 67
- 11:40 LDV-based vibration measurement of a stiffened plate covered by a rubber coating with multi-layered periodic porous in air  
Huang, Xiuchang; Zhu, Dawei; Tian, Jin; Hua, Hongxing 67
- 12:00 Adulteration of underwater acoustic measurements  
Schael, Stefan 67
- 12:20 Numerical Study on Non-Cavitating Noise of Marine Propeller  
Jang, Ji-Sung; Kim, Hyung-Taek; Joo, Won-Ho 67
- 12:40 Optimisation applied to composite marine propeller noise  
Mulcahy, N Lex; Croaker, Paul; McGuckin, Damian G; Brandner, Paul A; Kessissoglou, Nicole 67

**Monday 11:20-12:20 Room 206**

**T4b Noise and health- overall effects and susceptible groups**

**Chair: Stephen Stansfeld, Irene van Kamp**

**68**

- 11:20 Non-specific physical symptoms and related functioning in people with self-reported noise sensitivity  
Baliatsas, Christos; Van Kamp, Irene; Hooiveld, Mariette; Yzermans, Joris; Lebre, Erik 68
- 11:40 What factors are associated with noise sensitivity in the UK population?  
Clark, Charlotte; Smuk, Mel; Stansfeld, Stephen; Van De Kerckhove, Rik; Notley, Hilary 68
- 12:00 Influence of visual factors on noise annoyance evaluation caused by road traffic noise in indoor environment  
Ma, Hui; Nie, Wenjing 68

**Monday 13:40-15:20 Room 220**

**K2a Applying building envelop design for noise mitigation**

**Chair: Maurice Yeung, Shiu-keung Tang**

**69**

- 13:40 Noise Control Potential of Vacuum Isolation Panels  
Walters, Sheldon; Dance, Stephen 69
- 14:00 Investigations on road noise level spatial variability within a specially designed acoustic balcony  
Naish, Daniel A; Tan, Andy C C; Demirbilek, F Nur 69

14:20	Prediction method of insertion loss of detached houses against road traffic noise based on a point sound source model- Prediction formula considering the heights of buildings and a prediction point Fujimoto, Kazutoshi; Tominaga, Toru; Morita, Kengo; Hirata, Tomoko	69
14:40	The sound transmission loss across ventilation window under active noise cancellation Tang, Shiu Keung; Tong, Yean-ghing; Tsui, Kwong-lam	69
15:00	Numerical analysis of sound insulation performance of double-layer wall with vibration absorbers using FDTD method Lin, Shuo-Yen; Shinichi, Sakamoto	70

**Monday 13:40-15:00 Room 219**

**P1b Vibration and Shock**

**Chair: Len Koss, Vincent Rouillard**

**70**

13:40	Transient response of complex stiffness system using a green function from the Hilbert Transform and the steady space technic. Bae, Seung-Hoon; Jeong, Wei Bong; Cho, Jin-Rae	70
14:00	Defect size estimation and analysis of the path of rolling elements in defective bearings with respect to the operational speed Moazenahmadi, Alireza; Petersen, Dick; Howard, Carl; Sawalhi, Nader	70
14:20	In-Situ Assessment of Building Isolation Bearings Mackenzie, Neil; Lee, Yong Keat; Dawson, Bill	70
14:40	Free vibration analysis of elastically connected multiple-beams with general boundary conditions using improved Fourier series method Du, Jingtao; Xu, Deshui; Zhang, Yufei; Yang, Tiejun; Liu, Zhigang	70

**Monday 13:40-15:40 Room 218**

**L1c Active control of sound**

**Chair: Bosun Xie, Kean Chen**

**71**

13:40	Design of Active Noise Control System Applied to Helicopter Cabins Yan, Shenggang; Tang, Dakai; Zhang, Xiaonei; Yu, Haoxin	71
14:00	Effect of transducer mismatch on the performance of spherical microphone arrays Rao, Dan	71
14:20	Active noise control based on state feedback by a concentrated mass model Hisano, Shotaro; Ishikawa, Satoshi; Kijimoto, Shinya; Koba, Yosuke	71
14:40	Withdrawn2 Withdrawn2,	71
15:00	Active noise reduction of a coupled rectangular cavity using active wave control Watanabe, Motoya; Iwamoto, Hiroyuki; Tanaka, Nobuo	72
15:20	Active Structural Acoustic Control of Sound Power Radiation from a Soft-Core Sandwich Panel Kiran, Sahu; Jukka, Tuhkuri	72

**Monday 13:40-15:00 Room 217**

**V1b Metrology - calibration and realisation of standards**

**Chair: Doug Manvell, Longbiao He**

**72**

13:40	First results in the realization of the unit Watt in airborne sound Voelkel, Katharina; Bethke, Christian; Brezas, Spyros; Wittstock, Volker	72
14:00	Influence of reflecting plane having finite surface density on sound power level of reference sound sources calibrated in hemi free-field Yamada, Keisuke; Takahashi, Hironobu; Horiuchi, Ryuzo	72
14:20	Calibration Methodologies and the Accuracy of Acoustic Data Beyers, Craig	72
14:40	The Effect of Wind on Low Frequency Noise Lin, I-Chun; Hsieh, Yein-Rui; Shieh, Ping-Fei; Chuang, Hsun-Cheng; Chou, Li-Chung	73

**Monday 13:40-15:20 Room 216**

**C2a Airframe/flow-induced-noise**

**Chair: Danielle Moreau, Thomas Geyer**

**73**

13:40	Measuring owl flight noise Geyer, Thomas; Sarradj, Ennes; Fritzsche, Christoph	73
14:00	Effects of wing tip shaping on noise generation Klei, Christine E; Buffo, Rainer M; Stumpf, Eike	73
14:20	Analysis and Control of Flow-Acoustic Feedback-Loop Interactions in Transitional Airfoils Golubev, Vladimir; Nguyen, Lap; Mankbadi, Reda; Roger, Michel	73

14:40	Wind Tunnel Test of Trailing Edge Serrations for the Reduction of Wind Turbine Noise Fischer, Andreas; Bertagnolio, Franck; Shen, Wen Zhong; Madsen, Jesper; Madsen, Helge Aagaard; Bak, Christian; Devenport, William; Intaratap, Nanyaporn	74
15:00	Influence of Structural Elasticity on Trailing Edge Noise Chen, Li; Kessissoglou, Nicole	74

**Monday 13:40-15:40 Room 215**

**A2b Education - to the profession**

**Chair: Courtney Burroughs, Marion Burgess**

**74**

13:40	European Acoustics Association Schools Maffei, Luigi; Vorländer, Michael; Jambrošić, Kristian	74
14:00	Experiences of MOOCs and 25 year short courses for industries Kim, Yang-Hann	74
14:20	Audio and Acoustical Response Analysis Environment (AARAE): a tool to support education and research in acoustics Cabrera, Densil; Jimenez, Daniel; Martens, William Leigh	74
14:40	Study and practice of joint teaching between ZJU and UWA Pan, Jie; Stone, Brian; Guzzomi, Andrew; Sun, Hongmei; Zheng, Jing; Tong, Yuhui; Du, Xuhao; Xia, Yinzhu	75
15:00	The NOISE database and other electronic and web-based tools for researchers and educators Beach, Elizabeth Francis; Gilliver, Megan; Williams, Warwick	75
15:20	Car mechanic training course and acoustic technique education Nakamura, Kinji	75

**Monday 13:40-15:20 Room 214**

**H2a Outdoor sound propagation**

**Chair: Rob Bullen, Ho-Chul Shin**

**75**

13:40	Acoustic Study and Visualization of a complex echo at the Klondike Bluffs, in the Arches National Park, Utha, USA Heilmann, Gunnar; Navvab, Mojtaba; Boeck, Magdalena; Vonnrhein, Benjamin	75
14:00	Experimental validation of the modelling of surface roughness effects by an effective impedance Faure, Olivier; Gauvreau, Benoit; Junker, Fabrice; Lafon, Philippe	76
14:20	Field experiment on sound propagation from an elevated directional source Sakamoto, Shinichi; Tkanashi, Toshikazu; Yokoyama, Sakae; Ishii, Hirokazu	76
14:40	Withdrawn7 Withdrawn7,	76
15:00	Field experiment on ground-to-ground sound propagation from a directional source Takanashi, Toshikazu; Sakamoto, Shinichi; Yokoyama, Sakae; Ishii, Hirokazu	76

**Monday 13:40-15:40 Room 213**

**Q2c Numerical methods in vibro-acoustics**

**Chair: Vicente Cutanda Henriquez, Daniel Wilkes**

**76**

13:40	The Adaptive Order FEM approach for vibro-acoustic simulations: a report on a newly implemented technology with application examples demonstrating its superior performance to conventional FEM methods Vansant, Koen; Hallez, Raphael	76
14:00	A reduced-order stochastic finite element analysis for structures with uncertainties Yang, Ji; Faverjon, Béatrice; Peters, Herwig; Kessissoglou, Nicole	77
14:20	A study of the assumptions used in statistical energy analysis Lafont, Thibault; Totaro, Nicolas; Le Bot, Alain	77
14:40	Modelling the forced response of a stiffened structure Forrest, James	77
15:00	The Numerical Prediction and Features Analysis of Cylindrical Shell Acoustic Radiation Noise Cao, Hongli; Fang, Shiliang; An, Liang	77
15:20	Coupled analysis of two-dimensional acoustic and membrane vibration by concentrated mass model Ishikawa, Satoshi; Kijimoto, Shinya; Owaki, Ryoma; Matsuo, Ataru	77

**Monday 13:40-15:20 Room 212**

**B2 Machinery N&V - Engines**

**Chair: Zhuang Li**

**78**

13:40	Experimental Analyses of Vibration and Noise of Faulted Planetary Gearbox Li, Zhuang	78
14:00	Parametrically Excited Vibration in Rolling Element Bearings Srinath, R; Sarkar, A; Sekhar, A Seshadri	78

14:20	Withdrawn4	
	Withdrawn4,	78
14:40	Vibration reduction of brush cutter considering human response characteristic	
	Uemura, Masanori; Yoshida, Junji; Miyakawa, Shigeru; Oono, Teruhito; Ishikawa, Daiga	78
15:00	Coupling analysis of torsional vibration and engine rotational speed control system of marine propulsion shating	
	Yu, Shuwen; Liu, Yan; Han, Xiao; Chen, Meilong; Li, Wanyou	78

#### Monday 13:40-15:20 Room 211

##### N4a Classroom acoustics

**Chair: James Whitlock**

**79**

13:40	New generation learning environments: creating good acoustic environments - policy to implementation	
	Robinson, Amanda; Rose-Munro, Leanne	79
14:00	An investigation into the acoustics of an open plan compared to enclosed Kindergarten classroom	
	Mealings, Kiri Trengove; Buchholz, Jorg M; Demuth, Katherine; Dillon, Harvey	79
14:20	The same reverberation time in two identical rooms does not necessarily mean the same levels of speech clarity and sound levels when we look at impact of different ceiling and wall absorbers.	
	Campbell, Colin; Svensson, Carsten; Nilsson, Erling	79
14:40	Acoustical Quality Assessment of Lecture halls at Lund University, Sweden	
	Said Youssef, Rabab; Bard, Delphine; A Mahmoud, Abd El Fattah; Mkrm Esa, Nahed	79
15:00	A pilot study on the influence of language on the results of speech intelligibility tests in classrooms	
	Radosz, Jan; Zawieska, Wiktor M	80

#### Monday 13:40-15:40 Room 210

##### N7a Acoustic criteria in regulations and classification schemes for buildings

**Chair: Birgit Rasmussen, John LoVerde**

**80**

13:40	International proposal for an acoustic classification scheme for dwellings – Background and perspectives	
	Rasmussen, Birgit	80
14:00	A new approach to building acoustics regulation in Canada	
	Zeitler, Berndt; Schoenwald, Stefan; Quirt, David	80
14:20	Heavy/soft impact sound criteria and regulation in Korea	
	Jeong, Jeong Ho	80
14:40	Classification scheme of floor impact sounds with the standard rubber ball in dwellings	
	Sato, Hiroshi; Yoshimura, Junichi	80
15:00	Defining vehicular noise levels to manage risk associated with exterior facade design	
	LoVerde, John J; Dong, Wayland; Rawlings, Samantha	81
15:20	How to modify a tested fire-rated wall to improve its sound transmission rating, while maintaining its official fire-rated qualification	
	Forester, Harold	81

#### Monday 13:40-15:40 Room 209

##### D2b Vehicle noise vibration and harshness (NVH)

**Chair: Joseph Lai, Paul Kennings**

**81**

13:40	The Influence of Vibrations on Vehicle Occupant Fatigue	
	Azizan, Mohd Amzar; Fard, Mohammad	81
14:00	Automobile Power-train—Coupling Vibration Analysis on Vehicle System	
	Ding, Heng; Zhang, Weihua; Chen, Wuwei; Shi, Peicheng	81
14:20	Developing Powertrain Mounting Systems in the Virtual Engineering World Using a Full Vehicle NVH Simulator	
	Kennings, Paul; Layfield, Jonathan; Tarabra, Marco; Fothergill, David; Syred, Frank; Franks, Graham	82
14:40	The Transmission of Vibration at Various Locations on Vehicle Seat to Seated Occupant Body	
	Ittianuwat, Ratchaphon; Fard, Mohammad; Kato, Kazuhito	82
15:00	Study on startup transient vibration of a vehicle with 3-cylinder engine	
	Fu, Jianghua; Pang, Jian; Hu, Chengtai; Xu, Xiaomin; Deng, Renwei; Kuang, Xiaohong	82
15:20	Road noise sensitivity analysis with respect to suspension geometry	
	Kosaka, Fumihiko; Mizuno, Hiroaki; Inoue, Tsuyoshi; Takagi, Kentaro	82

#### Monday 13:40-15:20 Room 208

##### D4c Pavement modelling and measurement techniques

**Chair: Paul Donovan, Gaetano Licitra**

**83**

13:40	Assessing the acoustic properties of audio-tactile road markings	
	Goubert, Luc; Debroux, Philippe; Gail, Annette; Zöller, Marek; De Clerck, Kristof; Verleyen, Lenert	83
14:00	ODSURF: Optimized low noise urban road surfaces	
	Bérenghier, Michel; Gusia, Peter Johann	83

14:20	On the sound absorption coefficient of porous asphalt pavements for oblique incident sound waves Bezemer-Krijnen, Marieke; Wijnant, Ysbrand H; De Boer, Andre; Bekke, Dirk A	83
14:40	Influence of surface textures of road markings on tyre/road marking noise Gail, Annette; Bartolomaeus, Wolfram; Zöller, Marek	83
15:00	Comparative assessment for low-noise pavements by means of the ISO 11819 and the OBSI Buret, Marc; McIntosh, James; Simpson, Cassandra	84

**Monday 13:40-15:40 Room 207**

**R2 Underwater noise measurement**

	<b>Chair: Paul Dylejko</b>	<b>84</b>
13:40	Patch near-field acoustical holography based on vector hydrophone array Hu, Bo; Yang, Desen; Shi, Shengguo; Shi, Jie; Sun, Yu	84
14:00	Using low cost single-board microcontrollers to record underwater acoustical data Travaglione, Ben; Munyard, Andrew; Matthews, David	84
14:20	Marine Soundscape Ecology Sydney, Harris; Radford, Craig	84
14:40	Characterising the acoustic footprint of Australia's new research vessel RV Investigator Kloser, Rudy; Martin, Tara; Sherlock, Matt	84
15:00	Modeling ocean noise on the global scale Porter, Michael B; Henderson, Laurel J	85
15:20	A modelling approach to spatial extrapolation of ocean ambient noise measurements Heaney, Kevin D	85

**Monday 13:40-15:20 Room 206**

**S1a Soundscape and its diversity in history and culture**

	<b>Chair: Koji Nagahata</b>	<b>85</b>
13:40	Withdrawn1 Withdrawn1,	85
14:00	Soundscape Study of Urban Public Spaces along the Sea Shore Kabilan, Tharangini; Mohan, Anjana; Jeyachandran, Keerthika; Ramasamy, Kalaiselvi	85
14:20	The Urban Park Soundscape in Mountainous Cities: A case study in Chongqing Li, Heng; Xie, Hui; Kang, Jian	85
14:40	Analysis of soundscape of selected urban public places and its impact on their assessment by users Kamenicky, Matej	86
15:00	Withdrawn9 Withdrawn9,	86

**Monday 15:40-17:00 Room 220**

**K2b Applying building envelop design for noise mitigation**

	<b>Chair: Maurice Yeung, Shiu-keung Tang</b>	<b>86</b>
15:40	Tackling Traffic Noise Through Plenum Windows – An Application in Hong Kong Yeung, Maurice; N G, Isaac; Lam, John; Tang, Shiu Keung; Lo, David; Yeung, David	86
16:00	Design for noise mitigation measures for public housing developments in Hong Kong Lo, David; Yim, Stephen; Leung, Kenneth	86
16:20	Investigation of sound insulation for a Supply Air Window – field measurements and occupant response Søndergaard, Lars Sommer; Legarth, Søren Vase	86
16:40	Cost reduction of noise treatments in the oil & gas industry - design of noise mitigation for gas compressor stations using engineering optimisation Davis, David James	87

**Monday 15:40-18:00 Room 219**

**T1 Reaction to aircraft noise**

	<b>Chair: Truls Gjestland, Femke Gelderblom</b>	<b>87</b>
15:40	The economic value of aircraft noise effects: a UK perspective Sanchez, Diana; Berry, Bernard; Knowles, Andy	87
16:00	Continuous Descent Approach (CDA) compared to Regular Descent Procedures: Less Annoying? White, Kim; Arntzen, Michael; Bronkhorst, Adelbert; Meeter, Martijn	87
16:20	The impact of civil versus military aircraft noise on noise annoyance Gelderblom, Femke B; Gjestland, Truls; Granøien, Idar L N; Taraldsen, Gunnar	87
16:40	Stated choice valuation of aircraft noise and other environmental externalities at Bangkok Suvarnabhumi Airport Cheramakara, Narudh; Bristow, Abigail; Budd, Lucy; Zanni, Alberto	88

17:00	The next generation of supplementary aviation noise metrics and their use in managing aviation noise. Porter, Nicole; Knowles, Andy; Fisher, Nick; Southgate, Dave	88
17:20	New insights into perception of aircraft and community noise events Adams, Keith	88
17:40	Relaxations of operating restrictions on Noise and resident's reaction at Narita International Airport Ogata, Saburo; Shinohara, Naoaki	88

**Monday 16:00-18:00 Room 218**

**L2 Signal processing for active control**

	<b>Chair: Jing Lu, Teik Lim</b>	<b>89</b>
16:00	Multivariable control of tonal disturbances using minimization of the maximum error signal through adaptive error signal weighting Cheer, Jordan; Daley, Steve	89
16:20	Adapting an MSE controller for active noise control to nonstationary noise statistics Barkefors, Annea; Sternad, Mikael	89
16:40	Adaptive feedback noise control with leaky FeLMS algorithm Chen, Kai; Paurobally, Roshun; Pan, Jie; Qiu, Xiaojun	89
17:00	A modified frequency domain adaptive filter for active noise control Lu, Jing; Nirong, Li; Ning, Han	89
17:20	Active sound design for a passenger car based on adaptive order filter Lee, Sang Kwon; Lee, Seung Min; Kang, In Deuk; Shin, TaeJin	89
17:40	Active control of vehicle powertrain noise using inverse model LMS algorithm Sun, Guohua; Feng, Tao; Li, Mingfeng; Xu, Ji; Lim, Teik C	90

**Monday 15:40-17:20 Room 217**

**T8b Sound quality**

	<b>Chair: Klaus Genuit, Roland Sottek</b>	<b>90</b>
15:40	Noise Reduction Measures of Noisy Kitchen Devices and Evidence of their Improvement by an Objective Analysis of Spontaneous EEG Measurements Fischer, Martin; Spessert, Bruno M; Emmerich, Edeltraut	90
16:00	The influence of the sensation of rhythm on comfort and productivity Yamaguchi, Masao; Hanawa, Kazuto; Toi, Takeshi	90
16:20	Effect on car interior sound quality according to the variation of noisy components of tire-pattern noise Shin, Sung-Hwan; Hashimoto, Takeo; Hatano, Shigeko	90
16:40	Stereo or binaural headphones for sound location Cohen, Graeme J	91
17:00	Rhythmic constant pitch time stretching for digital audio Trevorrow, Brendan	91

**Monday 16:00-18:00 Room 216**

**C2b Airframe/flow-induced-noise**

	<b>Chair: Danielle Moreau, Thomas Geyer</b>	<b>91</b>
16:00	Estimation of pressure fluctuations in a turbulent boundary layer based on vibro-elastic models MacGillivray, Ian; Skvortsov, Alex	91
16:20	The effect of flow on the natural frequencies of a flexible plate Peters, Herwig; Chen, Li; Kessissoglou, Nicole	91
16:40	Attenuation of acoustic resonances in an inclined open cavity using Micro Perforated Panels Gonzalez Diaz, Cristobal; Ortiz, Santiago; Cobo, Pedro	91
17:00	The flow-induced noise of square finite wall-mounted cylinders in different boundary layers. Porteous, Ric; Moreau, Danielle; Doolan, Con J; Prime, Zebb	92
17:20	Effects of Hydrodynamic and Acoustic Pressure Fluctuations on Transmitted Sound in Wavenumber-Frequency Domain Okutsu, Yasuhiko; Hamamoto, Naoki	92
17:40	Self-noise prediction of a sharp-edged strut using a quasi-periodic CFD-BEM technique Karimi, Mahmoud; Croaker, Paul; Kessissoglou, Nicole; Doolan, Con J; Marburg, Steffen	92

**Monday 16:00-17:40 Room 215**

**U1 Technical expertise in noise assessment and management**

	<b>Chair: Pam Gunn, Emma Shanks</b>	<b>92</b>
16:00	Discussion on noise control at workplaces Pääkkönen, Rauno; Saine, Kari; Seppänen, Saara; Ollilla, Tapani	92

16:20	Comparative study of the performance of smartphone-based sound level meter apps, with and without the application of a 1/2" IEC-61094-4 working standard microphone, to IEC-61672 standard metering equipment in the detection of various problematic workplace noise environments	93
	Robinson, David Paul; Tingay, James	
16:40	Protection of workers from risks caused by loud sound fields. Comparison between the European and the United States standards.	93
	Sabato, Alessandro; Sabato, Adolfo; Reda, Alfredo	
17:00	A practical comparison of occupational noise standards	93
	Tingay, James; Robinson, David Paul	
17:20	New Zealand Code of Practice for retail fireworks - Revision of the noise testing provisions: Experiences and findings	93
	Page, Wyatt H; McLaren, Stuart J	

#### Monday 15:40-17:20 Room 214

##### H2b Outdoor sound propagation

**Chair: Rob Bullen, Ho-Chul Shin**

**94**

15:40	Field noise measurement in the huge industrial plants for accurate prediction	94
	Hida, Takahiro	
16:00	Determination of noise damping by forests	94
	Trimpop, Mattias; Mann, Peter	
16:20	Ground effect due to periodic and resonant roughness structures	94
	Shin, Ho-Chul; Taherzadeh, Shahram; Attenborough, Keith	
16:40	Determining the transmission loss of apertures above the plane wave cutoff frequency	94
	Li, Jiazhu; Chen, Jian; Li, Can	
17:00	Acoustic Yagi-Uda Antenna Using Resonance Tubes	94
	Tamura, Yuki; Yatabe, Kohei; Ouchi, Yasuhiro; Oikawa, Yasuhiro; Yamasaki, Yoshio	

#### Monday 16:00-18:20 Room 213

##### Q2d Numerical methods in vibro-acoustics

**Chair: James Forrest, Steffen Marburg**

**95**

16:00	Vibration analysis of a steam turbine blade	95
	Mohan, R S; Sarkar, A; Sekhar, A Seshadri	
16:20	Vibration transfer analysis based on characterization of vibration energy dissipation	95
	Kitahara, Atsushi; Yoshimura, Takuya	
16:40	Free vibrations of a box-type structure by plates with arbitrary boundary conditions	95
	Zhang, Kaipeng; Zhang, Tao; Wu, Han; Shi, Dongyan	
17:00	Improvement of Experimental SEA model accuracy using Independent Component Analysis	95
	Nakamura, Hiroki; Chida, Shohei; Yamazaki, Toru	
17:20	Impulsive Response Analysis Using Transient Energy Distribution Analysis	96
	Chida, Shohei; Nakamura, Hiroki; Yamazaki, Toru	
17:40	The modeling and free vibration analysis of coupled plates of various types	96
	Shi, Shuangxia; Jin, Guoyong; Chen, Mingfei	
18:00	Numerical noise generation in modelled bearing vibration signals	96
	Singh, Sarabjeet; Howard, Carl; Hansen, Colin; Kopke, Uwe	

#### Monday 16:00-17:40 Room 212

##### B1 Fan and duct noise

**Chair: Colin Tickell**

**96**

16:00	Standard, quiet and super quiet – the modelling of flow and the reduction of turbulences	96
	Bradwell, Simon	
16:20	Local improvement of flow and noise performances of axial-flow fans in a household refrigerator	96
	Seong-hun, Kim; Seung, Heo; Cheolung, Cheong; Taehoon, Kim	
16:40	Fan duct noise elimination by the use of helicoidal resonators	97
	Lapka, Wojciech	
17:00	Withdrawn6	97
	Withdrawn6,	
17:20	Stall detection using near-field low frequency and pressure modulation in turbomachines	97
	Corsini, Alessandro; Feudo, Sara; Tortora, Cecilia; Ullucci, Graziano	

**Monday 15:40-16:20 Room 211**

**N4b Classroom acoustics**

**Chair: James Whitlock**

**97**

15:40 Classrooms and voice recognition applications in a foreign language teaching

Ono, Yuichi; Ishihara, Manabu; Onishi, Akio; Yamashiro, Mitsuo

97

16:00 Vocal problems for teachers and school acoustics - a field study

Durup, Nick; Shield, Bridget; Dance, Stephen; Sullivan, Rory

97

**Monday 16:40-17:40 Room 211**

**N2 Healthcare facility acoustics**

**Chair: Kenric Van Wyk**

**98**

16:40 Review of design approaches to acoustics in Australian hospitals

Zoontjens, Luke; Cockings, Thomas

98

17:00 A summary of the 2014 FGI and sound & vibration guidelines for healthcare facilities

Van Wyk, Kenric; Horan, Daniel; Murphy, Kristen

98

17:20 Acoustic design guidelines for dementia care facilities

Hayne, Michael James; Fleming, Richard

98

**Monday 16:00-17:40 Room 210**

**N7b Acoustic criteria in regulations and classification schemes for buildings**

**Chair: Birgit Rasmussen, John LoVerde**

**99**

16:00 Open plan offices - classification scheme based on ISO 3382-3 parameters

Nocke, Christian

99

16:20 Psychoacoustical evaluation of heavyweight floor impact sounds in apartment buildings

Jeon, Jin Yong; Oh, Seong Min

99

16:40 A new metric to quantify and evaluate low frequency impact noise

LoVerde, John J; Dong, Wayland

99

17:00 Determination of vibration acceptability and annoyance design indicators for human response to wooden-floor vibrations

Negreira, Juan; Trollé, Arnaud; Jarnerö, Kirs; Sjökvist, Lars-Göran; Bard, Delphine

99

17:20 Extensions of EN 12354 vibration reduction index expressions by means of FEM calculations

Crispin, Charlotte; De Geetere, Lieven; Ingelaere, Bart

99

**Monday 16:00-18:00 Room 209**

**D2c Vehicle noise vibration and harshness (NVH)**

**Chair: Zhichao Hou, Paul Kennings**

**100**

16:00 Modelling of Fluid-Structure Interactions in the Hydraulic Circuit of Passive Interconnected Suspensions

Zhao, Jing; Zhang, Nong; Ji, Jin Chen

100

16:20 The characteristic identification of disc brake squeal based on ensemble empirical mode decomposition

Yao, Liang; Hiroshi, Yamaura

100

16:40 Instability prediction of brake squeal by nonlinear stability analysis

Zhang, Zhi; Oberst, Sebastian; Lai, Joseph C S

100

17:00 Vehicle Chassis Decoupling Control Based on Neural Network Inverse Method

Yang, Jun; Zhao, Linfeng; Chen, Wuwei; Huang, He; Xia, Guang

100

17:20 Target setting and source contribution for sound quality of a motorcycle

Lu, Ming-Hung; Jen, Ming Une

101

17:40 Indoor pass-by noise engineering: a motorbike application case

Bianciardi, Fabio; Janssens, Karl; Choukri, Mostapha; Van Der Auweraer, Herman

101

**Monday 15:40-18:00 Room 208**

**D6 Tyre/road noise - tyre factors**

**Chair: Piotr Mioduszewski, Ulf Sandberg**

**101**

15:40 Characterisation of low-noise tyres for the roads of Hong Kong

Hung, Wing-tat; Leung, Randolph Chi-kin; Lam, Yat Ken

101

16:00 An investigation of the relationship between texture and tyre/road noise for different types of road surfaces and passenger car tyres

Berge, Truls; Viggen, Erlend Magnus

101

16:20 Tyre tread pattern noise optimization by a coupled source-human perception model

Bekke, Dirk A; Wijnant, Ysbrand H; De Boer, Andre; Bezemer-Krijnen, Marieke

102

16:40 Temperature influence on tyre/road noise of selected tyres

Mioduszewski, Piotr; Taryma, Stanisław; Woźniak, Ryszard

102



17:00	A study of the tyre cavity resonance and its mitigation using modal analysis method Chanpong, Napasin; Mohamed, Zamri; Wei, Haiqiao; Watkins, Simon; Wang, Xu	102
17:20	Influence of Circumferential Tread Pattern Stiffness on Tire Road Noise Generation under Driving Torque Stalter, Frank; Gauterin, Frank	102
17:40	A Simulation Methodology for Tire/Road Vibration Noise analysis Yintao, Wei; Feng, Xijing; Xiang, Dabing; Chen, Yalong	102

**Monday 16:00-18:00 Room 207**

**R3b Underwater noise and its control**

**Chair: Nicole Kessissoglou** **103**

16:00	Attenuation of low frequency underwater noise using arrays of air-filled resonators Wochner, Mark S; Lee, Kevin M; McNeese, Andrew R; Wilson, Preston S	103
16:20	Underwater noise generated by merchants ships in coastal waters of the Gulf of Gdansk Listewnik, Karol	103
16:40	Modelling underwater shipping noise in the Great Barrier Reef Marine Park using AIS vessel track data MacGillivray, Alexander; McPherson, Craig; McPherson, Geoff; Izett, Jonathan; Gosselin, Jeremy; Li, Zizheng; Hannay, David	103
17:00	Is underwater thermal noise useful? Readhead, Mark L	103
17:20	Study on the effect of alignment style on shafting-shell coupled system radiated noise caused by propeller force Cao, Yipeng; Zhang, Runze; Yang, Guodong	104
17:40	Real variability in ship systems' noise and vibration. Design and through-life management implications for underwater noise and habitability McIntosh, David James	104

**Monday 15:40-16:20 Room 206**

**S1b Soundscape and its diversity in history and culture**

**Chair: Koji Nagahata** **104**

15:40	On the Study of Effects of Views to Water Space on Noise Annoyance Perceptions at Homes Leung, T M; Chau, C K; Tang, Shiu Keung; Pun, L S C	104
16:00	WithdrawnA WithdrawnA,	104

**Monday 16:40-17:40 Room 206**

**S2 Soundscape and auditory cognition**

**Chair: Dick Botteldooren** **104**

16:40	How the meaning a person gives to tranquility could affect the appraisal of the urban park soundscape Botteldooren, Dick; Filipan, Karlo; Boes, Michiel; De Coensel, Bert	104
17:00	Studies of Combination Effects of Sound on Biology and Cognition- Interdisciplinarity in Action Mossberg, Frans	105
17:20	Temporal features extraction for the binaural soundscape samples Wang, Daiwei; Deng, Zhiyong; Li, Xinxin; Liu, Aili	105

**Tuesday 08:20-09:20 Room Plenary**

**Keynote 3**

**Chair: Norman Broner** **105**

08:20	Noise and Low frequency noise from Wind Turbines Søndergaard, Bo	105
-------	---	-----

**Tuesday 08:20-09:20 Room 213**

**Keynote 4**

**Chair: John Davy** **105**

08:20	The impact of building acoustics on speech comprehension and student achievement Wang, Lily M	105
-------	--	-----

**Tuesday 09:20-11:00 Room 218**

**M1 Metamaterial**

**Chair: Stuart Bolton** **106**

09:20	A simple model of effective elastic properties of materials with inclusions Skvortsov, Alex; MacGillivray, Ian	106
-------	---	-----

09:40	Noise shielding using active acoustic metamaterials with electronically tunable acoustic impedance Mokry, Pavel; Steiger, Katerina; Vaclavik, Jan; Psota, Pavel; Dolecek, Roman; Marton, Pavel; Kodejska, Milos; Cernik, Martin	106
10:00	Random Incidence Transmission Loss of a Metamaterial Barrier System Varanasi, Srinivas; Bolton, J. Stuart; Siegmund, Thomas	106
10:20	Acoustic metamaterial panel composed of funnel-shaped cell unit having multi-band negative material properties Cho, Sungjin; Kim, Boseung; Min, Dongki; Kang, Jeonghoon; Park, Junhong	106
10:40	Tailoring Acoustic Metamaterials to Aeroacoustic Applications Iemma, Umberto; Carley, Michael; Pellegrini, Riccardo	106

**Tuesday 09:20-10:40 Room 217**

**G1 Wind turbines -Evaluation at neighbours I**

**Chair: Con Doolan, Mark Bastasch**

**107**

09:20	Special Noise Character in Noise from Wind Farms Lenchine, Valeri V; Song, Jonathan	107
09:40	Investigating the impacts of wind turbine noise on quality of life in the Australian context: A case study approach. McBride, David Iain; Shepherd, Daniel; Thorne, Robert	107
10:00	Outcome of systematic research on wind turbine noise in Japan Part 1 Tachibana, Hideki	107
10:20	Outcome of systematic research on wind turbine noise in Japan Part 2 Tachibana, Hideki	108

**Tuesday 09:20-10:40 Room 216**

**C3a EU research projects on aircraft noise**

**Chair: Dominique Collin, Samir Gerges**

**108**

09:20	European aviation noise research network (X-NOISE) Collin, Dominique	108
09:40	Optimisation for low Environmental Noise impact AIRcraft - OPENAIR Kors, Eugene; Collin, Dominique	108
10:00	AFLoNext – A European Contribution to Airframe Noise Control Bauer, Michael; Büscher, Alexander; Pott-Pollenske, Michael	108
10:20	Fundamental indirect noise generation by interactions between entropy, vorticity and acoustic waves in the context of aero engine applications Ullrich, Wolfram Christoph; Schulze, Moritz; Sattelmayer, Thomas	109

**Tuesday 09:20-10:40 Room 215**

**A3a Noise policy**

**Chair: Maurice Yeung, Marion Burgess**

**109**

09:20	The evolution of noise policy and noise management in England during the life of the UK's Institute of Acoustics Grimwood, Colin; Turner, Stephen	109
09:40	A Metric Matrix Establishment for Cases Studies on the Effectiveness of the Key Environmental Protection Policies for Transportation Pollution Control Zhang, Jiping; Schomer, Paul D; Buret, Marc; Zhang, Lei; Wu, Dian; Boyle, James	109
10:00	Challenges in Planning against Road Traffic Noise in Hong Kong Wu, Marco; Ng, Isaac; Szeto, Wing Kwok; Yeung, Maurice	109
10:20	Progress on environmental noise policies from 2008-2013 in Asia and the world Schwela, Dietrich H; Finegold, Lawrence S; Gjestland, Truls	110

**Tuesday 09:20-11:00 Room 214**

**H3 Noise mapping prediction tools**

**Chair: Gilles Daigle**

**110**

09:20	Fast traffic noise mapping of cities using the Graphics Processing Unit of a personal computer Salomons, Erik M; Zhou, Han; Lohman, Walter J A	110
09:40	Lessons from round 2 noise mapping in England Hepworth, Peter; Shilton, Simon; Jones, Nigel; Burdett, Matthew	110
10:00	Statistical Method for an Assessment of Actions against Noise and Air Pollution in Order to compare the total Improvement in an Investigation Area Zacharias, Frank-Christian; Kunka, Rainer; Hoar, Christopher F J	110
10:20	A low-budget road traffic noise model for individual building evaluation - a case study in Western Australia Felder, Martin; Burgess, Marion; Arnold, Jörg	110

10:40	A web-based approach for the evaluation of acoustic performance of development designs and assessment of performance of mitigation elements	111
	Hoar, Christopher F J; Wong, Kin Man; Noor, Noor Azlan Mohammed	

**Tuesday 09:40-10:40 Room 213**

**Q2e Numerical methods in vibro-acoustics**

**Chair: Abhijit Sarkar, Daniel Wilkes** **111**

09:40	Dispersion diagrams of a water-loaded cylindrical shell obtained from the structural and acoustic responses of the sensor array along the shell	111
	Jung, B K; Ryue, J; Hong, C S; Jeong, Wei Bong; Shin, K K	
10:00	Acoustic and flexural wave energy conservation for a thin plate in a fluid	111
	McMahon, Darryl	
10:20	Acoustic forcing of flexural waves and acoustic fields for a thin plate in a fluid	111
	McMahon, Darryl	

**Tuesday 09:20-11:00 Room 212**

**Q6a Inverse approaches in vibro-acoustics**

**Chair: Jeong-Guon Ih, Stephen Hambric** **112**

09:20	Research on eigenfrequency shifts due to cracks in cylindrical structures and the application in non-destructive testing	112
	Stache, Martin; Guettler, Marcus; Marburg, Steffen	
09:40	Vibration rendering on a thin plate by actuator array on the boundary	112
	Woo, Jung-Han; Ih, Jeong-Guon	
10:00	Separation of non-stationary sound fields using single layer pressure-velocity measurements	112
	Bi, Chuan-Xing; Geng, Lin; Zhang, Xiao-Zheng	
10:20	Approximate model of sound source in consideration of evanescent waves in far-field acoustical holography	112
	Wang, Ziteng; Yang, Diange; Miao, Feng; Wang, Rujia; Wen, Junjie; Lian, Xiaomin	
10:40	Comparison of patch acoustic holography methods for confined space	113
	Havránek, Zdeněk; Beneš, Petr; Klusáček, Stanislav	

**Tuesday 09:20-10:40 Room 211**

**N6a Noise in lightweight structures**

**Chair: Jean-Luc Kouyoumji, Heinz Ferk** **113**

09:20	A model based on loudness level to describe airborne sound insulation	113
	Neubauer, Reinhard; Kang, Jian	
09:40	Influence of design and leakages of the window-wall connection on the sound insulation.	113
	Ferk, Heinz; Buchegger, Blasius; Meissnitzer, Marlon	
10:00	Improvement of sound insulation performance at low frequencies by several fibrous absorbers in lightweight double leaf partition	113
	Sugie, Satoshi; Yoshimura, Junichi; Iwase, Teruo	
10:20	Parametric study of direct airborne insulation of wood stud walls in midrise construction	114
	Zeitler, Berndt; Schoenwald, Stefan; King, Frances	

**Tuesday 09:20-10:40 Room 210**

**N8c Room acoustics**

**Chair: Nazli Bin Che Din, Reiji Tomiku** **114**

09:20	Absorption modeling with ensemble averaged impedance for wave-based room acoustics simulations	114
	Otsuru, Toru; Tomiku, Reiji; Okuzono, Takeshi	
09:40	A technique based on the equivalent source method for measuring the surface impedance and reflection coefficient of a locally reacting material	114
	Zhang, Yong-Bin; Lin, Wang-Lin; Bi, Chuan-Xing	
10:00	A coherent image source method for sound prediction in long spaces with a sound absorbent ceiling	114
	Min, Hequn; Chen, Yan; Qiu, Xiaojun	
10:20	A trial on calculating the equivalent reflection coefficient by acoustic distance measurement method based on phase interference in the actual sound actual field	114
	Nakasako, Noboru; Neki, Yuma; Nakayama, Masato; Shinohara, Toshihiro; Uebo, Tetsuji	

**Tuesday 09:20-11:00 Room 209**

**D2d Vehicle noise vibration and harshness (NVH)**

**Chair: Joseph Lai, Zhichao Hou** **115**

09:20	Vehicle noise functional performance indicators using tire sound intensity	115
	Donavan, Paul; Janello, Carrie	

09:40	Parameter quantification for evaluation of vehicle's impulsive BSR noise Lee, Sinyeob; Kwak, Yun-sang; Kim, Boseung; Lee, Jongho; Park, Junhong	115
10:00	Mechanism of Noise Generation on Outer Rotor Motor Ikeda, Kazumasa; Semura, Junichi; Ohzawa, Tsukasa	115
10:20	Verification of contribution separation technique for vehicle interior noise using only response signals Hirano, Tomohiro; Yoshida, Junji	115
10:40	Development of a prototype system to evaluate of contribution rate of each noise source in road traffic noise Houzu, Hiroyuki; Sakamoto, Ichiro; Nishi, Takahiro; Ishihama, Masao; Sawatari, Katsumi	115

**Tuesday 9:40-11:00 Room 208**

**D8a Motor vehicle noise - policy and regulation**

**Chair: Hans Bendtsen, James McIntosh**

**116**

09:40	The Dutch Road Noise Mitigation Program Faber, Nico	116
10:00	Value for Money in Road Traffic Noise Abatement Milford, Ingunn; Aasebo, Sigve Jarl; Strommer, Kjell	116
10:20	The Swiss way to silent roads Walker, Urs	116
10:40	The danish national road noise strategy Pedersen, Frank; Kristensen, Brian	116

**Tuesday 09:20-10:40 Room 207**

**R4 Detection, localisation and classification of sources**

**Chair: Alec Duncan**

**117**

09:20	Advanced signal processing methods for the analysis of transient radiated noise from submarines Leissing, Thomas; Audoly, Christian; Lachambre, Hélène; Stempfel, Guillaume	117
09:40	Application of the virtual time-reversal technique to transient sources localization in complex immersed struc Leissing, Thomas; Audoly, Christian; Guyader, Jean-Louis; Guyader, Guillaume; Buisson, Quentin; Morange, Jean-Louis	117
10:00	Performance of time domain and time-frequency domain adaptive beamformers with moving sound sources Bao, Chaoying	117
10:20	Cross correlation matched field localization for unknown emitted signal waveform using two-hydrophone Yao, Shuai; Li, Kun; Fang, Shiliang	117

**Tuesday 09:40-11:00 Room 206**

**T3a Effects of noise on humans**

**Chair: Lily Wang, Andreas Liebl**

**118**

09:40	Effects of room acoustics on comprehension of foreign-accented speech by native and non-native English-speaking listeners Peng, Zhao; Hanna, Kristin E; Boyd, Brenna N; Wang, Lily M	118
10:00	Vibration properties of hand-arm system while holding a grip Kuwada, Masashi; Yoshimura, Takuya; Tsurumi, Yasuaki; Yamada, Daisuke	118
10:20	Assessment of noise-induced annoyance by tones in noise from building mechanical systems Lee, Joonhee; Wang, Lily M	118
10:40	Combined effects of low frequency vertical vibration and noise on whole-body vibration sensation Hiroshi, Matsuda; Nobuo, Machida	118

**Tuesday 11:00-12:00 Room 220**

**E3 Railway wheel and rail noise**

**Chair: Barry Murray**

**119**

11:00	Curve Squeal: Causes, Treatments and Results Hanson, David; Jiang, Jiandong; Dowdell, Bruce; Dwight, Richard	119
11:20	Acoustic rail grinding – measures of long term effectiveness: Epping to Chatswood Rail Link case study Vegh, Serge; Kochanowski, Radek; Croft, Briony	119
11:40	Bearing defect size estimation for extended raceway defects Petersen, Dick; Howard, Carl	119

**Tuesday 12:00-12:40 Room 220**

**E4 Rail acoustics policy**

**Chair: Mark Batstone**

**119**

12:00	Comparison of Kilde and NORD2000 rail noise prediction methodologies De Lisle, Simon; Burgemeister, Kym	119
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12:20	A simplified approach for evaluating noise impact from high-speed lines Zhang, Xuetao	120
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**Tuesday 11:00-12:40 Room 219**

**T7 Loudness and other psycho-acoustical parameters**

**Chair: Klaus Genuit, Roland Sottek** **120**

11:00	Improvements in calculating the loudness of time varying sounds Sottek, Roland	120
11:20	Loudness Using a Threshold Correction Factor Novak, Colin; Ule, Helen; Gaspar, Robert	120
11:40	Development of a new loudness model in consideration of audio-visual interaction Aizawa, Kai; Kamogawa, Takashi; Arimitsu, Akihiko; Toi, Takeshi	120
12:00	Noise evaluation based on loudness-perception characteristics of older adults Kurakata, Kenji; Mizunami, Tazu	121
12:20	Measurement of attention to auditory signal in noisy environment Sato, Hiroshi	121

**Tuesday 11:20-12:20 Room 218**

**M2 Nanomaterials in acoustics**

**Chair: Anthony Zander** **121**

11:20	Acoustic absorption behaviour of carbon nanotube arrays Ayub, Md; Zander, Anthony C; Howard, Carl; Cazzolato, Benjamin S; Shanov, Vesselin N; Alvarez, Noe T; Huang, David M	121
11:40	Thermophones using carbon nanotubes and alternative nanostructures for high power sound generation and noise cancellation Aliev, Ali E	121
12:00	Improving sound absorption bandwidth of micro-perforated panel by adding porous materials Li, Dengke; Chang, Daoqing; Liu, Bilong; Tian, Jing	121

**Tuesday 11:20-12:40 Room 217**

**G2 Measurement of wind turbine noise**

**Chair: Lars Sondergaard** **122**

11:20	An investigation of Different Secondary Noise Wind Screen Designs for Wind Turbine Noise Applications Novak, Colin; Sjöström, Anders; Ule, Helen; Bard, Delphine; Sandberg, Göran	122
11:40	Wind turbine sound - metric and guidelines Larsson, Conny; Öhlund, Olof	122
12:00	Wind turbine noise measurements - How are results influenced by different methods of deriving wind speed? Broneske, Sylvia	122
12:20	Correlation of amplitude modulation to inflow characteristics Madsen, Helge Aagaard; Bertagnolio, Franck; Fischer, Andreas; Bak, Christian	122

**Tuesday 11:00-12:20 Room 216**

**C3b EU research projects on aircraft noise**

**Chair: Dominique Collin, Samir Gerges** **123**

11:00	IDEALVENT: Characterization of installation effects in aircraft Environmental Control Systems Schram, Christophe; Kucukcoskun, Korcan; Christophe, Julien; Van De Wyer, Nicolas	123
11:20	COSMA – A European Approach on Aircraft Noise Annoyance Research Bauer, Michael; Collin, Dominique; Iemma, Umberto; Janssens, Karl; Márki, Ferenc; Müller, Uwe	123
11:40	Multi-objective optimization of takeoff and landing procedures: level abatement vs quality improvement of aircraft noise Iemma, Umberto; Burghignoli, Lorenzo; Centracchio, Francesco; Galluzzi, Valerio	123
12:00	NINHA: Noise Impact of aircraft with Novel engine configurations in mid- to High Altitude operations Van Oosten, Nico; Collin, Dominique	123

**Tuesday 11:00-12:40 Room 215**

**A3b Noise policy**

**Chair: Maurice Yeung, Marion Burgess** **124**

11:00	Control of noise from public entertainment activities in Hong Kong Kwok, Kwun Ting; Cheng, Kin Wui	124
11:20	Residential acoustic amenity in 'vibrant' mixed use areas Wheatley, Glenn Robert	124

11:40	Live music and the 'agent of change' principle McArdle, Sean; Lee, Gillian; Hui, Elizabeth	124
12:00	New techniques to determine specific noise for increasing the effectiveness of continuous unattended noise monitoring systems Manvell, Douglas; Stollery, Phil	124
12:20	Continuous noise monitoring network design: an end user perspective Sparke, Clayton James	125

**Tuesday 11:00-12:20 Room 213**

**Q2f Numerical methods in vibro-acoustics**

**Chair: Stephen Conlon, Weikang Jiang** **125**

11:00	Sound transmission between rooms coupled through partition with elastically restrained edges Zhang, Yufei; Du, Jingtao; Liu, Yang; Yang, Tiejun; Liu, Zhigang	125
11:20	Transfer-matrix-based approach for an eigenvalue problem of a coupled rectangular cavity Iwamoto, Hiroyuki; Tanaka, Nobuo	125
11:40	Study on aero-acoustic structural interactions in fan-ducted system Chiang, Yan Kei; Choy, Yat Sze; Cheng, Li; Tang, Shiu Keung	125
12:00	Modal contributions to the acoustic responses of fluid-loaded shells Qu, Yegao; Hua, Hongxing; Peters, Herwig; Kessissoglou, Nicole	126

**Tuesday 11:20-12:40 Room 212**

**Q6b Inverse approaches in vibro-acoustics**

**Chair: Jeong-Guon Ih, Nourredine Atalla** **126**

11:20	A shape classification for the acoustic radiator using its sound field Kim, Koo-Hwan; Kim, Yang-Hann	126
11:40	A moving sound source localization method based on TDOA Miao, Feng; Yang, Diange; Wang, Rujia; Wen, Junjie; Wang, Ziteng; Lian, Xiaomin	126
12:00	High-resolution nearfield acoustic holography based on iterative weighted equivalent source method Xu, Liang; Bi, Chuan-Xing; Zhang, Xiao-Zheng; Zheng, Chang-jun	126
12:20	Withdrawn8 Withdrawn8,	126

**Tuesday 11:00-12:40 Room 211**

**N6b Noise in lightweight structures**

**Chair: Jeffrey Mahn, Rikard Öqvist** **127**

11:00	Challenges for acoustic calculation models in "Silent Timber Build", Part 2 Kouyoumji, Jean-Luc; Bard, Delphine Gérard; Borello, Gérard; Guigou, Catherine	127
11:20	Laboratory data examining impact and airborne sound attenuation in heavy timber loft style construction. Byrick, Wilson Robert	127
11:40	Effects of sample construction, sample size and niche depth on measured sound transmission loss Wareing, Robin R; Davy, John Laurence; Pearse, John R	127
12:00	The uncertainty in sound insulation of an industrially prefabricated lightweight timber construction Öqvist, Rikard	127
12:20	Laboratory facilities for sound transmission measurements – validation by measurement and simulation methods Meissnitzer, Marlon; Buchegger, Blasius; Ferk, Heinz	128

**Tuesday 11:00-12:40 Room 210**

**N8d Room acoustics**

**Chair: Toru Otsuru, Delphine Bard** **128**

11:00	The prediction of the complex characteristic acoustic impedance of porous materials Larner, David James; Davy, John Laurence	128
11:20	A BEM study of the influence of musicians on onstage sound field measures in auditoria Panton, Lilyan; Holloway, Damien	128
11:40	An explicit time-domain finite-element method for room acoustics simulation Okuzono, Takeshi; Otsuru, Toru; Sakagami, Kimihiro	128
12:00	Digital sound system modelling and design Davis, Lauren; Mackenzie, Neil	128
12:20	Evaluation of the acoustic performance of a theatrical space set up in a restored Latomia in Ragusa Iblea Patania, Francesco; Gagliano, Antonio; Nocera, Francesco; Cicero, Andrea	129

**Tuesday 11:40-12:40 Room 209**

**S4a Soundscape and methods of evaluation**

**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**129**

11:40 Measuring a Soundscape of the captive Southern White Rhinoceros (*Ceratotherium simum simum*)

Wiseman, Susan; Wilson, Preston S; Sepulveda, Frank

129

12:00 Towards a quantitative tool to assess the soundscape

Welch, David; Shepherd, Daniel; Dirks, Kim N; Tan, Mei Yen

129

12:20 Soundscape Transects: Case Studies from New York City and O'ahu

Carter, J Parkman

129

**Tuesday 11:20-12:00 Room 208**

**D8b Motor vehicle noise - policy and regulation**

**Chair: Hans Bendtsen, James McIntosh**

**130**

11:20 Outcome based optimisation of road traffic noise mitigation

Kean, Simon

130

11:40 Buffer distances for surface roads and elevated highways correlated with pre-existing ambient noise

Zhang, Jiping; Buret, Marc; Wu, Shuoxian; Zhao, Yuezhe; Shen, Saiyan; Zhang, Xin

130

**Tuesday 11:20-12:40 Room 207**

**R5 Bubble acoustics**

**Chair: Joe Cuschieri**

**130**

11:20 Application of lattice Boltzmann method to research bubble interacting with spherical particle

Shi, Dongyan; Wang, Zhikai; Zhang, Aman

130

11:40 Interaction of a pair of horizontally aligned bubbles in gravity field

Jiao, Han; Shi, Dongyan; Wang, Zhikai; Li, Hongqun

130

12:00 Planar laser induced fluorescence imaging of bubble formation

Fedrizzi, Marcus; Soria, Julio

131

12:20 Acoustic imaging of surface ship wakes

Kouzoubov, Alexei; Wood, Shane; Ellem, Richard

131

**Tuesday 11:20-12:20 Room 206**

**T3b Effects of noise on humans**

**Chair: Lily Wang, Andreas Liebl**

**131**

11:20 Transferability of the results from laboratory basic research on cognitive impairment by background sound to real life offices

Liebl, Andreas; Kittel, Maria

131

11:40 Road traffic noise, air pollution and cardio-respiratory health in European cohorts: a harmonised approach in the BioSHaRE project

Blangiardo, Marta; Cai, Samuel; De Hoogh, Kees; Gulliver, John; Morley, David; Doiron, Dany; Elliott, Paul; Hansell, Anna; Hodgson, Susan

131

12:00 Prediction of virtual sound source elevation improved by including input source spectral shape in the prediction equation

Manor, Ella; Martens, William Leigh

132

**Tuesday 13:40-15:20 Room 220**

**E2 Ground-borne vibration and noise from railways**

**Chair: Barry Murray, Mark Batstone**

**132**

13:40 Force Density Measurements at Sound Transit

Nelson, James; Watry, Derek; Faner, Patrick; Lamb, Isabelle; Reed, Tracy; Wright, Armin

132

14:00 Use of a "Hybrid" Empirical/Finite Element Approach for Predicting Groundborne Vibration from Rail Systems

Saurenman, Hugh; Roulo, Eric

132

14:20 A parametric study on the influence of track irregularities upon train induced ground vibration

Yokoyama, Hidefumi; Yashiro, Kazuyuki; Kato, Shinjiro; Ohta, Takehiro

132

14:40 Study on elevated light rail induced vibration attenuation along the surrounding ground

Liu, Changqing; Zhou, Yude; Tu, Ying; Xu, Weimin

133

15:00 Experimental modal analysis of high-speed railway carriage

Ouyang, Shan; Sui, Fusheng

133

**Tuesday 13:40-15:20 Room 219**

**V2a Sound visualization and manipulation**

**Chair: Yang-Hann Kim, William Martens**

**133**

- |       |   |     |
|-------|---|-----|
| 13:40 | Exploring the limitations and expectations of sound source localization and visualization techniques.<br>Heilmann, Gunnar; Doeblner, Dirk; Boeck, Magdalena | 133 |
| 14:00 | Developing beam-forming devices to detect squeak and rattle sources by using FPGA<br>Kim, Youngkey; Kang, Jungoo; Lee, Myunghan                             | 133 |
| 14:20 | Detection and direction estimation of a sudden loud sound for the hearing assistive eyeglasses<br>Kim, Ki-Won; Choi, Jung-Woo; Kim, Yang-Hann               | 133 |
| 14:40 | Non-stationary Holography on Arbitrary Source Shapes<br>Gomes, Jesper; Ishii, Yutaka; Ginn, Bernard   | 134 |
| 15:00 | Reconstruction of sound fields with a spherical microphone array<br>Fernandez-Grande, Efren; Tim, Walton  | 134 |

**Tuesday 13:40-15:40 Room 218**

**L3a Applications and systems for active control**

**Chair: Xiaojun Qiu, Woon Seng Gan**

**134**

- |       |   |     |
|-------|---|-----|
| 13:40 | Applying Active Noise Control Technique for Augmented Reality Headphones<br>Ranjan, Rishabh; Woon Seng, Gan; Yong-Kim, Chong  | 134 |
| 14:00 | Active Snore Control System Integrated with Apnea Detector<br>Kuo, Sen M; Chang, Cheng-Yuan; Pottim, Karunakar; Liu, Lichuag  | 134 |
| 14:20 | A decoupled hybrid structure for active noise control with uncorrelated narrowband disturbances<br>Wu, Lifu; Qiu, Xiaojun; Burnett, Ian S; Eva, Cheng; Guo, Yecai                     | 135 |
| 14:40 | Development of a voice shutter (Phase 1: A closed type with feed forward control)<br>Nishimura, Masaharu; Tanaka, Toshihiro; Shiratori, Koji; Sakurama, Kazunori; Nishida, Shinichiro | 135 |
| 15:00 | Active flow control of the exhaust noise from internal combustion piston engine<br>Leclercq, Damien J J; Howard, Carl   | 135 |

**Tuesday 13:40-15:00 Room 217**

**G3 Wind turbines - Evaluation at neighbours II**

**Chair: Renzo Tonin**

**135**

- |       |   |     |
|-------|---|-----|
| 13:40 | Using Wind Farm Noise Auralisations for Effective Community Consultation<br>Butera, Frank; Burgemeister, Kym; Fisher, Kai; Mounter, David       | 135 |
| 14:00 | The noise characteristics of 'compliant' wind farms that adversely affect its neighbours<br>Large, Sarah; Stigwood, Mike                        | 136 |
| 14:20 | The Relevance of the Precautionary Principle to wind farm noise planning<br>Thorne, Bob   | 136 |
| 14:40 | Initial findings of the UK Cotton Farm Wind Farm long term community noise monitoring project<br>Stigwood, Mike; Stigwood, Duncan; Large, Sarah | 136 |

**Tuesday 13:40-15:20 Room 216**

**C4a New experimental techniques**

**Chair: Vincent Valeau, Carsten Spehr**

**136**

- |       |  |     |
|-------|--|-----|
| 13:40 | Beamforming array optimisation and phase averaged sound source mapping on a model wind turbine<br>Prime, Zebb; Doolan, Con J; Zajamsek, Branko   | 136 |
| 14:00 | Development of the Microphone-Array Measurement Technique for use in Cryogenic and Pressurized Wind Tunnels<br>Ahelfeldt, Thomas; Spehr, Carsten | 136 |
| 14:20 | Beamforming of aeroacoustic sources in the time domain<br>Fischer, Jeoffrey; Valeau, Vincent; Brizzi, Laurent-Emmanuel                           | 137 |
| 14:40 | Correlation of parallel car interior and exterior beamforming measurements in a wind tunnel<br>Neugebauer, Stefan; Rösel, Reinhard; Döbler, Dirk | 137 |
| 15:00 | Three-dimensional beamforming of aeroacoustic sources.<br>Porteous, Ric; Prime, Zebb; Valeau, Vincent; Doolan, Con J; Moreau, Danielle           | 137 |

**Tuesday 13:40-15:20 Room 215**

**A3c Noise policy**

**Chair: Maurice Yeung, Marion Burgess**

**137**

- |       |  |     |
|-------|--|-----|
| 13:40 | Challenge on Environmental Mitigation Measures on Site Formation Work to Achieve Win-Win-Win Situation for Project Proponent,<br>Lee, Lawrence; Cheung, M K; Liu, Alfa | 137 |
|-------|--|-----|



14:00	Effective noise objectives for industrial and resource developments – setting, compliance assessment monitoring and audit Tickell, Colin	138
14:20	Noise sentinel – a proactive approach to noise management in mining operations at BHP Billiton Worsley Alumina Pty Ltd Kenny, Silver; Manvell, Douglas	138
14:40	Quiet Construction: State-of-the-Art Methods and Mitigation Measures Cheng, Kin Wui; Law, Chi-wing; Wong, Cheung-lam	138
15:00	Quality Powered Mechanical Equipment System to Reduce Construction Noise in Hong Kong Law, Chi-wing; Wong, Cheung-lam	138

## **Tuesday 13:40-15:40 Room 214**

### **H4a Airport noise modelling and measurement**

**Chair: Ichiro Yamada, Chris Middleton** **139**

13:40	Challenges in Producing an Australian Noise Exposure Forecast McLeod, Ian; Latimore, Mark	139
14:00	Land-use planning at airports in Germany Weinandy, Rene; Myck, Thomas; Thierbach, Roman	139
14:20	Reliability of aircraft noise evaluation by measurement for comparison with prediction Shinohara, Naoaki; Yamada, Ichiro	139
14:40	Measurement of noise exposure planar distribution in aircraft approach path vicinity Ishii, Hirokazu; Yokota, Takatoshi; Makino, Koichi; Shinohara, Naoaki; Sugawara, Masayuki	139
15:00	Noise assessment in the neighbourhood of Italian military airports Filomena, Vincenzo; De Vivo, Luciano; Notarnicola, Lorenzo; Aversano, Renato; Tusciano, Manolo	140
15:20	Angular and distance dependence of the standard deviation of maximum sound level for aircraft noise Wall, Martin; Liljergren, Mikael; Heed, Christer; Tari, Alborz	140

## **Tuesday 13:40-15:20 Room 213**

### **Q3a Vibro-acoustic methods for noise control treatments**

**Chair: Nourredine Atalla, Stephen Hambric** **140**

13:40	Numerical modelling of the vibro-acoustic behavior of a closed vehicle with frequency dependent polymer materials Bouayed, Kaiss; Mordillat, Philippe; Mebarek, Lassen; Hamdi, Mohamed Ali	140
14:00	Research on vibration and sound radiation characteristics of ship stiffened composite plate structure Pang, Fu-zhen; Song, Hong-bao; Miao, Xu-hong	140
14:20	Optimal design of unconstrained damping material on a thin panel by using topology optimization Yamamoto, Takashi; Yamada, Takayuki; Izui, Kazuhiro; Nishiwaki, Shinji	141
14:40	Optimal Configurations of ACLD/Plate for Bending Vibration Control using INSGA-II Zhang, Dongdong; Zheng, Ling; Li, Yinong	141
15:00	Stochastic porous model of a bone-implant healing process using polynomial chaos expansion Yang, Ji; Faverjon, Béatrice; Dureisseix, David; Swider, Pascal; Kessissoglou, Nicole	141

## **Tuesday 13:40-15:20 Room 212**

### **Q7 Modal analysis**

**Chair: Robert Randall, Stephen Conlon** **141**

13:40	Automotive cabin characterization by acoustic modal analysis Peeters, Bart; El-kafafy, Mahmoud; Accardo, Giampiero; Bianciardi, Fabio; Janssens, Karl	141
14:00	Using frequency and modal analysis to attenuate low frequency waves Ziaran, Stanislav	142
14:20	Regeneration of frequency response functions from poles and zeros: a discussion with implications for cepstrum-based operational modal analysis Smith, Wade A; Randall, Robert Bond	142
14:40	Removal of shaft speed related components from the response signals of a machine with varying speed prior to Operational Modal Analysis Coats, Michael David; Randall, Robert Bond	142
15:00	A detailed experimental modal analysis of a clamped circular plate Matthews, David; Sun, Hongmei; Saltmarsh, Kyle; Wilkes, Daniel Ryan; Munyard, Andrew; Pan, Jie	142

## **Tuesday 13:40-15:40 Room 211**

### **N6c Noise in lightweight structures**

**Chair: Jeffrey Mahn, Jean-Luc Kouyoumji** **143**

13:40	A new building acoustical concept for lightweight timber frame constructions De Geetere, Lieven; Ingelaere, Bart	143
-------	---	-----

14:00	The Optimization of a Wooden Floor Design Based on Validated Finite Element Models Mahn, Jeffrey; Hopkins, Carl; Filippoupolitis, Marios; Schanda, Ulrich; Vörtl, Raphael; Krajči, Luboš	143
14:20	Approximate formulae for the average one sided specific radiation wave impedance of a finite rectangular panel Davy, John Laurence; Lerner, David James; Wareing, Robin R; Pearce, John R	143
14:40	Prediction of Acoustic Performance of Composite Steel Floors Ballagh, Keith Orsourn; Chung, Hyuck	143
15:00	Measurements of junction vibration level differences of timber framed constructions Homb, Anders	143
15:20	Flanking sound transmission in an innovative lightweight clay block building system with an integrated insulation used at multifamily houses Buchegger, Blasius; Ferk, Heinz; Meissnitzer, Marlon	144

**Tuesday 13:40-15:40 Room 210**

**N8e Room acoustics**

**Chair: Toru Otsuru, Noriko Okamoto**

**144**

13:40	Generalized alternative image theory to estimating sound field for complex shapes of indoor spaces Kong, Byunghak; Lee, Kyuho; Jang, Seokjong; Park, Seo-Ryong; Lee, Soogab	144
14:00	Theory and three-dimensional numerical simulation of sound propagation along a long enclosure with side opening Chu, S H K; Tang, Shiu Keung	144
14:20	Reducing Noise and Optimizing Sound within Working Spaces Probst, Fabian	144
14:40	Parameters design of a nonlinear membrane absorber applied to an acoustic cavity Shao, Jianwang; Wu, Xian	145
15:00	Development and sound absorption of interior adjustable acoustical panels Chou, Chuan-wen; Lai, Rong Ping; Chien, Shao-Chun; Yeh, Po Hung	145
15:20	Finite element sound field analysis for correction of absorption coefficient in reverberation room Tomiku, Reiji; Otsuru, Toru; Okamoto, Noriko; Okuzono, Takeshi; Azechi, Yoshiki; Yoshida, Tsuyoshi	145

**Tuesday 13:40-15:40 Room 209**

**D3a Electric / hybrid vehicles**

**Chair: Dong Chul Park, David Quinn**

**145**

13:40	Vibration Control of In-Wheel SRM for Electric Vehicle Applications Sun, Wei; Li, Yinong; Xu, Guangzhong; Zhang, Nong	145
14:00	Measurement and analysis of the interior noise and the transfer path of acoustic phenomena into the driver cabin of a battery electric vehicle Fischer, Jan; Behrendt, Matthias; Lieske, Dirk; Albers, Albert	146
14:20	Study of high frequency noise from electric machines in hybrid and electric vehicles Bassett, Timothy Whitehead; Tate, Simon; Maunders, Matt	146
14:40	Vibro-acoustic measurements and techniques for electric automotive applications Sarrazin, Mathieu; Gillijns, Steven; Janssens, Karl; Van Der Auweraer, Herman; Verhaeghe, Kevin	146
15:00	Comprehensive Automotive Active Sound Design part 1: electric and combustion vehicles Bodden, Markus; Belschner, Torsten	146
15:20	Comprehensive Automotive Active Sound Design part 2: Operational Sounds and Brand Sound Belschner, Torsten; Bodden, Markus	147

**Tuesday 13:40-15:20 Room 208**

**D5 Ultralow noise surfaces**

**Chair: Truls Berge, Luc Goubert**

**147**

13:40	Results from first Danish full scale test section with poroelastic road surface Bendtsen, Hans; Stahlfest Holck Skov, Rasmus; Andersen, Bent	147
14:00	Tyre/road noise reduction by a poroelastic road surface Ejsmont, Jerzy; Swieczko-Zurek, Beata; Sandberg, Ulf; Mioduszewski, Piotr	147
14:20	Developing a durable and ultra low noise poroelastic pavement Goubert, Luc	147
14:40	Innovative low noise surfaces – comparison of damping and absorption Freitas, Elisabete Fraga; Dias Rodrigues, José; Araújo, Jorge; Silva, Hugo	148
15:00	The best porous asphalt pavement in Sweden so far Sandberg, Ulf; Mioduszewski, Piotr	148

**Tuesday 13:40-15:40 Room 207**

**R6a Underwater noise from pile driving**

**Chair: Marten Nijhof**

**148**

- |       |  |     |
|-------|--|-----|
| 13:40 | Analytical model for the sound pressure waveform radiated underwater when an offshore steel pipe pile is driven with an impact hammer<br>Hall, Marshall V  | 148 |
| 14:00 | A comparison of numerical methods for the time domain modelling of pile driving noise in the near field<br>Wilkes, Daniel Ryan; Gourlay, Tim; Gavrilov, Alexander N  | 148 |
| 14:20 | Overview of existing Noise Mitigation Systems for reducing Pile-Driving Noise<br>Bellmann, Michael   | 149 |
| 14:40 | Caltrans compendium of underwater sound data from pile driving – 2014 update<br>Rodkin, Richard; Pommerenck, Keith   | 149 |
| 15:00 | The new noise mitigation system 'Hydro Sound Dampers': history of development with several hydro sound and vibration measurements<br>Bruns, Benedikt; Kuhn, Christian; Stein, Philipp; Gattermann, Jörg; Elmer, Karl-Heinz | 149 |
| 15:20 | New achievements in underwater noise modelling for offshore pile driving<br>Trimoreau, Benjamin; Smidt Lützen, René; Vindahl Kringelum, Jon; Shajarati, Amir; Skjellerup, Peter  | 149 |

**Tuesday 13:40-15:00 Room 206**

**S4b Soundscape and methods of evaluation**

**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**150**

- |       |  |     |
|-------|--|-----|
| 13:40 | Aures – The Advanced Environment Noise Monitoring System – Leq(A) or new measurement technology?<br>Leskinen, Antti; Hjort, Roy; Saine, Kari; Gao, Zengxin                   | 150 |
| 14:00 | WYSAHIWYG (What You See And Hear Is What You Get): Learning from photocartography in mapping the cross-modal features of the soundscape<br>Carter, J Parkman; Braasch, Jonas | 150 |
| 14:20 | QUADMAP, three pilots and a methodology<br>Wolfert, Henk   | 150 |
| 14:40 | WithdrawnB<br>WithdrawnB,  | 151 |

**Tuesday 15:40-18:00 Room 220**

**T6a Psycho-acoustics in noise evaluation**

**Chair: Hugo Fastl, Joachim Scheuren**

**151**

- |       |   |     |
|-------|---|-----|
| 15:40 | ISO 532 – Living and working with alternative loudness standards<br>Scheuren, Joachim   | 151 |
| 16:00 | Continuous judgment of sound quality of electric home appliances<br>Kuвано, Sonoko; Namba, Seiichiro; Fastl, Hugo; Putner, Jakob  | 151 |
| 16:20 | Psychoacoustic experiments on some unwanted interior car sounds<br>Fastl, Hugo; Beidenhauser, Georg   | 151 |
| 16:40 | Measurement of air-conducted and bone-conducted dental drilling sounds<br>Yamada, Tomomi; Kuвано, Sonoko; Yasuno, Yoshinobu; Kaku, Jiro; Ebisu, Shigeyuki; Hayashi, Mikako                                      | 151 |
| 17:00 | The comparison of psychological evaluation between military aircraft noise and civil aircraft noise<br>Morinaga, Makoto; Yamamoto, Ippei; Tsukioka, Hidebumi; Makino, Koichi; Kuвано, Sonoko; Matsumoto, Mitsuo | 152 |
| 17:20 | Ground-borne vibrations, sounds and secondary airborne sounds from tramways: a psychoacoustic evaluation including health aspects<br>Cik, Michael; Lercher, Peter   | 152 |
| 17:40 | Overall loudness of short time-varying sounds<br>Schlittenlacher, Josef; Hashimoto, Takeo; Kuвано, Sonoko; Namba, Seiichiro   | 152 |

**Tuesday 15:40-18:00 Room 219**

**T2 Reaction to traffic noise**

**Chair: Truls Gjestland, Hans Bendtsen**

**152**

- |       |  |     |
|-------|--|-----|
| 15:40 | Subjective experiment on auditory localization for traffic alarm sounds in a heavy truck<br>Yokoyama, Sakae; Tachibana, Hideki; Makinouchi, Hideo  | 152 |
| 16:00 | Experimental study of traffic noise and human response in an urban area: deviations from standard annoyance predictions<br>Salomons, Erik M; Janssen, Sabine A; Verhagen, Henk L M; Wessels, Peter W | 153 |
| 16:20 | The influence of location of the privileged vehicle siren on the vehicle traffic safety<br>Gorski, Pawel; Zawieska, Wiktor M   | 153 |
| 16:40 | Noise annoyance for a motorway compared to urban roads<br>Bendtsen, Hans; Pedersen, Torben Holm; Le Ray, Guillaume; Kragh, Jørgen  | 153 |

17:00	Using mathematical models to predict annoyance from combined noise sources in the city of Dubai Elmedhi, Hussein	153
17:20	Structural equation model of road traffic noise annoyance in Vietnam Nguyen, Thu Lan; Yano, Takashi; Yokoshima, Shigenori; Morihara, Takashi	154
17:40	Social surveys on community response to road traffic in five cities in Vietnam Shimoyama, Koji; Nguyen, Thu Lan; Yano, Takashi; Morihara, Takashi	154

**Tuesday 16:00-18:00 Room 218**

**L3b Applications and systems for active control**

**Chair: Xiaojun Qiu, Woon Seng Gan**

**154**

16:00	A new structure for nonlinear narrowband active noise control using Volterra filter Liu, Jian; Xiao, Yegui; Chen, Hui; Liu, Wenbo	154
16:20	Basic study on active acoustic shielding: phase 6 improving the method to enlarge AAS window-2 Murao, Tatsuya; Nishimura, Masaharu; Sakurama, Kazunori; Nishida, Shinichiro	154
16:40	Active noise control in practice: transformer station Buikema, Edwin; Van Der Ploeg, Fokke D; Granneman, Jan H	155
17:00	An integrated passive and active control system for reducing haul Lin, Zhibin; Zhang, Limin; Qiu, Xiaojun; Pan, Jie	155
17:20	Applying an active noise barrier on a 110 KV power transformer in Hunan Zou, Haishan; Huang, Xiaofan; Hu, Sheng; Qiu, Xiaojun	155
17:40	Virtual sound barrier for indoor transformers Tao, Jiancheng; Wang, Shuping; Qiu, Xiaojun; Han, Ning; Zhang, Linke	155

**Tuesday 16:00-17:40 Room 217**

**G4 Measurement - Infrasound, LFN, Tonality**

**Chair: Mark Bastasch**

**156**

16:00	Infrasound and blade pass frequency levels in areas adjacent to wind farms Lenchine, Valeri V; Song, Jonathan	156
16:20	Investigation of the time dependent nature of infrasound measured near a wind farm Zajamsek, Branko; Hansen, Kristy; Hansen, Colin	156
16:40	Propagation thresholds and measurement of infrasound to establish separation distances from wind farm turbines to residences Thorne, Bob	156
17:00	Analysis of wind turbine low frequency noise prediction accuracy Evans, Tom; Cooper, Jonathan; Alamshah, Wahid	156
17:20	Comparison of the noise levels measured in the vicinity of a wind farm for shutdown and operational conditions Hansen, Kristy; Zajamsek, Branko; Hansen, Colin	156

**Tuesday 16:00-17:40 Room 216**

**C4b New experimental techniques**

**Chair: Vincent Valeau, Carsten Spehr**

**157**

16:00	On the effect of mean flow profile, wavelength and array length on focal-resolution of a quadrupole source using aeroacoustic time-reversal Mimani, Akhilesh; Doolan, Con J; Medwell, Paul R	157
16:20	Aeroacoustic time-reversal in the presence of a reflecting surface Mimani, Akhilesh; Doolan, Con J; Medwell, Paul R	157
16:40	Detection and quantification of building air infiltration using remote acoustic methods Raman, Ganesh; Chelliah, Kanthasamy; Prakash, Manisha; Muehleisen, Ralph T	157
17:00	Identification of acoustic event of selected noise sources in a long-term environmental monitoring systems Klaczynski, Maciej; Wszolek, Tadeusz; Cioch, Witold; Wszolek, Wieslaw; Pawlik, Pawel; Mleczko, Dominik; Grzeczka, Anna	157
17:20	Sound source localisation using a single acoustic vector sensor and multichannel microphone phased arrays Jing, Wen-Qian; Fernandez Comesaña, Daniel; Perez Cabo, David	158

**Tuesday 15:40-16:40 Room 215**

**U2 Noise management in challenging industries**

**Chair: Pam Gunn, Emma Shanks**

**158**

15:40	Development of an Occupational Noise Exposure Reduction Project for Defence in Australia Teague, Peter; Conomos, James; Alexandrou, Vasos; Jennings, Martin	158
16:00	Defending workers against hearing loss: Why aren't workers hearing our message? Else, Benjamin; Jennings, Martin	158

16:20	Noise in the United Kingdom printing industry: then and now Shanks, Emma	158
-------	---	-----

**Tuesday 16:40-17:40 Room 215**

**B5 Buy quiet**

<b>Chair: John Macpherson, Pam Gunn</b>	<b>159</b>
---	------------

16:40	Sound pressure level and sound power level declarations: navigating the maze Shanks, Emma	159
17:00	Is the airborne sound power level of a source unambiguous? Kurtz, Patrick	159
17:20	New York City's New Noise Code and NYU's Citygram-Sound Project Shamoon, Charles; Park, Tae Hong	159

**Tuesday 16:00-17:40 Room 214**

**H4b Airport noise modelling and measurement**

<b>Chair: Ichiro Yamada, Chris Middleton</b>	<b>159</b>
--	------------

16:00	Practical method of considering effects of terrain and building structures on sound propagation Yamada, Ichiro	159
16:20	Experimental study of meteorological and ground effects on outdoor sound propagation for developing aircraft noise prediction model Yokota, Takatoshi; Makino, Koichi; Matsumoto, Toshio; Yamamoto, Kohei; Ishii, Hirokazu	160
16:40	Including atmospheric propagation effects in aircraft take-off noise modeling Arntzen, Michael; Hordijk, Martijn; Simons, Dick G	160
17:00	Influence of the atmospheric stratification on the sound propagation of single flights Zellmann, Christoph; Wunderli, Jean Marc	160
17:20	Assessing all noise sources in one model. Implementation of INM and ECAC 3rd Edition in Noise Mapping Software Notario, Antonio	160

**Tuesday 15:40-17:00 Room 213**

**Q3b Vibro-acoustic methods for noise control treatments**

<b>Chair: Nourredine Atalla, Stephen Hambric</b>	<b>161</b>
--	------------

15:40	Modeling and experimental validation of cellular porous material with large resonant inclusions Doutres, Olivier; Atalla, Nouredine; Osman, Haisam	161
16:00	Prediction of Sound Transmission through Elastomeric Bulb Seals Atamer, Serkan; Çaliskan, Mehmet; Özgen, Gökhan O	161
16:20	Applying dynamic mechanical analysis to research & development for viscoelastic damping materials Rasa, Alexander	161
16:40	Optimization design method for Constrained Damping layer's noise reduction based on the Hoff sandwich plate theory Shi, Dongyan; Wang, Qingshan; Shi, Xianjie	161

**Tuesday 17:00-18:00 Room 213**

**Q4a Vibration and vibro-acoustic experiments**

<b>Chair: Stephen Conlon, Stephen Hambric</b>	<b>162</b>
---	------------

17:00	Analysis of seismic response on the excitation of support structures Ziaran, Stanislav; Cekan, Michal; Chlebo, Ondrej; Musil, Milos	162
17:20	Assessment of Vibrations from a Seismic Test Facility Lee, Yong Keat; Mackenzie, Neil	162
17:40	An approach to optimal sensor placement for vibration tests on large structures Yuan, Chunhui; Zhang, Junjie	162

**Tuesday 15:40-17:40 Room 212**

**B3 Machinery N&V - Computations**

<b>Chair: Xia Pan</b>	<b>162</b>
-----------------------	------------

15:40	Acoustic radiation response prediction of thin-walled box with particle dampers using multiphase flow theory of gas-particle Wu, Chengjun; Wang, Dongqiang; Yang, Ruichao; Lei, Xiaofei	162
16:00	Sound radiation from a water-loaded cylinder due to machine noise Pan, Xia; Tso, Yan; Forrest, James; Peters, Herwig	163
16:20	A Rayleigh-Ritz method based on improved Fourier series for vibration analysis of cylindrical shell coupled with elastic beams Zhang, Runze; Cao, Yipeng; Li, Liaoyuan	163

16:40	Vibration Input Identification using Dynamic Strain Measurement Itofuji, Takumi; Yoshimura, Takuya	163
17:00	Analytical model for the airborne sound pressure waveform radiated when an offshore steel pipe pile is driven with an impact hammer Hall, Marshall V	163
17:20	The new method for focusing properties of the acoustical steady field in room Liu, Song; Li, Sheng	163

**Tuesday 16:00-18:00 Room 211**

**N6d Noise in lightweight structures**

**Chair: Rikard Öqvist, Heinz Ferk** **164**

16:00	Vibration reduction in lightweight floor/ceiling systems with a sand-sawdust damping layer Chung, Hyuck; Emms, Grant	164
16:20	Noise control by design: A tool intended for architectural use Sentop, Ayca; Tamer Bayazit, Nurgun; Altun, M Cem	164
16:40	Design of a standalone, modular test facility for measuring sound transmitted through a common ceiling plenum Barclay, Edward A; Wareing, Robin R; Pearce, John R	164
17:00	Research on sound insulation of multiple-layer structure with porous material and air-layer Bai, Guofeng; Zhan, Pei; Sui, Fusheng; Yang, Jun	164
17:20	The equivalent translational compliance of steel studs and resilient channel bars Hirakawa, Susumu; Davy, John Laurence	164
17:40	Sound insulation of application for composite wood panel Chou, Chuan-Wen; Chen, Chen Yu; Lai, Rong Ping; Sun, Philip	165

**Tuesday 16:00-18:00 Room 210**

**N5 Propagation and generation of low frequency noise in buildings**

**Chair: Delphine Bard, Klas Hagberg** **165**

16:00	Comparison of the results of a laboratory experiment and a field study with regard to acoustic quality in wooden buildings and recommendations for classification of acoustic quality Liebl, Andreas; Späh, Moritz; Bartlomé, Olin; Kittel, Maria	165
16:20	Low frequency sound transmission in multifamily wooden houses Hagberg, Klas; Bard, Delphine	165
16:40	Acoustic Solutions for Wooden Intermediate Floors Bartlomé, Olin; Liebl, Andreas	165
17:00	Challenges for acoustic calculation models in "Silent Timber Build", Part 1- FEM Bard, Delphine; Negreira, Juan; Kouyoumji, Jean-Luc; Borello, Gérard; Guigou, Catherine	166
17:20	Cost benefit analysis of acoustic treatments for inner-city residential premises near entertainment venues Borgeaud, David	166
17:40	Improvement effect of the infrasound and vibration due to repair of the bridge Fukada, Saiji; Kaneishi, Yoshimune; Hama, Hirokazu; Okada, Hiroyuki	166

**Tuesday 16:00-18:00 Room 209**

**D3b Electric / hybrid vehicles**

**Chair: Dong Chul Park, David Quinn** **166**

16:00	Subjective evaluation of additive sound designed to reinforce acoustic feedback of electric vehicle Gwak, Doo Young; Yoon, Kiseop; Seong, Yeolwan; Lee, Soogab	166
16:20	Sound design of electric vehicles - Challenges and risks Genuit, Klaus; Fiebig, André	167
16:40	Urban environment audio simulation for contextual evaluation of Quiet Vehicles' sound design Misdariis, Nicolas; Gerber, Julien; Aleonard, Julien	167
17:00	Designing and delivering the right sound for quiet vehicles Allman-Ward, Mark; Williams, Roger; Heinz, Thorsten; Demontis, Maurizio	167
17:20	Detectability and hearing impression of additional warning sounds for electric or hybrid vehicles Yamauchi, Katsuya; Sano, Takaichi; Hasegawa, Shin; Tamura, Fumio; Takeda, Yuichiro	167
17:40	Development of a next-generation audible pedestrian alert system for EVs having minimal impact on environmental noise levels project eVADER Quinn, David C.	168

**Tuesday 15:40-17:20 Room 208**

**D7 Modelling and mapping traffic noise**

**Chair: Ben Hinze, Kym Burgemeister**

**168**

- 15:40 Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the Acoustical Society of Japan – Part 1:  
Outline of the calculation model  
Sakamoto, Shinichi; Matsumoto, Toshio; Tajika, Terutoshi; Fukushima, Akinori 168
- 16:00 Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the Acoustical Society of Japan – Part 2:  
Study on sound emission of road vehicles  
Okada, Yasuaki; Tajika, Terutoshi; Sakamoto, Shinichi 168
- 16:20 The effects of vegetation on road traffic noise  
Peng, Jeffrey; Bullen, Robert; Kean, Simon 168
- 16:40 Noise modelling of road intersections  
Lau, Akil; Lee, Yong Keat; Dawson, Bill; Name, Neil 168
- 17:00 Effects upon the urban noise of prioritizing bicycle traffic at intersections  
Cueto, Jose Luis; Hernandez, Ricardo; Fernandez, Francisco; Sales, Diego; Priego, Javier Cristino 169

**Tuesday 16:00-17:40 Room 207**

**R6b Underwater noise from pile driving**

**Chair: Joe Cuschieri**

**169**

- 16:00 An efficient model for prediction of underwater noise due to pile driving at large ranges  
Nijhof, Marten J J; Binnerts, Bas; De Jong, Christ A F; Ainsle, Michael A 169
- 16:20 New Hydro Sound Dampers to reduce piling underwater noise  
Elmer, Karl-Heinz; Savery, John 169
- 16:40 Hydro sound measurements during the installation of large diameter offshore piles using combinations of  
independent noise mitigation systems  
Bruns, Benedikt; Stein, Philipp; Stein, Philipp; Kuhn, Christian; Gattermann, Jörg 169
- 17:00 Dynamic measurements of pile deflections as a source of underwater sound emissions during impact driving of  
offshore pile foundations  
Kuhn, Christian; Sychla, Hauke; Stein, Philipp; Bruns, Benedikt; Gattermann, Jörg; Degenhardt, Jan 170
- 17:20 On the estimation of prediction accuracy in numerical offshore pile driving noise modelling  
Lippert, Tristan; Heitmann, Kristof; Ruhnau, Marcel; Lippert, Stephan; Von Estorff, Otto 170

**Tuesday 16:00-18:00 Room 206**

**S3 Soundscape and noise control**

**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**170**

- 16:00 The measurement of soundscapes – Is it standardizable?  
Genuit, Klaus; Fiebig, André 170
- 16:20 On seeking methodology to "measure" a soundscape  
Schomer, Paul D 170
- 16:40 How do ordinary people evaluate noise pollution in the context of environmental issues?  
Nagahata, Koji 171
- 17:00 Sharing ideas about noise management and community design  
Dubbink, David 171
- 17:20 Soundscape Identification in Noise Annoyance Evaluation  
Yu, Lei; Kang, Jian; Liang, Hong; Xie, Charles 171
- 17:40 Soundscape mapping in urban contexts using GIS techniques  
Hong, Joo Young; Jeon, Jin Yong 171

**Wednesday 08:20-10:40 Room 220**

**T6b Psycho-acoustics in noise evaluation**

**Chair: Hugo Fastl, Sonoko Kuwano**

**172**

- 08:20 A Study on sound quality evaluation index of car door latch and improving sound quality by modifying door latch  
assembly design  
Jo, Hyeonho; Seong, Weonchan; Lee, Hyeongrae; Kim, Seonghyeon; Park, Dongchul; Kang, Yeon June 172
- 08:40 Evaluation of Diesel powertrain noise -Difference between Professional and Non-professional-  
Hashimoto, Takeo; Hatano, Shigeko; Shin, Sung-Hwan 172
- 09:00 Simulation of gear rattle to aid in the development of sound quality metrics for diesel engine component  
specification  
Sobecki, Brandon; Davies, Patricia; Bolton, J. Stuart 172
- 09:20 In-service measurement of heavy vehicle engine brake noise  
Kean, Simon; Bullen, Robert; Arredondo, Jose 172
- 09:40 Influence of low SPL and bird twittering sounds on the loudness for road traffic noise  
Kuwano, Kazuki; Yoshida, Junji 172

10:00	Influences of Vehicle Exterior Images on Sound Quality Ratings: German vs. Japanese Drivers Yoshida, Junji; Volk, Florian; Fastl, Hugo; Rigoll, Gerhard	173
10:20	A psychoacoustic assessment of road traffic noise for indoor aural comfort in high-rise built environment Sheikh, Mahbub Alam; Lee, Siew Eang	173

**Wednesday 08:20-10:20 Room 219**

**V2b Sound visualization and manipulation**

	<b>Chair: Yang-Hann Kim, Jung-Woo Choi</b>	<b>173</b>
08:20	Wideband acoustical holography Hald, Jorgen	173
08:40	Development of the Double NAH method Nagamatsu, Masao	173
09:00	Multi-spectral acoustical imaging Nakamura, Kentaro; Guo, Xinhua	174
09:20	A microphone position calibration method in a reverberant environment for a randomly distributed array Teng, Pengxiao; Xiao, Ying; Yang, Yichun	174
09:40	Virtual in-ear microphone for in-vehicle noise control based on array technology and modified zero point attraction LMS algorithms Adnadjevic, Mirjana; Botteldooren, Dick	174
10:00	Creation of a single sound field for multiple listeners Poletti, Mark Alister; Betlehem, Terence	174

**Wednesday 08:20-10:40 Room 218**

**L4a Active vibration control and active structural acoustic control**

	<b>Chair: Li Cheng, Youngjin Park</b>	<b>175</b>
08:20	Analysis of frequency-domain active noise control algorithm with parallel structure Lee, Nokhaeng; Park, Youngjin	175
08:40	Active Noise Control Experiments for an Acoustic-Structural Coupled Enclosure using Structural-Based Virtual Sensors Halim, Dunant; Cheng, Li	175
09:00	On synchrophasing control of vibration for a floating raft vibration isolation system Yang, Tiejun; Zhou, Liubin; Brennan, Michael J; Zhu, Minggang; Liu, Zhigang	175
09:20	Semi-active noise suppression based on SSD technique using piezoelectric elements Ji, Hongli; Cheng, Li; Qiu, Jinhao; Nie, Hong	175
09:40	Active vibration control using compliant-based actuators Mareta, Sannia; Halim, Dunant; Popov, Atanas	175
10:00	Combined force-moment actuator for ASAC Jiricek, Ondrej; Jandak, Vojtech; Brothnek, Marek	176
10:20	A study on the influence of model uncertainties on the performance of a feedback control based ASAC system Bagha, Ashok K; Modak, S V	176

**Wednesday 08:20-10:20 Room 217**

**G5 Evaluation of wind turbine noise source mechanisms**

	<b>Chair: Lars Sondergaard</b>	<b>176</b>
08:20	Application of stochastic wind model to investigate swishing characteristics of infrasound and low frequency noise from wind turbine Lee, Gwang-Se; Cheong, Cheolung	176
08:40	Cyclic pitch for the control of wind turbine noise amplitude modulation Bertagnolio, Franck; Madsen, Helge Aagaard; Fischer, Andreas; Bak, Christian	176
09:00	Tonal characteristics of wind turbine drive trains Dawson, Bill; Mackenzie, Neil	177
09:20	Wind Turbine Tower Resonance Sjöström, Anders; Novak, Colin; Ule, Helen; Bard, Delphine; Persson, Kent; Sandberg, Göran	177
09:40	Numerical simulation and aeroacoustic noise modelling of a wind turbine using a blade section in an annulus Wasala, Sahan Hasaranga; Norris, Stuart Edward; Cater, John Edward	177
10:00	Classification of damage for planetary gear of wind turbine simulator Seo, Yun-Ho; Kim, Sang-Ryul; Kim, Bong-Ki; Lee, Seong-Hyun; Kim, Jae-Seung	177



**Wednesday 08:20-09:40 Room 216**

**C5 Aircraft engine noise**

**Chair: Michael Bauer, Luís Campos**

**177**

08:20	Aeroacoustic source localization on open rotor aircraft model in wind tunnel tests Chiariotti, Paolo; Martarelli, Milena; Tomasini, Enrico Primo; Castellini, Paolo	177
08:40	Adapting a propeller noise model for aircraft at cruising altitudes Blunt, David M; Jones, Adrian; Mewett, David	178
09:00	Lattice Boltzmann Study of the Geometric Effect of a Perforated Orifice on Its Damping Performance Ji, Chenzhen JI; Zhao, Dan; Li, Shihuai; Li, Xinyan	178
09:20	A Coherence Approach to Characterizing Broadband Sound Fields in Ducts Joseph, Phillip	178

**Wednesday 09:40-11:00 Room 216**

**C6 Jet noise**

**Chair: John Cater**

**178**

09:40	Challenges associated with studying nonlinear distortion of acoustic waveforms emitted by high-speed jets Baars, Woutijn J; Tinney, Charles E; Hamilton, Mark F	178
10:00	Using Post analysis of a noise sample stream in place of noise monitor based thresholds in the detection of aircraft noise Harding Ferrier, Myles; Ferrier, Douglas	178
10:20	Acoustic characteristics of annular jets Bellidega, Krishna Chaitanya; Dhamanekar, Abhijit; Srinivasan, K	179
10:40	Severity assessment of circular orifice synthetic jet based on sound pressure level Kanase, Mahesh; Mangate, Laxmikant; Chaudhari, Mangesh	179

**Wednesday 08:40-10:20 Room 215**

**W1 Instrumentation**

**Chair: Sebastian Oberst**

**179**

08:40	Controlling Cyanobacteria with ultrasound Leclercq, Damien J J; Howard, Carl; Hobson, P; Dickson, S; Zander, Anthony C; Burch, M	179
09:00	Report of low power noise monitoring system using solar panel Sato, Naru; Kazama, Ryosuke; Ohya, Masaharu	179
09:20	An innovative signal processing technique for the extraction of ants' walking signals Oberst, Sebastian; Enrique, Nava Baro; Lai, Joseph C S; Evans, Theodore A	179
09:40	Measurement Examples of a New Wireless Measuring System Yonemoto, Yuichi; Kurosawa, Yu; Nakajima, Yasutaka; Ohya, Masaharu	180
10:00	Infrasound sensors and their calibration at low frequency Larsonnier, Franck; Uszakiewicz, Hans-Günter; Mende, Michael	180

**Wednesday 08:20-10:40 Room 214**

**H5 Numerical methods for predicting outdoor sound propagation**

**Chair: Maarten Hornikx**

**180**

08:20	Effect of input data in the impact studies of road traffic noise in a time-domain model Guillaume, Gwenaël; Gauvreau, Benoit	180
08:40	Incorporating directivity in the Pseudospectral time-domain method by using spherical harmonics Georgiou, Fotis; Hornikx, Maarten	180
09:00	Three-dimensional wave-based simulation of outdoor sound propagation using the constrained interpolation profile method with a variable-grid technique Ishizuka, Takashi; Okubo, Kan	180
09:20	Noise propagation simulation in and around buildings using improved integral energy equations Masuda, Kiyoshi	181
09:40	Calculation of Acoustic Green's Function using BEM and Dirichlet-to-Neumann-type boundary conditions Harwood, Adrian R G; Dupère, Iain D J	181
10:00	Acoustic Green's functions using the Sinc-Galerkin method Harwood, Adrian R G; Dupère, Iain D J	181
10:20	Comparison of the results of numerical and geometrical outdoor acoustic simulations in a real-life area Hoshi, Kazuma; Oshima, Takuya; Hiraguri, Yasuhiro	181

**Wednesday 08:20-10:20 Room 213**

**Q4b Vibration and vibro-acoustic experiments**

**Chair: Stephen Conlon, Nourredine Atalla**

**181**

08:20	Experimental study on sound transmission in condenser Kong, Weitao; Xu, Wang; Ming, Pingjian; Liu, Gongmin	181
08:40	Vibration analysis based on time-frequency analysis with a digital filter: Application to nonlinear system identification Itoh, Yoshiaki; Imazu, Taku; Nakamura, Hiroki; Yamazaki, Toru	182
09:00	The actuality of acousto-mechanical resonances for noise control Vinokur, Roman	182
09:20	A new high-frequency impedance tube for measuring sound absorption coefficient and sound transmission loss Kimura, Masateru; Kunio, Jason; Schuhmacher, Andreas; Ryu, Yunseon	182
09:40	Broadband dynamic parameters measurement by longitudinal vibration testing using pulse wave Hou, Hong; Wei, Zhengyu; Dai, Yang; Yang, Jianhua	182
10:00	Improving the sound insulation of construction boards with a high damping glue Kinnari, Lasse	183

**Wednesday 08:40-10:40 Room 212**

**Q5 Vibro-acoustics of lightweight composite panels**

**Chair: Stephen Hambric, Steffen Marburg**

**183**

08:40	Sound radiation from the waveguide double plate regarding air cavity between the upper and lower plates Kim, H; Ryue, J	183
09:00	Quieting a rib-framed honeycomb core sandwich panel for a rotorcraft roof Hambric, Stephen; Shepherd, Micah; Snider, Royce; May, Carl	183
09:20	Patterned fibre constrained layer damping for composite materials Verstappen, Andre P; Pearse, John R	183
09:40	Dynamic Laminate Model for Broadband Frequency Prediction Borello, Gérard; Duval, Arnaud	183
10:00	Global sensitivity analysis of acoustic transmission models Christen, Jean-Loup; Ichchou, Mohamed; Troclet, Bernard; Ouisse, Morvan	184
10:20	Numerical modelling and experimental determination of the dynamic behaviour of composite structures Cohen, Brandon; Dylejko, Paul; Moore, Stephen; Phillips, Andrew	184

**Wednesday 08:20-10:20 Room 211**

**K1a Noise barriers**

**Chair: Jean Piere Clairbois, Crina Oltean-Dumbrava**

**184**

08:20	Sustainability Criteria for standardisation of noise reducing devices Oltean-Dumbrava, Crina; Clairbois, Jean-Pierre	184
08:40	The frequency and angular dependence of the absorption coefficient of common types of living plants Prisutova, Jevgenija; Horoshenkov, Kirill; Groby, Jean-Philippe; Brouard, Bruno	184
09:00	Lightweight noise barrier Ho, Wilson; Wong, Wylog; Naveed, Yasir	185
09:20	A study on sound insulation using rectangular plenum chamber arrays Lee, Seong-Hyun; Kim, Sang-Hoon	185
09:40	Three dimensional quasi-periodic noise barriers M B Fard, Samaneh; Peters, Herwig; Kessissoglou, Nicole; Marburg, Steffen	185
10:00	Transformation of sound by a phononic crystal Côté, Nicolas; Vasseur, Jérôme; Souron, Quentin; Hladky-Hennion, Anne-Christine	185

**Wednesday 08:40-10:20 Room 210**

**N9a Impact noise in buildings**

**Chair: Berndt Zeitler, Atsuo Hiramitsu**

**186**

08:40	Subjective evaluation of floor impact sound of wood-frame construction dwellings in different living situation Sato, Hiroshi; Hirota, Tomohito; Hiramitsu, Atsuo; Tanaka, Manabu	186
09:00	Uncertainties and validation procedures for the Compact Measurement Setup Schmidt, Jan-Henning; Wittstock, Volker; Langer, Sabine C	186
09:20	Field Floor Impact Noise South-East Queensland (Australia) Huang, Eric Hsin-Cheng	186
09:40	Floor impact sound insulation of timber three-story school building for final full-scale fire test Hiramitsu, Atsuo; Hasemi, Yuji; Kaku, Teruhiko	186
10:00	Comparison of Resiliently Suspended Floating Slab Constructions Downey, Paul; Byrick, Wilson; Bonnycastle, William	186

**Wednesday 08:40-10:20 Room 209**

**D9a Mufflers and silencers**

**Chair: Yatsze Choy, James McIntosh**

**187**

08:40	Performance of multiple micro-perforated panels in a duct Liu, Y; Choy, Yat Sze; Chiang, Yan Kei	187
09:00	Improving muffler performance using simulation-based design Cui, Fangsen; Wang, Ying; Cai, Richard Chao	187
09:20	Acoustic performance of a plate with varying perforations Wang, Xiaonan; Zhang, Weichen; Ying, Lechun	187
09:40	Adaptive quarter wavelength tube tuned by varying air temperature Doherty, Kieran; Larizza, Francesco; Tripodi, Matthew; Howard, Carl	187
10:00	Potential of fibre-reinforced components for lightweight construction machines with low noise emission Kolbe, Frank; Dannemann, Martin; John, Sebastian; Modler, Niels	187

**Wednesday 08:40-10:00 Room 208**

**F1a Noise events from transportation noise**

**Chair: Lex Brown, Bert de Coensel**

**188**

08:40	An overview of concepts and past findings on noise events and human response to surface transport noise Brown, Alan Lex	188
09:00	The role of noise events in noise research, policy and practice (peaks, events or both...) Van Kamp, Irene; Van Poll, Ric	188
09:20	Are noise events from surface transport predictable? Insights from a wide measurement campaign Can, Arnaud; Guillaume, Gwenaél; Gauvreau, Benoit	188
09:40	A concept on predicting road network scale noise event probability by road function Naish, Daniel A	188

**Wednesday 08:20-10:40 Room 207**

**R7 Numerical methods in underwater acoustics - Transmission**

**Chair: Doug Cato**

**189**

08:20	The influence of finely layered seabeds on acoustic propagation in shallow water Duncan, Alec J; Gavrilov, Alexander N; Koessler, Matthew W	189
08:40	Tidal effects on acoustic propagation off eastern Australia Robertson, Robin; Hartlipp, Paul	189
09:00	Acoustic ray propagation in the waters off eastern Australia using ocean glider data Clements, Jacqueline; Robertson, Robin	189
09:20	Further Considerations for Approximating a Physics-Based Model of Surface Reflection Loss Jones, Adrian; Zinoviev, Alex; Bartel, David Wayne	189
09:40	The spatial structure of an acoustic wave propagating through a layer with high sound speed gradient Zinoviev, Alex; Bartel, David Wayne	190
10:00	A forecasting method for near-field scattering characteristics of underwater complex shells Zhao, Anbang; Zhao, Zhishan; Zhou, Bin	190
10:20	Results of the ray-tracing based solver BEAM for the approximate determination of acoustic backscattering from thin-walled objects Burgschweiger, Ralf; Schäfer, Ingo; Ochmann, Martin; Nolte, Bodo	190

**Wednesday 08:20-10:00 Room 206**

**S5 Soundscapes and health related quality of life**

**Chair: Peter Lercher, Daniel Shepherd**

**190**

08:20	Health in the noise context: the relativity of absolute health Shepherd, Daniel; Dirks, Kim N; McBride, David Iain; Welch, David	190
08:40	Aviation-related noise-induced annoyance and health-related quality of life Dirks, Kim N; Shepherd, Daniel; Welch, David; McBride, David	191
09:00	Assessing the relationship between perceived disturbances from traffic, restorative qualities of the living environment, and health Von Lindern, Eike; Hartig, Terry; Lercher, Peter	191
09:20	Influence of soundscape and interior design on anxiety and perceived tranquillity of patients in a healthcare setting Watts, Greg; Khan, Amir; Pheasant, Rob	191
09:40	Sound Source Study in Shenzhen China Liang, Hong; Yu, Lei; Zhao, Kang Sai; Zhang, Ming Di	191

**Wednesday 11:00-13:00 Room 220**

**T6c Psycho-acoustics in noise evaluation**

**Chair: Sonoko Kuwano, Peter Lercher**

**192**

11:00	Train noise - A psychoacoustic investigation for indoor aural comfort in high-rise urban environment in the tropics Sheikh, Mahbub Alam; Lee, Siew Eang	192
11:20	Progress in calculating tonality of technical sounds Sottek, Roland	192
11:40	Signal repetition rates and their relationship to the pleasantness of multi-tone sounds Toepken, Stephan; Scheel, Henning; Weber, Reinhard	192
12:00	Unsupervised feature learning on monaural DOA estimation using convolutional deep belief networks Yan, Chen; Mengyao, Zhu; Nicolas, Epain; Craig, Jin	192
12:20	Effects of active noise control on subjective annoyance and cortical neural activities for car engine noise Ito, Tomoki; Ishimitsu, Shunsuke; Nakagawa, Seiji	193
12:40	Effect of Visual Stimulus on Subjective Impression of Indoor Sound Fields with Various Reverberation Times Ishikawa, Ayumi; Terashima, Takane; Tokunaga, Yasunobu	193

**Wednesday 11:00-13:00 Room 219**

**V2c Sound visualization and manipulation**

**Chair: Jung-Woo Choi, William Martens**

**193**

11:00	Enhanced sound field reproduction within prioritized control region Chen, Hanchi; Abhayapala, Thushara D; Zhang, Wen	193
11:20	Standardization of Korean head-related transfer function based on tensor-singular value decomposition Son, Daehyuk; Park, Youngjin; Jang, Sei-jin	193
11:40	Linear optimal source distribution mapping for binaural sound reproduction Zheng, Jianwen; Lu, Jing; Qiu, Xiaojun	194
12:00	Discovering a physical parameter associated with a near-field sound control: comparing HRTFs of nine loudspeakers in a non-anechoic room Kim, Sungyoung; Gosselin, Philip; Okumura, Hiraku	194
12:20	Distance perception of a nearby virtual sound source reproduced by a linear loudspeaker array Kang, Dong-Soo; Choi, Jung-Woo; Kim, Yang-Hann; Martens, William Leigh	194
12:40	Manipulation of source width based on sound field reproduction Lee, Jung-Min; Choi, Jung-Woo; Kim, Yang-Hann	194

**Wednesday 11:00-13:00 Room 218**

**L4b Active vibration control and active structural acoustic control**

**Chair: Li Cheng, Youngjin Park**

**195**

11:00	Using a psychoacoustic criterion for the actuator placement in an active structural acoustic control system Papantoni, Veatriki; Hesse, Christian; Rose, Michael; Monner, Hans Peter	195
11:20	A novel semi-active quasi-zero stiffness vibration isolation system using a constant-force magnetic spring and an electromagnetic linear motor Leav, Orddom Y; Eriksson, Carolina; Cazzolato, Benjamin S; Robertson, William S; Ding, Boyin	195
11:40	Source identification of a vibrating plate using phase conjugation and interior boundary element method Liu, Song; Li, Sheng	195
12:00	Design of natural frequency adjustable electromagnetic actuator and active vibration control test Liu, Xueguang; Han, Chao; Wang, Ye; Yang, Tiejun; Du, Jingtao; Zhu, Minggang	195
12:20	An experimental investigation on the acoustic performance of a flapping wing Micro-Air-Vehicle Lu, Zhenbo; Marco, Debiasi; Nguyen, Quoc Viet; Chan, Woei-Leong	195
12:40	Development of a noise reduction system with piezoelectric material to transmitted noise (Structure for improvement of the noise reduction effect) Yamamoto, Katsuya; Ishimori, Akiyoshi; Sato, Hiroyuki; Asahina, Mineyuki	196

**Wednesday 10:40-11:40 Room 217**

**G6 Measurement - Modeling and propagation**

**Chair: Kristy Hansen, Renzo Tonin**

**196**

10:40	Influence of non-standard atmospheric conditions on turbine noise levels near wind farms Cooper, Jonathan; Evans, Tom; Alamshah, Vahid	196
11:00	Assessing the Validity of Wind Farm Noise Monitoring Data for Periods of Partial Wind Farm Operation Mitchell, Andrew	196
11:20	Noise Propagation from a Vertical Axis Wind Turbine Möllerström, Erik; Larsson, Sebastian; Ottermo, Fredric; Hylander, Jonny; Bååth, Lars	196

**Wednesday 11:00-13:00 Room 216**

**C7 Computational aeroacoustics**

**Chair: Akhilesh Mimani , Paul Croaker** **197**

11:00	Boundary Condition for the Implementation of Arbitrary Acoustical Modes Witthaus, Sina; Seume, Joerg R	197
11:20	The nonlinear inhomogeneous Galbrun-Equation: Derivation and possible Ways to solve numerically Guettler, Marcus; Marburg, Steffen	197
11:40	Calculation of Duct Flow Noise Using CE/SE Method Chan, Horus Y H; Lam, Garret C Y; Leung, Randolph Chi-kin	197
12:00	A particle accelerated CFD-BEM technique applied to aeroacoustic scattering Croaker, P; Kessissoglou, Nicole; Marburg, Steffen	197
12:20	Numerical investigation of the refraction effects by jet flows in anechoic wind tunnels Redonnet, Stéphane; Bulte, Jean	198
12:40	Self-noise prediction of a flat plate using a hybrid RANS-BEM technique Croaker, Paul; Kessissoglou, Nicole; Karimi, Mahmoud; Doolan, Con J; Chen, Li	198

**Wednesday 11:00-12:20 Room 215**

**U3 Personal hearing protectors and headsets**

**Chair: Pam Gunn, Ben Elsey** **198**

11:00	Earmuff Comfort Evaluation Gerges, Rafael; Gerges, Samir N Y	198
11:20	Comparison of speech intelligibility between normal headsets and bone conduction hearing devices at call center Maeda, Setsuo; Kobayashi, Koji; Nakatani, Hidenori; Nakatani, Akiko	198
11:40	Anthropometry of External Auditory Canal by Non-contactable Measurement Tu, Tsung-Hsien; Yu, Jen-Fang; Wang, Ren-Hung; Chen, Yen-Sheng	198
12:00	Construction Apprentices, Work and Noise Kosny, Agnieszka; Benke, Geza; Allen, Amy; Dimitriadis, Christina; Ewan, MacFarlane; Sim, Malcolm	199

**Wednesday 11:00-12:40 Room 213**

**Q4c Vibration and vibro-acoustic experiments**

**Chair: Steve Conlon** **199**

11:00	Low frequency sound transmission of stiffened panels Kim, Hyun-Sil; Kim, Jae-Seung; Lee, Seong-Hyun; Seo, Yun-Ho	199
11:20	Vibrational Energy Flow in Carbon Composite Structures Jaber, Mariam; Schneeweiss, Helmut; Bös, Joachim; Melz, Tobias	199
11:40	Measurement of Structural Intensity Using an Angular Rate Sensor Omata, Nobuaki; Nakamura, Hiroki; Waki, Yoshiyuki; Kitahara, Atsushi; Yamazaki, Toru	199
12:00	Influence of background noise on non-contact vibration measurements using particle velocity sensors Fernandez Comesaña, Daniel; Yang, Fan; Tijs, Emiel	200
12:20	Experimental and numerical tools for the characterization of ultrasonic propagation for nuclear reactor application Van De Wyer, Nicolas; Schram, Christophe; Van Dyck, Dries; Dierckx, Marc	200

**Wednesday 11:00-13:00 Room 212**

**P2 Vibrations in bridges, foot bridges and similar structures**

**Chair: Len Koss, Vincent Rouillard** **200**

11:00	Mini-trampoline vibration exciter- Force measurements Koss, Leonard Louis; Rouillard, Vincent	200
11:20	A review of impact dampers to control cross wind vibration of structures due to vortex shedding Koss, Leonard Louis; Melbourne, William H	200
11:40	Research activities on INCE/J RTV (Road Traffic Vibration)-Model Part: 1 Prediction of road traffic vibration for elevated roads Shimura, Masayuki; Kamiakito, Noboru; Fukada, Saiji; Sabo, Yasuyuki; Matsumoto, Yasunao; Osafune, Toshikazu; Iwabuki, Hiroshi; Yabe, Akito; Hama, Hirokazu	201
12:00	Research activities on INCE/J RTV (Road Traffic Vibration)-Model - Part: 2 Prediction of ground-borne vibration induced by traffic from cutting- and banking-structure roads - Kunimatsu, Sunao; Kitamura, Yasutoshi; Yokota, Akinori; Uchida, Hidenobu; Shimura, Masayuki; Sano, Yasuyuki; Osafune, Toshikazu; Iwabuki, Hiroshi; Ishida, Riei; Hirao, Yoshihiro	201
12:20	Modal floor parameters and their correlation with footfall vibration Duschlbauer, Dominik; Miller, Aaron	201
12:40	Vibration insulation of footbridges so as to reduce human discomfort Sjöström, Anders; Clausén, Christin; Ingemansson, Victor; Austrel, Per-Erik; Persson, Kent; Sandberg, Göran; Bard, Delphine; Novak, Colin; Ule, Helen	201

**Wednesday 10:40-12:00 Room 211**

**K1b Noise barriers**

<b>Chair: Jean Piere Clairbois, Crina Oltean-Dumbrava</b>	<b>202</b>
10:40 The effectiveness of particle damping for use on vertical surfaces Ott, Mark; Weisbeck, Jeffrey; Gerges, Samir N Y; Bustamante, Marcelo	202
11:00 On enhanced sound absorption by non-uniform liners Campos, L M B C; Oliveira, J M G S	202
11:20 On the effect of shear and bias flow on the performance of acoustic liners Campos, L M B C; Legendre, C; Sambuc, C	202
11:40 An experimental investigation of cavity noise control using mistuned Helmholtz resonators Chintapalli, V Surya Narayana Reddi; Padmanabhan, Chandramouli	202

**Wednesday 10:40-13:00 Room 210**

**N9b Impact noise in buildings**

<b>Chair: Berndt Zeitler, Atsuo Hiramitsu</b>	<b>203</b>
10:40 Design and Acoustic Performance of a Spring Isolated Outdoor Rooftop Basketball Court Campbell, Alex; Cosstick, Lloyd; Murray, Timothy; Yates, David	203
11:00 Direct impact sound insulation of cross laminate timber floors with and without toppings Zeitler, Berndt; Schoenwald, Stefan; Sabourin, Ivan	203
11:20 Flanking transmission in three different lightweight wooden building types Sjöström, Anders; Negreira, Juan; Bard, Delphine; Sandberg, Göran; Novak, Colin; Ule, Helen	203
11:40 Comparing low frequency impact noise using a tapping machine and heavy/hard impact source on various fitness floor assemblies Gartenburg, Paul	203
12:00 Measuring Ln without using a tapping machine? Dodd, George; Yen, Benjamin	203
12:20 Accuracy of prediction methods for impact sound pressure levels Griffin, Daniel	204
12:40 Effect of modulation on perceived annoyance of floor impact noise Lee, Sinyeob; Hwang, Dukyoung; Park, Junhong	204

**Wednesday 10:40-12:00 Room 209**

**D9b Mufflers and silencers**

<b>Chair: Yatsze Choy, James McIntosh</b>	<b>204</b>
10:40 Sound attenuation using duct silencers with micro-perforated panel absorbers Yu, Xiang; Cheng, Li; Tong, Yuhui; Pan, Jie	204
11:00 Performance analysis of a suction muffler in a hermetic reciprocating compressor using CAA techniques based on Lattice Boltzmann Method Lee, Songjune; Cheong, Cheolung; Lee, Hyo Jae; Kim, Haeseung	204
11:20 Acoustic two-port simulation model for the particle oxidation catalyst (POC®) Hynninen, Antti; Åbom, Mats	205
11:40 Hybrid coupling method to nonlinear acoustic source and linear duct system in compressor Oh, Seungjae; Wang, Semyung	205

**Wednesday 10:40-12:20 Room 208**

**F1b Noise events from transportation noise**

<b>Chair: Lex Brown, Bert de Coensel</b>	<b>205</b>
10:40 Smart sound monitoring for sound event detection and characterization De Coensel, Bert; Botteldooren, Dick	205
11:00 Influence of loudness of noise events on perceived sound quality in urban context Delaitre, Pauline; Lavandier, Catherine; Ribeiro, Carlos; Quoy, Mathias; D'Hondt, Ellie; Gonzalez Boix, Elisa; Kamboona, Kennedy	205
11:20 Sound Exposure Levels from Trains and Sleep Disturbance Jabben, Jan; Potma, Charlos	206
11:40 Mobility and life quality relationships – Measurement and perception of noise in urban context Misdariis, Nicolas; Marchiano, Regis; Susini, Patrick; Ollivier, Francois; Leiba, Raphael; Marchal, Jacques	206
12:00 Towards new less noisy mobility patterns in cities Wolfert, Henk	206

**Wednesday 11:00-13:00 Room 207**

**R3 Numerical methods - Interaction with submerged structures**

**Chair: Adrian Jones** **206**

- |       |   |     |
|-------|---|-----|
| 11:00 | Moving boundary similarity method and its application on ship structural borne noise prediction<br>Pang, Fu-zhen; Miao, Xu-hong; Tang, Dong; Song, Hong-bao                                     | 206 |
| 11:20 | An Analytical Substructure Method for the Analysis of Vibration Characteristics on Conical-Cylindrical-Spherical Combined Shells in Vacuum<br>Chen, Meixia; Xie, Kun; Wei, Jianhui; Deng, Naiqi | 207 |
| 11:40 | Wave based method for vibration and acoustic characteristics analysis of underwater cylindrical shell with bulkheads<br>Xie, Kun; Chen, Meixia; Deng, Naiqi; Xu, Kun                            | 207 |
| 12:00 | The study on sound radiation of semi-submerged cylindrical with antisymmetric velocity distribution<br>Zhang, Junjie  | 207 |
| 12:20 | Sound radiation from nested cylindrical shells<br>Wu, Hongjian; Peters, Herwig; Kessissoglou, Nicole  | 207 |
| 12:40 | Lattice-Boltzmann simulation of circular column coupled with square column in cross flow<br>Shi, Dongyan; Li, Hongqun; Wang, Zhikai; Jiao, Han  | 207 |

**Wednesday 10:20-11:20 Room 206**

**K3 Noise control within offshore facilities and maritime vessels**

**Chair: Greg Stewart** **208**

- |       |  |     |
|-------|--|-----|
| 10:20 | Verification of a Duct Resonator Array for Larger Pipe Diameters<br>Newman, Michael James; Garrido, Maria; Liu, Zheji; Ryliskis, Andre-Pierre; Colette, Julien; Eugui, Inigo; Haaheim, Ole Georg | 208 |
| 10:40 | A method for demonstration of ALARP for noise control<br>Keswick, Paul; McLoughlin, James; Stewart, Greg   | 208 |
| 11:00 | Isolator Internal Resonance and Radiated Noise from Ships<br>Dylejko, Paul; MacGillivray, Ian; Skvortsov, Alex   | 208 |

**Wednesday 11:40-13:00 Room 206**

**Q2g Numerical methods in vibro-acoustics**

**Chair: Weikang Jiang, James Forrest** **208**

- |       |   |     |
|-------|---|-----|
| 11:40 | Research on vibration and acoustic radiation of planetary gearbox housing<br>Zhang, Tianmu; Shi, Dongyan; Zhuang, Zhong   | 208 |
| 12:00 | Analysis of acoustic radiation of a ring-stiffened cylindrical shell in underwater based on precise integration transfer matrix method<br>Pang, Fu-zhen; Wu, Chuang; Wang, Qingshan; Song, Hong-bao | 209 |
| 12:20 | Free vibration analysis of orthotropic rectangular Mindlin plates with general elastic boundary conditions<br>Shi, Dongyan; Zhuang, Zhong; Zhang, Tianmu  | 209 |
| 12:40 | Withdrawn5<br>Withdrawn5,   | 209 |

**Wednesday 14:00-15:00 Room Plenary**

**Plenary 2**

**Chair: Norman Broner** **209**

- |       |  |     |
|-------|--|-----|
| 14:00 | Soundscape planning as a complement to environmental noise management<br>Brown, Alan Lex | 209 |
|-------|--|-----|

**Monday 09:20-Tuesday 18:00 Foyer**

**Posters** **209**

The numbers in this session indicate the location of the poster on the poster boards. Authors are asked to be at their posters to answer questions from 13:20 to 13:40 on Monday 17 and Tuesday 18 November 2014.

- |   |  |     |
|---|--|-----|
| 1 | Management Policy on Community Noise to Improve the Quality of Life – Focused on Apartment Noise<br>Park, Young Min; Kim, Kyoung Min   | 209 |
| 2 | The Influence of the Load Condition upon the Radial Distribution of Electromagnetic Vibration and Noise in a Three-Phase Squirrel-Cage Induction Motor<br>Sato, Yuta; Hirotsuka, Isao; Nakamura, Masanori; Iguchi, Akihiko; Hayashi, Daisuke; Takahashi, Yousuke | 210 |
| 3 | A Noisy Vehicle Surveillance Camera (NoivelCam) System<br>Agha, Apoorv; Gan, Woon Seng; Chong, Yong-Kim; Ang, Boon-Wee   | 210 |
| 4 | A Study of Pavement Noise for Asphalt Pavements with Different Service Life in National Highway<br>An, Deok-Soon; Lee, Jae-Jun; Ohm, Byungsik; Son, Hyeon-Jang; Kwon, Sooahn   | 210 |

5	A Study of Traffic Noise Characteristic of Pavement Types Using NCPX Method Son, Hyeon-Jang; An, Deok-Soon; Lee, Jae-Jun; Kim, Yong-Joo	210
6	Vehicle suspension and steering nonlinear integrated system coordinated control based on human-vehicle function allocation Wang, Hongbo; Yang, Liuqing; Hu, Yanping	211
7	Integrated test system for tyre/road noise – ISO/DIS 11819-2 and AASHTO TP76-12 methods Li, Xun; Lim, Vincent	211
8	RONDA - CPX Trailer Initial Test Results Tonin, Renzo; Szabo, Attila	211
9	Environmental impact assessment of road noise with noise map in Korea Sun, Hyosung	211
10	Basic study on inset position of stack in the system with branch tubes for applying thermoacoustic silencer to multi cylinder engine muffler Sakamoto, Shinichi; Kawamoto, Satoshi; Orino, Yuichiro; Ota, Yoshitaka; Inui, Yoshitaka; Watanabe, Yoshiaki	211
11	A study on the prediction of the noise reduction performance according to applying the rail web-damper in curved track section Kim, Jinho	212
12	Railway noise impact assessment: An overview of the Railway Noise and Vibration Research project in South Korea Hong, Jiyoung; Koh, Hyo-In; Jang, Seunho; Lee, Soogab	212
13	Wind turbine noise: practical immission measurements Fauville, Benoît; Moïny, Francis	212
14	Experimental approach on transmission of low-frequency sound into a building Doi, Tetsuya; Iwanaga, Keiichiro; Naka, Yusuke	212
15	Application of fractal dimension to the evaluation of environmental sound Makabe, Yoshiaki; Muto, Kenji	212
16	Using the interpolation in the DIN EN ISO 17201-1 Trimpop, Mattias	212
17	Numerical Analysis of Sound Wave Propagation Using CIP-MOC Method with Non-Uniform Grid Matsumura, Yuta; Okubo, Kan; Tagawa, Norio; Tsuchiya, Takao; Ishizuka, Takashi	213
18	An evaluation on comfortable sound design of unpleasant sounds based on chord-forming with bandlimited sound Ohshio, Yoshitaka; Ikefuji, Daisuke; Nakayama, Masato; Nishiura, Takanobu	213
19	A Design of Comfortable Dental Treatment Sound Based on Auditory Masking Ikefuji, Daisuke; Suhara, Yuko; Nakayama, Masato; Nishiura, Takanobu; Yamashita, Yoichi	213
20	One-dimensional unidirectional acoustic boundary through active control method Han, Ning; Tao, Jiancheng	213
21	Robust time-domain acoustic contrast control design under uncertainties in the frequency response of the loudspeakers Cai, Yefeng; Liu, Li; Wu, Ming; Yang, Jun	213
22	Narrow area control for individual sound image generation by combining NBSFC and liner loudspeaker array Nakayama, Yumiko; Tatekura, Yosuke	214
23	A study of the position of the reference microphone of active noise control of feedforward type for MRI noise Muto, Kenji; Nakayama, Shohei; Osada, Ryosuke; Yagi, Kazuo; Chen, Guoyue	214
24	Active reduction of sound transmission in aircraft cabins: a smarter use of vibration exciters Boulandet, Romain; Michau, Marc; Micheau, Philippe; Berry, Alain	214
25	Application of disturbance-observer-type velocity estimator to electroacoustic absorber for noise absorbing Cho, Youngeun; Wang, Semyung; Park, Kihwan	214
26	Numerical and experimental analysis of the effectiveness of material composition of piezoelectric elements with chosen shapes on plate vibration reduction Wiciak, Jerzy; Trojanowski, Roman; Wiciak, Margareta	215
27	Measurement of Temperature Dependence in the Piezoelectric Active Element of a Knock Sensor Klusáček, Stanislav; Fialka, Jiri; Havránek, Zdeněk; Beneš, Petr; Pikula, Stanislav	215
28	Characteristics of polymeric interlayer films and its impact on acoustical performance of laminated glass Ko, Sangwon; Hong, Jiyoung; Koh, Hyo-In	215
29	Study of Enhanced Sound-absorbing performance for Polyurethane Foam which Carbon Nano-tube is applied Park, Jang-Seok; Choi, Kyung-Min; Lee, Jung-Wook	215
30	Privacy protection method for speech using small speakers placed around a head Mochizuki, Maya; Osumi, Ayumu; Ito, Youichi	216
31	Improvement of PC Hearing Support System: The Use of One-USB-OS Ishihara, Manabu; Ono, Yuichi; Ideo, Mitsumi; Sato, Tomokazu	216
32	Priority of subjective attribute in discrimination between sound fields of architectural spaces Terashima, Takane; Ishikawa, Ayumi; Tokunaga, Yasunobu	216
33	A design of reflective audio spot with parabolic reflector for sound pressure improvement on separating emission of carrier and sideband waves Konabe, Ryosuke; Matsui, Tadashi; Ikefuji, Daisuke; Nakayama, Masato; Nishiura, Takanobu	216



34	A study on 3-D Sound Field Localization System Using Parametric Loudspeaker and Indirect Loudspeakers for Reverberation Reproduction	216
	Wada, Tomoyuki; Ikefuji, Daisuke; Nakayama, Masato; Nishiura, Takanobu	
35	Multiple Audio Spots Design Based on Separating Emission of Carrier and Sideband Waves	217
	Matsui, Tadashi; Ikefuji, Daisuke; Nakayama, Masato; Nishiura, Takanobu	
36	Evaluation on flexible beamformers with curved-type parametric loudspeaker for spatial audible area design	217
	Komori, Shinya; Ikefuji, Daisuke; Nakayama, Masato; Nishiura, Takanobu	
37	Objective comparison between Ambisonics basic decoding and a SIRR-based parametric decoding in the context of concert hall auralization	217
	Espitia Hurtado, Juan Pablo; Polack, Jean-Dominique; Warusfel, Olivier	
38	Development of GPGPU-Based Interactive Simulation for Numerical Analysis of Sound Wave Propagation	217
	Kawada, Naoki; Okubo, Kan; Tagawa, Norio; Tsuchiya, Takao	
39	Bootstrap masker generation method for speech masking systems	218
	Kobayashi, Yosuke; Kondo, Kazuhiro	
40	Basic study on improvement of stage acoustics by active method	218
	Matsuo, Takuma; Terashima, Takane; Ishikawa, Ayumi	
41	High accuracy calculating model for sound field simulation with DFT-based FDTD on polar-quaternion-based axis towards craft restoration	218
	Nakano, Kota; Nakayama, Masato; Nishiura, Takanobu; Yamashita, Yoichi	
42	Design sensitivity analysis of the acoustic dispersion relations	219
	Hyun, Jaeyub; Wang, Semyung	
43	An impedance tube measurement technique for controlling elastic behavior of test samples	219
	Satoh, Toshikazu; Kimura, Masateru; Yamaguchi, Michiyuki; Kunio, Jason	
44	Experiment and study of tactile characteristics resulting from vibration of a touch panel	219
	Ishihara, Manabu; Suzuki, Shin-nosuke; Yoshida, Masahi; Shirataki, Jun; Itako, Kazutaka	
45	Beat period control of bell sound using an operational modal analysis	219
	Kim, Seockhyun; Lee, Joong Hyuck; Kim, Jung Tae	
46	Underwater acoustic passive localization base on multipath arrival structure	219
	An, Liang; Chen, Lijun	
47	Effectiveness of background music for noises in hospital wards	220
	Matsumoto, Junko; Tagaya, Akira	
48	A research on the validity of expression method of sonic environment by using Japanese onomatopoeias	220
	Akita, Takeshi; Tsujimura, Sohei; Sano, Naoko; Koga, Takaaki	
49	Investigation on high-frequency noise in public space.	220
	Ueda, Mari; Ota, Atsushi; Takahashi, Hironobu	
50	A study of degraded-speech identification based on spectral centroid	220
	Furoh, Takayuki; Fukumori, Takahiro; Nakayama, Masato; Nishiura, Takanobu	
51	Survey on vehicle horn use in urban areas of Korea	221
	Takada, Masayuki; Suzuki, Satoshi; Kim, Ki-Hong; Iwamiya, Shin-ichiro	
52	The effects of the aircraft noise and multiple echoes on speech intelligibility of outdoor public address system	221
	Takanashi, Koki; Hodoshima, Nao	
53	Influence of Visual Information on Subjective Evaluation of Road Traffic Noise	221
	Tokunaga, Yasunobu; Terashima, Takane; Ishikawa, Ayumi	
54	High directivity masking sound system for achieving speech privacy	221
	Tamesue, Takahiro; Saeki, Tetsuro	
55	On frequency characteristics of bone conduction actuators by measuring loudness, acceleration and otoacoustic emission	221
	Qin, Xiuyuan; Chisaki, Yoshifumi; Usagawa, Tsuyoshi	
56	Efficiency evaluation of subspace-based spectral subtraction based on iterative eigenvalue analysis in real environments	222
	Nagano, Yuki; Fukumori, Takahiro; Nakayama, Masato; Nishiura, Takanobu	
57	Evaluation of clipping-noise suppression of stationary-noisy speech based on spectral compensation	222
	Fukumori, Takahiro; Hayakawa, Makoto; Nakayama, Masato; Nishiura, Takanobu; Yamashita, Yoichi	
58	Influences of whole-body vibration on roughness sensation	222
	Yonehara, Makiko; Yoshino, Hirokazu; Tatsuno, Junya; Maeda, Setsuo; Kyogoku, Hideki	
59	The empirical assessment of human vibration propagated in building and HVAC systems	222
	Forouharmajd, Farhad; Ahmadvand, Masoumeh	
60	On a Binaural Model with Front-back Discriminator using Artificial Neural Network trained by multiple HRTF catalogs	223
	Yoshino, Shun; Tomita, Takuro; Chisaki, Yoshifumi; Usagawa, Tsuyoshi	
61	A triple microphone array for surround sound recording	223
	Chen, Rilin; Teng, Pengxiao; Yang, Yichun	
62	Localization of multiple environmental sound sources by MUSIC method with weighted histogram	223
	Yamamoto, Mari; Tatekura, Yosuke	

63	The study on the woofer speaker characteristics due to design parameters Kim, Byoung-sam; Park, Jin-young; Xu, Young; Lee, Tae-keun; Sun, Hongtu	223
64	Virtual sensing in the reverberant field based on the harmonic signal from the emitting source. Badan, Marco Aurélio B C; Duarte, Marcus A V; Miranda, João G O; Nishida, Pedro P R	223
65	Impedance matrix of rubber-cord fluid-filled hose Sokolov, Aleksei	224
66	Footprint analysis concerning noise: approaches, tools and opportunities Goretti, Michele; Cotana, Franco	224
67	Breathing mechanism of a cracked rotor subject to non-trivial mass unbalance Spagnol, Joseph Patrick; Wu, Helen	224
68	Sensitivity analysis of source region size on results of Stochastic Noise Generation and Radiation model Niedoba, Pavel; Bajko, Jaroslav; Jícha, Miroslav; Libor, Čermák	224
69	Relationship between soundscape and historical-cultural elements of Historical Areas in Beijing: a case study of Qianmen Avenue Liu, Aili; Liu, Fucheng; Deng, Zhiyong; Chen, Wanli	224
70	A three-stage method for sound field reproduction in rooms with reflection boundary: theory and experiments Peng, Bo; Zheng, Sifa; Liao, Xiangning; Lian, Xiaomin	225
71	Reducing noise pollution by increasing sound absorption of carpets Akdere, Musa; Hannig, Anke; Kietzing, Tanja; Seide, Gunnar; Gries, Thomas	225
72	Investigation of vibration transmission properties of compressor grommets in domestic refrigerators Kuyumcuoglu, Aleks; Sakalli, Ozgun	225
73	Modeling sound radiation from a baffled vibrating plate for different boundary conditions using an elementary source technique Putra, Azma; Shyafina, Nurain; Thompson, David; Muhammad, Noryani; Mohd Nor, Mohd Jailani; Zaki, Nuawi	225
74	Practical consideration of noise from fans Burgess, Charles; Thompson, Rhys	225
75	Research on the directive property control for a phased rectangular loudspeaker array Xu, Xuezhong; Cheng, Zhang; Fang, Houlin; Yang, Junmei; Sun, Deyu; Zhang, Liangyong	226
76	A new method for monitoring far-field noise level with a few near-field sensors Cheng, Xiaobin; Wang, Xun; Yang, Jun; Tian, Jing	226
77	A Soundscape Research on the Route Gezi Park–Tunel Square Bahali, Serkan; Tamer Bayazit, Nurgun	226
78	Characterizing the ecology of the Aboriginal soundscape Muir, Bruce R	226
79	Determining noise effects from industrial development on Aboriginal soundscapes: insight into best practices Muir, Bruce R	226

**Sunday 17:00-18:00 Room Plenary**  
**Plenary 1**  
**Chair: Joachim Scheuren**

**130 Sound Sketch: Shaping sound in space and time using loudspeaker arrays**

*Choi, Jung-Woo*  
 KAIST, Korea

**ABSTRACT**

The control of the spatial distribution of noise and sound has been widely investigated for achieving passive and active noise control. By extending the concepts of active noise control and zones of quiet, one can sketch sound, i.e., synthesize sound fields of various shapes using loudspeaker arrays to achieve the desired sound quality in a finite zone of interest. Sound sketching involves reproducing existing sound fields as well as creating new shapes of sound fields that can scarcely be observed in common acoustical spaces. In this lecture, two representative problems related to sound shaping are presented: the synthesis of a personal sound zone, and the manipulation of virtual sound sources. Through the shaping of sound in space, sound fields can be focused over a selected area to form a personal sound zone within which a person hears only a specified sound program without being disturbed by other unwanted programs. In addition to focusing sound fields, it is possible to control a sound wavefront to produce virtual sound sources with various radiation patterns in a source-free space. The underlying array signal processing theories, developed since 2000, are introduced in regard to practical systems implemented for various applications. The novel paradigm for sound field control systems, the Sound of Things, is introduced with a sound sketch interface devised to facilitate gesture-based interaction between a person and a sound field.

**Monday 08:20-09:20 Room Plenary**  
**Keynote 1**  
**Chair: Marion Burgess**

**369 Can technology deliver acceptable levels of aircraft noise?**

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 Institute of Sound and Vibration Research, University of Southampton, United Kingdom

**ABSTRACT**

Meeting community expectations on aircraft noise has always presented a challenge to aircraft and engine manufacturers and to those involved in airport planning and air traffic management. It has been a critical issue for communities living close to airports since the introduction of turbojet and turbofan powered aircraft in civil aviation in the late 1960s and early 1970s. The technical progress which has been made during this period in reducing aircraft noise at source and mitigating its effects by noise reduction technologies is not widely understood or appreciated by the community. These remarkable achievements will be reviewed here, and an assessment presented of current progress towards meeting

ambitious new environmental targets for aircraft entering service between now and 2050. While much has been achieved, opportunities still exist to exploit further significant reductions in noise both for current aircraft layouts but also in the longer term for future aircraft and engines which may differ significantly from current configurations. The main sources of aircraft noise will be reviewed and areas identified in which the greatest noise reductions have been achieved. Areas will also be highlighted where future gains are likely. Much of the discussion will revolve around measures of the noise of a single aircraft at takeoff or approach. This forms the basis for noise certification metrics and the focus of industry efforts to reduce aircraft noise. This is only a part of the complex jigsaw of issues however which define the aircraft noise problem. These include the public's perception of what actually constitutes a noise nuisance and also critically the rate at which an expanding commercial fleet transitions to newer quieter aircraft.

**Monday 08:20-9:20 Rooms 219 & 220**  
**Keynote 2**  
**Chair: Charles Don**

**173 A new era for applications of active noise control**

*Qiu, Xiaojun (1); Lu, Jing (2); Pan, Jie (3)*  
 (1) RMIT University, Australia; (2) Nanjing University, China; (3) University of WA, Australia

**ABSTRACT**

The fundamental theories and methods of active noise control (ANC) have become well established over the last 30 years, so fewer academic research projects on ANC are funded nowadays. However, applications of the technology are entering a new golden era with greater numbers of companies investigating the applications of noise control in their products. One good example is the successful application of ANC on Apple's iPhone 5 to increase speech quality in communication by cancelling ambient noise. This paper discusses a number of ANC projects that we have conducted over the last ten years with emphasis on the various challenges encountered in the applications of ANC. Aspects covered include acoustical design methods, recently developed adaptive control algorithms, new control hardware and systems, and new applications. The projects discussed include active control of transformer noise, ANC in natural ventilation windows, and ANC in a communication chassis. Unlike our previous research, all these projects are funded by industry bodies, and their aims are not to perform academic research, but to develop commercial products.

**Monday 09:20-10:40 Room 218**  
**L1a Active control of sound**  
**Chair: Bosun Xie, Kean Chen**

**129 Analysis on the timbre of Ambisonics recording by circular and spherical microphone array using a binaural loudness model**

*Xie, Bosun (1); Liu, Yang (1)*  
 (1) South China University of Technology, China

**ABSTRACT**

Ambisonics are a series of flexible sound reproduction systems that decompose and reconstruct sound field by each order approximation of spatial harmonics decomposition. Circular or spherical microphone array has been used for Ambisonics recording. For an array with given radius as well as given number and configuration of microphones, the spatial harmonics signals up to certain temporal frequency and certain order can be derived from the array outputs with appropriate accuracy. When the temporal frequency exceeds the given limitation of array, however, spatial aliasing occurs in the derived spatial harmonics signals. Spatial aliasing in recording causes error in reconstructed sound field, which inevitably change the timbre in reproduction. The present work analyzes the timbre in Ambisonics recording by rigid circular and spherical microphone array. The binaural loudness level spectra are used as a criterion to evaluate the timbre in reproduction. The results indicate that, array recording influences little on the binaural loudness level spectra and thus timbre in final reconstructed sound field providing that the high-frequency limit of microphone array exceeds that of sound field reconstruction. Increasing number of microphones extends the high-frequency limit of array and thus improves the timbre.

**228 Reduction of air space behind piezoelectric absorbing panel using negative stiffness**

*Yamada, Keisuke (1); Yamagata, Kenta (2); Utsuno, Hideo (1)*  
 (1) Kansai University, Japan; (2) Kyoto University, Japan

**ABSTRACT**

This paper proposes a method of reduction of the air space behind the piezoelectric sound absorbing panel using the piezoelectric elements, negative capacitor, and resistor. Because the air space behind the panel works as an air spring, the natural frequency of the panel is increased by the air spring under the condition that the air space is small. Therefore, the purpose of this research is to decrease the increased natural frequency of the piezoelectric sound absorbing panel due to the air space behind the panel. The negative capacitor and resistor are coupled to the piezoelectric elements bonded on the panel. The piezoelectric elements and circuit give negative stiffness and positive damping to the panel. The governing equations were theoretically derived, and optimum values of the negative capacitance and resistance were respectively formulated. The effectiveness of the proposed method and the theoretical analysis were verified through simulations and experiments.

**248 A stability analysis of cluster active control system of sinusoidal sound in free space**

*Yu, Haoxin (1); Chen, Kean (1); Sang, Zhiming (2); Tang, Dakai (2)*  
 (1) Northwestern Polytechnical University, Xi'an, China; (2) Shaanxi Fenghuo Electronics Co. Ltd., China

**ABSTRACT**

Generally, the implementation of fully coupled multichannel active noise control system which has advantages in improving noise reduction and extending quiet zone requires considerable processing power. A practical method to decrease processing power is to decentralize the control; that is, implement many single input, single output independent controllers operating simultaneously instead of a large multiple input, multiple output system. However, the drawback of decentralized control is the risk of global instability. A new method was proposed for constructing an active noise control system to balance the complexity in multichannel systems and instability in the decentralized system. The proposed method consists of several independent multichannel sub-systems called cluster active control system, which is a modified version of the decentralized system and can improve stability at a reasonable computational cost. The purpose of this paper is to derive conditions under which globally stable control system behavior can be obtained in the case of cluster control for a sinusoidal disturbance. Hence, theoretical analysis and simulations are carried out to achieve the main objective which is to give practical conditions derived from the zero-pole map of the control system. These conditions only take into account the geometrical arrangement of the secondary sources and error sensors.

**314 Generation of localized sound using speaker array**

*Fukaya, Kigen (1); Iwamoto, Hiroyuki (1); Sanada, Akira (2); Tanaka, Nobuo (3)*  
 (1) Seikei university, Japan; (2) Industrial Center of Okayama Prefecture, Japan; (3) Tokyo Metropolitan University, Japan

**ABSTRACT**

This paper presents a methodology of generating a sound field in which the sound energy around the speakers is high while that in the other region is relatively low. Although directional loudspeaker that delivers sound energy only for the specific direction has been discussed in the past literature, such a method leaks sound to outside of the specific area because of reflection of the sound wave. To overcome this problem, a novel methodology of generating localized sound is presented which is based on the phenomena that radiated sound from vibration of a rectangular plate under the specific conditions decays drastically more than normal distance decay effect. First, spatial distribution of a rectangular plate vibration at a frequency where acoustic power becomes extremely low is verified, it being clarified localized sound is generated by coupling certain modes each other. Next, a matrix-type speakers array is used to imitate the spatial distribution that generates localized sound in order to achieve generating a sound field not only at a single frequency but in band-limited spectra. As a result, efficacy of speakers array to generate of localized sound is revealed.

**Monday 09:20-11:00 Room 217**  
**T8a Sound Quality**  
**Chair: Klaus Genuit, Roland Sottek**

**664 Improving sound quality measures through the multifaceted soundscape approach**

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**ABSTRACT**

Soundscape research represents a paradigm shift in the field of sound evaluation. First, it improves human perception, and, second, it expands on classical physical measurements and makes reference to the use of different investigative measurement methods. This multifaceted approach is basic to improving the validity of the research outcome on any subject or phenomenon, and it avoids systematic errors that can occur when relying on only one approach. The soundscape approach considers the conditions and purposes of a sound's production and how it is perceived. Consequently, it is necessary to understand that the evaluation of sound is a holistic process. The International Standard ISO/DIS 12913-1 has as its purpose the enabling of a broad international consensus on the definition of 'soundscape' and its respective evaluation. It is more than urgent to understand that there is the need to provide a solid foundation for communication across disciplines and professions with an interest in achievements on better solutions for the people concerned.

**708 Contribution of single sounds to sound quality assessments of multi-source environments**

*Skoda, Sabrina (1); Steffens, Jochen (2); Becker-Schweitzer, Jörg (1)*  
 (1) Duesseldorf University of Applied Sciences, Germany; (2) McGill University Montreal, Canada

**ABSTRACT**

In everyday life people are surrounded by several sound sources which complement each other in complex acoustical environments. Different models to predict annoyance reactions to combined noise sources, pre- dominantly based on loudness summation, have recently been proposed. However, it is still not understood how single sounds contribute to the evaluation of pleasantness of a multi-source environment, as the perceived sound quality is subject to numerous superposition and interaction effects of sounds with diverse acoustical characteristics. Therefore, the fundamental relationship between assessments of single and combined sound sources was investigated in the course of a listening experiment. Various sounds commonly occurring in suburban areas, including traffic noise, sounds from technical devices and natural sources, were evaluated in laboratory separately and combined in pairs with regard to their pleasantness. The results show that the combination ratings correspond to the sum of the single assessments and their interaction ( $R^2 = .95$ ). Moreover, less pleasant sounds have greater influence than pleasant sounds, which can be attributed to masking effects and the negativity bias. A regression model is proposed that provides a highly accurate prediction for simple sound combinations in laboratory context. Consequently, validation for acoustical environments of higher complexity is needed in future.

**112 Perception of sound quality of product sounds A subjective study using a semantic differential**

*Hülsmeier, David (1); Schell-Majoer, Lena (1); Rennies, Jan (1); Van De Par, Steven (2)*  
 (1) Fraunhofer IDMT Hearing Speech and Audio Technology, Germany; (2) Carl von Ossietzky Universität Oldenburg, Germany

**ABSTRACT**

How can quality of product sounds be measured? This question was investigated on basis of shaver, vacuum cleaner and spray sounds, which were matched in loudness according to DIN45631 and were separately presented to subjects. Using open questions, the perception of the sounds was determined and a list with word pairs was created as a basis for a semantic differential. The sounds were presented to subjects in a listening booth and were rated separately for each product group. The data were analysed by means of polarity profiles and factor analyses. Groupings could be found for sounds and word pairs. For the word pairs, one factor representing quality could be found for each product group. This factor, the factor loadings and the answers of the subjects were used as basis for a linear model. The results indicate that spectral and temporal properties of spray sounds correlate with perception of quality. Stationary spray sounds were rated with a high quality in contrast to spluttering sounds. Vacuum cleaners need to sound powerful and functional to be perceived as top quality. Precise, cutting and fast sounds were perceived as top quality for shavers. The results are discussed on basis of auditory models.

**251 Psychoacoustic analysis of HVAC noise with equal loudness**

*Hohls, Silke (1); Biermeier, Thomas (2); Blaschke, Ralf (2); Becker, Stefan (1)*  
 (1) University of Erlangen-Nuremberg, Germany; (2) Audi AG, Germany

**ABSTRACT**

In order to guarantee maximal comfort inside vehicles, noise pollution has to be minimized. When considering developments especially in electro mobility, one major sound source - the combustion engine - is eliminated. Hence, the ancillary units as sound sources become increasingly unmasked and thus, prevalent. The sound field developed by the heating, ventilation and air conditioning system (HVAC) then essentially affects the perceptible sound field inside the car cabin. For identifying the relevant psychoacoustic parameters for assessing the sound quality of HVAC noise, a listening test, using the preference paired-comparison technique, was performed on seven sound samples of different vehicles in the defrost mode. The sounds were equalized in their loudness on an average level. Thus, the aim of this study was to analyze the correlation between the listeners' preference and additional parameters beside the dominant parameter loudness. It was found that the sharpness, the articulation index and the roughness determine a preference decision when the loudness is eliminated from the sound samples.

**226 Study on evaluation method of the pure tone for small fan**

*Yamaguchi, Takao (1); Minorikawa, Gaku (1); Kihara, Masayuki (2)*  
(1) Hosei University, Japan; (2) Sharp Corporation, Japan

**ABSTRACT**

In the field of audio, visual and information technology equipment, small fan noise which includes many pure tones becomes annoying components. Pure tones are caused by the electromagnetic force of motor, the flow interference between blades and spokes, the acoustic modes of the structure and so on. These tones become not only the main contribution to the overall sound pressure level, but also unpleasant component. Some metrics for the pure tone have been presented, however the one which specified for small fan noise has not been developed. In this study, evaluation of multiple pure tones generated by small fan was attempted and examined by using sensory test.

**Monday 09:40-10:40 Room 216**

**C1a Aeroacoustics**

**Chair: Con Doolan**

**309 Study on modeling of flow induced noise using Lighthill's analogy and boundary element method**

*Mori, Masaaki (1); Masumoto, Takayuki (1); Ishihara, Kunihiro (2); Oshima, Takuya (3); Yasuda, Yosuke (4); Sakuma, Tetsuya (5)*  
(1) Cybernet Systems, Japan; (2) Tokushima Bunri University, Japan; (3) Niigata University, Japan; (4) Kanagawa University, Japan; (5) The University of Tokyo, Japan

**ABSTRACT**

We have calculated the flow-induced sound pressure field using Lighthill's acoustic analogy by means of an acoustic boundary element method (BEM). For this calculation, firstly, an unsteady flow field is calculated using a computational fluid dynamics (CFD) solver. Then acoustic sources are extracted from the result and transformed into the frequency domain. Finally, these are used as quadrupole acoustic sources in the acoustic BEM model. In the BEM calculation, because some of the CFD grid points exist quite close to the BEM elements, for example 100 times smaller than the element length, so the contribution from the sources must be evaluated quite preciously. To achieve this, the elemental integration of the source contribution is introduced. We have validated the procedure (CFD/BEM approach) by comparing with an experimental data. The first validation is a comparison of the acoustic pressure generated by a low Mach number flow past a 3D circular cylinder. The second validation is a comparison of the acoustic pressure induced by a low Mach number flow in a bending duct. Finally the transmitting acoustic pressure which is originally induced by a flow through an elastic structure is calculated by the structural-acoustic coupled model.

**476 Direct numerical simulation of flow and acoustic fields around an air-reed instrument with tone holes**

*Yokoyama, Hiroshi (1); Kobayashi, Masaki (1); Onitsuka, Hirofumi (2); Miki, Akira (2); Iida, Akiyoshi (1)*  
(1) Toyohashi University of Technology, Japan; (2) Yamaha Corporation, Japan

**ABSTRACT**

In order to clarify flow and acoustic fields around a recorder with opened and closed tone holes, direct aeroacoustics simulation was performed with compressible Navier-Stokes equations. For validation of the computational accuracy, the velocity distribution and sound pressure level were experimentally measured. The predicted velocity profile of jet ejecting from the windway is in good agreement with that of experiment. The numerical results show that the fundamental frequency and sound pressure level of predicted sound are almost the same as that of experiments. The path of the standing wave of the recorder was estimated with the pressure distribution. The open-end corrections found to be longer than those for a conventional simple pipe due to the effects of the impinging jet on the edge and the uniform flow in the resonator. When the vortices of the jet from the windway are getting near to the edge, strong deformation of the vortices occurs and expansion wave radiates in the resonator. The amplitude and phase of the acoustic particle velocity are almost the same as those of the jet itself. It indicates that the acoustic field amplifies the fluctuations of the jet and maintains the acoustic and fluid relations.

**517 Aerodynamic noise produced in flow around an automobile bonnet**

*Yokoyama, Hiroshi (1); Nakajima, Takahiro (1); Shinohara, Taishi (1); Miyazawa, Masashi (2); Iida, Akiyoshi (1)*  
(1) Toyohashi University of Technology, Japan; (2) Honda R&D Co., Japan

**ABSTRACT**

To clarify the mechanism and conditions of the intense acoustic radiation from flows around a curvilinear body with a kink shape in an accelerated boundary layer, the experiments were performed with a low noise wind tunnel. The effects of the free-stream velocity and angle of the model to the horizontal surface in the downstream of the kink,  $\gamma$ , on the sound and flow fields were investigated. Consequently, the intense tones can be observed at  $\gamma = 5^\circ, 10^\circ$ . In these cases, the velocity fluctuations showed that the periodic vortex formations occur with the flow separation due to the kink. Also, it was clarified that the fundamental frequency of the tones has ladder-type behavior with reference to the flow velocity. These results indicated that the feedback loop, which consists of the vortex formation due to the kink and acoustic radiation around the trailing edge, is formed. Meanwhile, the intense tones did not radiate for the larger angle of  $\gamma = 15^\circ$ , where the vortex formation does not occur around the kink shape by the lack of flow separation. Also, for the smaller angle of  $\gamma = 0^\circ$ , the large flow separation prompted turbulent transition and the intense tones do not radiate.

**Monday 09:20-10:40 Room 215**  
**A1a Education - outreach to community**  
**Chair: Courtney Burroughs, Marion Burgess**

**65 Education and Outreach: I-INCE Publications**

*Burroughs, Courtney B (1); Thompson, James (2)*  
 (1) INCE, USA; (2) NIOSH, USA

**ABSTRACT**

One of the objectives of the member societies of the International Institutes of Noise Control Engineering (I-INCE) is the dissemination of useful information on the effects of noise, descriptions of the mechanisms and transmission of noise, and methods of noise control. Publications supported by I-INCE are one of the primary mechanisms for the dissemination of useful information on noise and its control. This paper presents an overview of the I-INCE publications, e.g. the Noise Control Engineering Journal, Noise News International and INCE conference papers. The objectives of these publications, mechanisms of publications and methods of access to these publications are discussed. Strategies for improving the usefulness to I-INCE members of these publications are outlined.

**78 Role for an Acoustical Society Journal**

*Burgess, Marion*  
 UNSW Canberra, Australia

**ABSTRACT**

The objectives for most acoustical societies include the concepts of promoting and advancing acoustics as well as supporting acousticians. The common means for achieving these objectives are the organization of meetings and the production and distribution of a publication. The basic publication is a newsletter that provides the means to keep the members informed on activities. As the society grows it is usual that the publication develops to include articles to better promote acoustics in the region. It is then not long before the society is producing a journal with a combination of news, notes and articles. This paper will discuss the role, benefits and challenges for a medium sized society in the production of a journal, using the journal Acoustics Australia as the example.

**22 Public participation at measures to reduce noise in Germany**

*Zeisler, Annett*  
 Federal Environment Agency, Germany

**ABSTRACT**

An essential part of a modern noise reduction strategy is the involvement of the public. This important approach is implemented in the European Environmental Noise Directive. According to this Directive, noise action plans will be developed with the participation of the public. In Germany, the individual participation in planning processes is increasingly in the focus of public interest and in political discussions. Especially, in context of large-scale infrastructure projects such as the expansion of an airport. The goal-oriented implementation of the participation process and the challenges of an effective participation are demonstrated at prominent examples. Moreover, proposals for a further development of the legal

requirements of the public participation at EU as well as international level will be presented. In this context, special consideration is given to measures of a clear and effective participation. The aim of these activities is to achieve a higher acceptance for official decisions of great importance. The involvement of the public in the decision-making process could also have a positive effect on their annoyance reaction because noise is often perceived as less loud if people are directly involved in the process.

**907 Communicating the noise message**

*Parnell, Jeffrey (1); Wassermann, John (2)*  
 (1) Dept of Planning and Environment, Australia; (2) Wilkinson Murray Pty Ltd, Australia

**ABSTRACT**

This paper revisits the key aspects of noise communication addressed by the authors in a previous paper and provides a summary of current practice and suggests strategies for improving the communication of information on noise so that it achieves the best outcomes. A discussion is presented on the limitations of noise assessments and public understanding as well as the consequences of good/bad noise communication. In addition, this paper also examines contemporary issues of changing expectations in communities and the dissemination of misinformation.

**Monday 09:40-11:00 Room 214**

**H1a Urban sound propagation**

**Chair: Timothy Van Renterghem**

**605 Comparison of acoustic pulse propagation between scale-model measurements and three-dimensional simulation over real-life urban topography**

*Oshima, Takuya (1); Ishizuka, Takashi (2); Kamijo, Takahide (1)*  
 (1) Niigata University, Japan; (2) Shimizu Corporation, Japan

**ABSTRACT**

In Inter-Noise 2013, the authors presented a study comparing acoustic propagation measurements over a 1:100 scale model of a real-life urban topography and large-scale three-dimensional finite-difference time-domain simulations. The results were presented in octave-band sound pressure levels. As a sequel to the 2013 paper, this paper compares the results in time domain. The waveforms of acoustic pulse propagation are computed by inverse filtering the source responses of an electric spark generator of the measurements and a Gaussian pulse of the simulation. The results show excellent matches at line-of-sight and single diffraction receiver positions in overall waveform structure, especially in arrival times of the diffracted and reflected pulses. The arrival time matched even after 0.7 s of traveling time. However, major discrepancies are observed at a receiver position which is affected by a combination of double diffraction and multiple reflections and positions affected by deep triple diffractions. Furthermore, in such positions, the simulated waveforms are found to have more energy in higher frequency. The discrepancies are possibly attributed to the use of rigid surfaces in the simulation and the lack of air absorption correction in the measured data processing.

**543 Calculation of sound propagation with highly reflective environments**

*Probst, Wolfgang*  
DataKustik GmbH, Germany

**ABSTRACT**

Engineering models applied to calculate noise levels in residential areas caused by traffic sources are ray-based approximations of the real wave propagation. Difficulties arise if many reflective objects like buildings influence sound propagation and if reflections contribute significantly to the resulting levels. There are different techniques to deal with these problems and all of them have their pros and cons. Some of them are discussed with special attention for the precision and repeatability necessary if these calculation methods shall be applied to check the conformity of infrastructure projects with existing legal requirements. Noise prediction for low noise back-yards near roads with heavy traffic and methods to calculate the levels increase in street canyons are discussed. It is shown that the assumption of specular reflection in nearly all calculation methods is a good approximation even with diffuse reflecting facades, but nevertheless limits the finally possible accuracy of noise prediction.

**446 Experimental analysis of the noise shielding by a green roof in response to rainfall**

*Van Renterghem, Timothy (1); Despriet, Mathias (1); Botteldooren, Dick (1)*  
(1) Ghent University, Belgium

**ABSTRACT**

A vegetated roof top (green roof) was shown to be the most promising building envelope greening measure to achieve quietness at a shielded side. In addition, such a measure comes with many ecological and economic benefits in addition to noise reduction. Noise abatement by green roofs has been assessed extensively before by detailed full-wave numerical simulations, by in-situ and full-scale laboratory diffraction experiments, and by characterizing the acoustic properties of the materials involved. In general, the absorption coefficient of any porous material is negatively affected by the presence of water. To assess the influence of rainfall on the acoustic performance of a green roof, a controlled in-situ diffraction experiment has been set up. The measurements, lasting for about 1.5 months, show a decrease in shielding with increasing moisture content, especially in the frequency range between 315 Hz and 1250 Hz. The difference in shielding between dry and (near) saturated state may amount up to 8 dB. Outside this frequency interval, diffraction over the green roof was hardly influenced by the volumetric water content of the substrate.

**270 Model based monitoring of traffic noise in an urban district**

*Van Der Eerden, Frits (1); Graafland, Freek (1); Wessels, Peter W (1); Segers, Arjo (1); Salomons, Erik M (1)*  
(1) TNO, The Netherlands

**ABSTRACT**

Noise control for an urban district starts by understanding the actual noise situation. A correct understanding is needed to take appropriate and cost efficient measures. For a noise burdened urban district, surrounded by road and rail traffic, the

traffic noise as well as the annoyance has been measured. The size of the district is approximately one square km. With the help of 35 microphones, applied in a scalable sensor network, the time-varying sound levels were recorded. These results were coupled to an engineering model to obtain the sound levels for the complete district as well as to discriminate between road and rail traffic noise. Also, a data assimilation technique has been applied to increase the agreement between the measurement and model results. For example, for Lden sound levels the standard used source strengths for road and rail needed to be adapted to better match the sound level measurement results. In a separate paper these corrected sound levels at the façades are coupled to annoyance survey results to derive a local exposure-response relation. The annoyance survey also indicated the importance of peak levels and vibrations. This is further investigated by considering the measured noise dynamics.

**Monday 09:20-11:00 Room 213**  
**Q2a Numerical methods in vibro-acoustics**  
**Chair: Steffen Marburg , Herwig Peters**

**23 Enhancing the low frequency vibration reduction performance of plates with embedded acoustic black holes**

*Conlon, Stephen (1); Fahnline, John (1); Feurtada, Phil (1); Semperlotti, Fabio (2)*  
(1) Penn State / ARL, USA; (2) Notre Dame, USA

**ABSTRACT**

Embedded Acoustic Black Holes (ABH) have been investigated as a passive treatment for noise and vibration control. The ABH effect is produced from a plate thickness power taper which results in a local asymptotic reduction of wave speed within the ABH. Theoretically the local wave speed approaches zero at the ABH center, causing the waves to take an infinite amount of time to reach the center, thus the waves are "trapped" in the black hole. This work focused on the low frequency performance of plates with periodic grids of ABHs for structural vibration and radiated sound reduction. Plates with embedded ABH grids were modeled with detailed Finite / Boundary Element models. The results show the ABHs reduce the narrow band vibration and radiated sound power by up to approximately 20 dB over that of the heavier uniform panel, at frequencies below the theoretical cut-on of the ABH as a broadband absorber. The low frequency performance of the ABH grids can be tailored based on the low frequency vibration characteristics of the ABH unit cell. Detailed results for several ABH plate configurations will be presented giving insight into key ABH low frequency design performance characteristics.

**216 FE based measures for structure borne sound radiation**

*Klaerner, Matthias (1); Marburg, Steffen (2); Kroll, Lothar (1)*  
(1) Technische Universität Chemnitz, Germany; (2) Universität der Bundeswehr München, Germany

**ABSTRACT**

The sound emission of thin-walled radiating components is a common objective of structural optimisation. Acoustic measures are not implemented in common FE-codes. Thus, different velocity based measures will be compared: the kinetic energy, the equivalent radiated power (ERP) and the lumped



parameter model (LPM). The most common approach - the ERP - is based on the sound intensity in normal direction and the sound pressure on the radiating surface. Assuming a unit radiation efficiency all-over the surface and neglecting local effects, this is a common approach for an upper bound of structure borne noise. Therein, the sound power finally results from the squared velocity integrated over the radiating surface and the constant fluid impedance. As ERP usually requires extra post processing to consider the velocity in normal surface direction, the kinetic energy is essential in common FEA results including all velocity components apart from the normal direction, too. Thus, it is less accurate but maybe usable for optimisation abilities. In contrast, LPM is a simplification of the Rayleigh-integral and thus gives quite accurate results but requires significant higher computational costs than ERP. Possibilities and limits of estimating the emitted sound power by these three methods will be shown.

### 389 Analytical and numerical approaches to predict radiated sound power of fluid-loaded cylindrical shells

Zhang, Yilin (1); Jiang, Weikang (2); Peters, Herwig (3); Kessissoglou, Nicole (3)  
(1) Shanghai Jiao Tong University, China, UNSW Australia, Sydney, Australia; (2) Shanghai Jiao Tong University, China; (3) UNSW Australia, Sydney, Australia

#### ABSTRACT

Prediction of the vibro-acoustic responses of fluid-loaded cylindrical shells is important for underwater vehicles. In this work, a number of analytical and numerical approaches to predict the radiated sound power of a fluid-loaded cylindrical shell are compared. In the first approach, an analytical methodology is used whereby the equations of motion for the cylindrical shell are solved by the method of modal superposition. The shell displacements are represented by a Fourier series and auxiliary functions. The radiation sound power is calculated by integrating the product of the pressure and velocity on the surface of the cylinder. In the second approach, an integrated analytical and numerical approach is implemented whereby the vibrational response of the cylindrical shell is used as an input to a boundary element model. The radiated sound power is subsequently obtained using the boundary element method. In the final approach, a fully-coupled finite element/boundary element model of the fluid-loaded cylinder is developed. Results for the radiated sound power from the various analytical, hybrid analytical/numerical and fully coupled numerical approaches are compared.

### 332 Experimentally uncertainty quantification in numerical and analytical beam models

Langer, P (1); Sepahvand, K (1); Krause, M (2); Marburg, Steffen (1)  
(1) Universität der Bundeswehr München, Deutschland; (2) Isko - engineers AG, Deutschland

#### ABSTRACT

In modern industrial processes such as developing new products, virtual prototyping is state of the art method to ensure short design cycles while dealing with low cost pressure. In order to meet these criteria, efficient and reliable simulations must be available. Numerical methods, especially the Finite Element Method (FEM) are commonly used in various

industrial fields e.g. the automotive sector, aircraft design and ship construction. The scope of this paper is to enhance the reliability of numerical models utilizing FEM when considering uncertain parameters of the underlying structure. Such parameters can be system related, i.e. geometry, material behavior, boundary conditions and mesh density as well as general assumptions in the process of modeling. Two well-known beam theories, i. e. Euler-Bernoulli and Timoshenko theory, have been utilized. At FE level, various elements available for modeling of beam structures in ABAQUS have been compared and evaluated. Experimental modal analysis have been performed on beam specimen to validate the results from analytical and FE models due to parameter uncertainties. A comparison between the numerical and analytical simulations with experiments reveal the element types with minimum deviation with regard to parameter uncertainties. Having sufficient knowledge of the dynamic behavior of simple beam samples, the complexity will be increased. This investigation developed instructions on how detailed a numerical model must be built to get satisfactory results.

### 30 Prediction of airborne and structure borne sound transmission through hearing protectors using FEM

Sgard, Franck (1); Brummund, Martin (2); Viallet, Guilhem (2); Boyer, Sylvain (2); Doutres, Olivier (3); Nelisse, Hugues (1); Laville, Frederic (2); Petit, Yvan (2); Boutin, Jerome (1)  
(1) IRSST, Canada; (2) ETS, Canada; (3) University of Sherbrooke, Canada

#### ABSTRACT

Individual hearing protection is a short term solution frequently used to protect workers against noise exposure. This work is part of a larger research program on the evaluation of real world attenuation of hearing protection devices (HPD) such as earplugs and earmuffs. Its objective is to develop a Finite Element (FE) model to predict both the airborne and structure borne sound transmission through an ear canal/hearing protector system. The model can help providing a better understanding of the acoustical behavior of this system and hence help designing better HPD ultimately. FEM can account for realistic ear and hearing protector geometries, materials with complicated physical behavioral laws and complex transmission phenomena through the different coupled domains in particular the tissues surrounding the ear canal. Several comparisons between numerical predictions and experimental results are presented. The sound transmission through the system is investigated using power balances and sensitivity analyses are carried out to identify the key parameters which govern the acoustic behavior of the system. The importance of parameters such as the system geometry, the coupling between the different domains and the loadings is discussed together with the characterization of the physical properties of each domain.

**Monday 10:00-11:00 Room 212**  
**B4a Machinery N&V - Plant**  
**Chair: Zhuang Li, Colin Tickell**

**495 Analysis of Sound Propagation in Finned Tube Bundle of HRSG in Power Plant**

*Ahn, Sungjong (1); Lee, Sanghyuck (1); Ha, Jinwoong (1); Shin, Eontak (1)*  
 (1) DOOSAN Heavy industries and Construction, South Korea

**ABSTRACT**

The HRSG (Heat Recovery Steam Generator) generates high noise level due to the exhaust noise from gas turbine and is reduced as passing HRSG component. The HRSG consists of four major components - inlet duct, main casing, outlet duct and stack. Occasionally, additional noise reduction structures such as inlet shroud and silencer are required to satisfy the noise limit level. Thus, the prediction of noise level may lead to significant design problem. In this paper, we developed prediction method for the noise reduction level of main casing. The main casing consists of finned tube bank which is considered as a silencer. The FEA (Finite Element Acoustic) is applied to noise attenuation process of tube bundle. The test in actual finned-tube bank is performed for the validation of analysis.

**79 Numerical and Experimental Study on Mechanism of Low Frequency Noise from Heat Recovery Steam Generator**

*Tang, Hongyun (1); Jiang, Weikang (1); Zhong, Zhenmao (2); Zhao, Yingjiu (2)*  
 (1) Shanghai Jiao Tong University, China; (2) Huadian Heavy Industries Co. Ltd, China

**ABSTRACT**

The low frequency noise from heat recovery steam generator (HRSG) makes dominant contribution to the noise on the boundary of plant, which generation mechanism is investigated in this presentation. The non-stationary flow field and aeroacoustic noise is studied with hybrid numerical simulation, which is comprised of CFD method based on Large Eddy Simulation (LES) and acoustic analogy by using Ffowcs Williams-Hawkings equation. Models of cylindrical tube, fin-tube and tube array are established respectively to investigate the feature of vortex noise. The results of numerical simulation are compared with the acoustic intensities measured at the site. It can be understood from the simulation that the flow passing through the heat exchanger tube will induce vortex shedding, which results in the low frequency noise in HRSG. The vortex noise of a cylindrical tube lead to the obvious characteristic tone frequency as same as the vortex shedding frequency, but the spiral fin reduces the characteristic frequency and sound level. For the tube array of heat exchanger, due to the enhanced interaction of the flow field among tubes, the vortex noise is narrowband noise with some bandwidth. More targeted methods can be used for noise reduction of HRSG according to the research results.

**27 Fatigue Life Estimation of Piping System for Evaluation of Acoustically Induced Vibration (AIV)**

*Izuchi, Hisao (1); Nishiguchi, Masato (1); Lee, Gary Y H (2)*  
 (1) Chiyoda Corporation, Japan; (2) Shell Global Solutions, Malaysia

**ABSTRACT**

One of the key design parameters to a process plant with large capacity is the risk of AIV (Acoustically Induced Vibration) on the flare piping system. AIV is a piping vibration phenomenon exhibiting high frequencies caused by large acoustic power generated by the pressure drop across a PRV (Pressure Relief Valve). The evaluation method for susceptibility of piping to AIV fatigue failure was first proposed by Carucci and Mueller around 30 years ago. Since then, several developments were reported. However, there has not been publication with reference to fatigue life estimation in relation to the AIV phenomena. This paper proposes a procedure to calculate the fatigue life for the AIV based on actual operating condition, design fatigue life curve, etc. In this procedure vibration stress level can be obtained from the expected sound power level. The stress level was then used to estimate the fatigue life using design fatigue life curve and AIV experimental data. It is hoped that this procedure would allow for possible AIV failures to be classified corresponding to the actual plant operation. This kind of AIV evaluation would be useful to determine the priority of the countermeasure to mitigate piping failure caused by AIV in the existing plant.

**Monday 09:20-11:00 Room 211**  
**N1 Speech privacy in buildings**  
**Chair: Jorge Patricio, Kenric Van Wyk**

**929 Speech Privacy and Intelligibility in Open-Plan Offices as an Impact of Sound-Field Diffuseness**

*Utami, Sentagi Sesotya (1); Sarwono, Joko (2); Al Rochmadi, Nurwachid (1); Suheri, Nanan (1)*  
 (1) Universitas Gadjah Mada, Indonesia; (2) Institut Teknologi Bandung, Indonesia

**ABSTRACT**

The research is based on ISO 3382-3:2012, a standard for speech privacy quality measurement in open-plan offices. Predicted speech privacy and distraction distances, the quality of speech intelligibility, and the diffuseness of the sound fields were observed. Within the past few decades, a new paradigm has emerged where reverberation control is not the only solution for good room acoustics. In certain open-plan office, quality of speech privacy and intelligibility should be similar for each workstation by creating a diffuse sound field. In many spaces, absorption and diffusion are solution in a form of acoustic panel, furniture and other elements, such as bookshelves in offices. The measurement in this research utilized multi-microphones. The degree of diffuseness was done by evaluating the coherences of impulse responses measured. Values of T30, C50, and RASTI were also evaluated. Further analysis on the sound field diffuseness was done by evaluating the coherence of early and late reflections, and also occurrences of the comb-filtering effect. Subjective evaluation of selected workstations was also conducted. The methods utilized in this research demonstrate

the ability for acousticians and architects to evaluate the effect of diffuseness on speech privacy and intelligibility quality of an open-plan office layout.

**592 Preliminary study of the acoustic behavior concerning an innovative prototype for indoor modular partitioning**

*Simões, Gonçalo (1); Patrício, Jorge (2); Faria, Paulina (1)*  
(1) FCT-UNL, Portugal; (2) LNEC, Portugal

**ABSTRACT**

This paper presents a preliminary acoustic study concerning the development of the first prototype of a patented removable module for interior partitioning. It is a prefabricated, vertical element for division of interior spaces that does not require the use of gutters or technical support. A set of such modules, linearly disposed, will create a division, allowing the personalization of any indoor area, including open office spaces, rooms, among others. The main characteristic that distinguishes this element from the existing solutions available on the market is that its mobility relies exclusively on a set of integrated bearings at the base of each module. Through an incorporated elevation system, the user can lower the module, move it to the desired position and re-elevate it until pressed against the ledge of the ceiling, making it stable. In this sense, and taking into account its acoustic behavior, several tests were made in the LNEC acoustics lab. Airborne sound insulation tests for different typologies of the prototype were conducted, according to the applicable standards EN ISO 354:2003, EN ISO 717-1:2013 and EN ISO 10140-2:2010. Some important conclusions and analysis of the prototype viability were extracted.

**869 The Influence of Abfuser Configuration to the Speech Privacy and Intelligibility in an Open Plan Office**

*Sarwono, Joko (1); Rachman, Arinda Puspita (1); Azzahra, Iva R Nisa (1); Utami, Sentagi Sesotya (2)*  
(1) Institut Teknologi Bandung, Indonesia; (2) Universitas Gajah Mada, Indonesia

**ABSTRACT**

Open plan office is an office plan which minimizes the use of full room divider such as a private office. Nowadays, open plan office is preferred because it provides many advantages such as working mobility and increasing teamwork between co-worker and managerial. This concept also fulfills today energy management issues. Open plan office provides minimum energy consumption especially in lighting and air conditioning. On the other hand, a problem that usually faced by worker whose work in open office plan, which has correlation in speech comfort, are audial interference caused by another sound or noise, and loss of speech privacy. One way to overcome this problem is by applying absorber – diffuser (abfuser) surfaces. In this paper, simulation of abfuser application in an open plan office model was done by using finite element and ray-tracing method. The simulation was carried out with the reference of ISO 3382- 3:2012 for Open Plan Office – measurement of acoustic parameter. Parameters that were varied in this simulation include absorption coefficient, scattering coefficient and the formation of abfuser surfaces. In situ measurements in the real Open Plan Office which was modeled in the simulation were conducted to provide comparison to the based model. The Simulation was used to determine the parameters of Abfuser which provides

optimum values to increase speech privacy and speech intelligibility for the open plan office model.

**638 An electronic database of speech sound levels**

*Nash, Anthony*  
Charles M. Salter Associates, USA

**ABSTRACT**

In early 1970's, the U.S. Environmental Protection Agency sponsored a research program involving speech sound levels in various noise environments. Bolt, Beranek and Newman (BB&N) conducted this research program under contract. Among other tasks, BB&N measured speech sound levels under controlled conditions from subjects using five categories of speech effort. In 1977, a summary report of the research program was prepared. This report was supported by a companion data supplement containing a statistical analysis of sound pressure levels measured at one meter from 97 individual subjects in an anechoic chamber. The data were obtained from a one-third-octave-band real-time analyzer, processed by a mini-computer, and then printed in the form of 482 cumulative statistical distributions. The 140,000 sound pressure levels in this printed data supplement have now been converted to an electronic database to create a convenient and efficient resource for the acoustical community. The data can be used for many purposes, including the prediction of speech privacy for a variety of speech efforts. This paper summarizes the contents of the database and discusses its possible applications.

**444 Improvement of body-conducted speech recognition using model estimation**

*Nakayama, Masashi (1); Ishimitsu, Shunsuke (1); Nakatani, Satoshi (2)*  
(1) Hiroshima City University, Japan; (2) Yamaguchi University, Japan

**ABSTRACT**

One problem with speech recognition is a low performance in noisy environments because it is easily influenced by aerial in air. Although the sound quality of body-conducted speech (BCS) and regular speech are different, with BCS recognition, it is possible to recognize an utterance in noisy environments with a rating of 98 dB sound pressure level (SPL) in our previous study. In this study, we investigate how to improve BCS recognition performance using model re-estimation methods of ML and MAP. An acoustic model uses parameters such as mean vector, covariance matrix, weight, and transition probability. Recognition performance is improved by model re-estimation of speech and BCS using maximum likelihood and maximum a posteriori methods, respectively. We confirmed that improvements in recognition performance are achieved for practical through the re-estimation of the covariance matrix and mean vector.

**Monday 09:20-11:00 Room 210**  
**N8a Room acoustics**  
**Chair: Toru Otsuru, Nazli Bin Che Din**

**960 Psychoacoustic analysis of preference reverberation time for Gamelan Bali Concert Hall**

*Nitidara, Ni Putu Amanda (1); Sarwono, Joko (1); Merthayasa, I G Nyoman (1)*  
 (1) Institut Teknologi Bandung, Indonesia

**ABSTRACT**

Lately, there has been increasing interest to design acoustic concert hall for Indonesia traditional music, for example Gamelan Bali. In order to obtain a good and comprehensive design, some research on acoustical properties of Gamelan itself must be conducted. One of the main concerns was to find the optimum value of reverberation time for Gamelan music. Unlike the orchestra and classical music performance, preference value of reverberation time for Gamelan Bali is not known yet. Psychoacoustic research was conducted to obtain the preference of reverberation time for Gamelan Bali. A number of respondents were included in the experiment to give the subjective ratings. The subjects were divided into three groups based on their knowledge and experience of Gamelan Bali music. The results suggest that group which is accustomed to Gamelan music produced more significant results in their subjective ratings than the other groups. Based on that results, the preference value of Gamelan reverberation time was concluded.

**1030 Withdrawn3**

*Withdrawn3,*

**ABSTRACT**

*Withdrawn3*

**649 Micro-perforated sheets as day-light ceilings**

*Nocke, Christian (1); Hilge, Catja (1); Scherrer, Jean-Marc (2)*  
 (1) Akustikbüro Oldenburg, Germany; (2) BARRISOL S.A.S, France

**ABSTRACT**

The theory of microperforated panel sound-absorbing constructions has been introduced by D.-Y. Maa in 1975. Many different applications of micro-perforated sound absorbing materials have been introduced. Materials that have been used to be micro-perforated have been metal, wood, plastics and many others. Stretched sheets used as ceilings, wall coverings and other set-ups have been applied for more than 40 years. In modern buildings ceilings often need to combine different functions, e.g. thermally activated and sound absorptive or sound absorptive and light emitting. With the micro-perforated sheets absorptive day-light ceilings can be built. 3D-shapes as well as printed sheets can be used for architectural or design purposes. Also the fully transparent micro-perforated sound absorber offers new design possibilities. In this contribution measured sound absorption coefficients of various set-ups with micro-perforated materials as well as combinations with different porous materials will be presented.

**894 The Design of MPP and its Application to Enhance the Acoustics of a Real Auditorium**

*Sarwono, Joko (1); Prasetyo, I (1); Andreas, S (1); William, A (1)*  
 (1) Institut Teknologi Bandung, Indonesia

**ABSTRACT**

Micro Perforated Panels (MPP) backed by air cavity is an acoustic absorber based on the Helmholtz resonance mechanism. MPP is potential to be an alternative acoustic absorber amid the carcinogenic issues of porous material. It is however, MPP has several limitations in its application. One of them is its narrow absorption bandwidth. One way to overcome this problem is by arranging some MPPs with particular parameters working on different absorption peaks to deal with wideband absorption as commonly required in room acoustic cases. In this paper the MPP were designed by simulation using Dah – You Maa model. There are four parameters that can be adjusted to get the right sound absorption coefficient from the MPP; those are panel thickness, pore diameter, cavity depth, and perforation area. Validations on the simulation results are carried out through Impedance Tube Measurements using transfer function method based on ISO 10534-2 standard. The paper also discusses the application of the MPP into a real auditorium by modeling and simulation. The aim is to overcome the acoustics problem for speech, classical music, and Indonesian traditional music performance in the auditorium. The influence of MPP's configurations on the acoustics of the auditorium are presented and discussed.

**632 Application of an in-situ measurement method using ensemble averaging technique to material development**

*Okamoto, Noriko (1); Otsuru, Toru (2); Tomiku, Reiji (2); Kamimizu, Takaaki (2); Yamaguchi, Makoto (3); Okuzono, Takeshi (4)*  
 (1) Ariake National College of Technology, Japan; (2) Oita University, Japan; (3) Kumamoto University, Japan; (4) Kobe University, Japan

**ABSTRACT**

An in-situ measurement method using ensemble averaging technique, i.e., EA method, is applied to evaluation for absorption characteristics of multi-functional interior materials using porous mortar in the research and development phase. First, absorption characteristics of small specimens are measured by the EA method in a reverberation room, and the repeatability of the measurement result is confirmed. Next, absorption characteristics of eight kinds of the porous mortars with different fine aggregate and target voids are measured by the method, and their absorption characteristics are compared with each other. Finally, the effect of finishing materials on absorption characteristics of the porous mortar is examined.

**Monday 09:20-10:40 Room 209**  
**D1 Road vehicle noise**  
**Chair: James McIntosh**

**99 Road traffic facade treatment in Israel**

*Epstein, David*  
 Epstein Acoustics Ltd., Israel

**ABSTRACT**

This paper outlines the program for facade treatment for traffic noise in Israel. The main principals of the program are: Facade treatment is only provided as part of a statutory plan for a new roadway or a substantial change to an existing road, monetary compensation is never given in lieu of treatment, the facade noise levels are determined by calculation only, using maximum potential noise-producing traffic conditions, the criteria for facade treatment are 64 dBA for residential buildings and 59 dBA for public buildings, the type of treatment is based on the amount the facade noise level exceeds the criterion. The average costs of facade treatments are 80,000 NIS (\$A25,000) for dwellings in multi-storey buildings, 210,000 NIS (\$A65,000) for single dwellings, 950,000 NIS (\$A300,000) for public buildings. Over the last 10 years, approximately 1,500 dwellings have been treated.

**139 Selection of state highway bridge expansion joints in noise sensitive areas**

*Chiles, Stephen*  
 NZ Transport Agency, New Zealand

**ABSTRACT**

Noise generated by vehicles passing over expansion joints has not been a significant factor in the selection of joint types for most existing state highway bridges in New Zealand. In response to concerns raised by residents living near a proposed new bridge in Wellington, the NZ Transport Agency commissioned research into noise from existing bridge joints on the state highway network to gain a better understanding of design and selection parameters. The research primarily used vehicle mounted noise and vibration transducers to obtain comparative data for a relatively large number of existing joints. Even for the same joint types significant variability in noise generated was found, meaning no clear ranking of different joint types could be established from the data. The installation and maintenance quality of the road surface and joint appears to be a significant factor in noise generated. Finger joints were found to provide consistent performance with noise towards the lower end of the range measured. Modular joints without surface treatment generated high noise levels. This paper sets out the methodology used for the measurement of bridge expansion joint noise and summarises the key findings from the research.

**360 Towards a reduction of noise emission of powered two-wheels – Part 1**

*Lelong, Joel (1); Chatagnon, Roger (1); Clerc, Christian (2); Jamin, David (3); Seigner, Maxime (3); Thivant, Michael (2)*  
 (1) IFSTTAR/LAE, France; (2) Vibratex SA, France; (3) Peugeot Scooters, France

**ABSTRACT**

Transportation in urban areas is often synonymous of traffic congestion. In the last decade, this situation led users to give up passenger cars and incited them to adopt powered two-wheelers (PTW), better adapted to the traffic hazards. However, the question of the noise emitted by PTW remains a concern for the population. In France, these vehicles are quoted in second position in the opinion surveys relative to the transportation noise. The main objective of the French research project Ascoot (Acoustique des scooters et des motocycles) is to propose solutions aiming to reduce the noise emitted by the most represented PTW in the current traffic. This paper summarizes the results obtained on the acoustical investigation of a panel of ten PTW (including an electric powered scooter). Global and third-octave noise analysis has been performed, relying on the classical Controlled Pass-by procedure, and on a determination of the directivity characteristics. Pass-bys at constant speed, with acceleration and deceleration have been considered, and the influence of mechanical parameters, as the engine capacity, is also analyzed. The noise emission of PTW has been finally compared with those of other means of transportation usually met in urban zones (light vehicles, medium heavy vehicles, buses, trams).

**363 Towards a reduction of noise emission of powered two-wheels - Part 2.**

*Thivant, Michael (1); Clerc, Christian (1); Jamin, David (2); Gauthier, Quentin (2); Lelong, Joel (3); Chatagnon, Roger (3)*  
 (1) Vibratex SA, France; (2) Peugeot Scooters, France; (3) IFSTTAR/LAE, France

**ABSTRACT**

Transportation in urban areas is often synonymous of traffic congestion. In the last decade, this situation led users to give up passenger cars and incited them to adopt powered two-wheelers (PTW), better adapted to the traffic hazards. In the frame of the French research project Ascoot (Acoustique des scooters et des motorcycles), this paper focuses on the acoustic optimization performed on two scooters, including diagnosis and computation methodologies, leading to technical solutions implemented on 2 prototypes. The acoustic sources were located and quantified by acoustic imaging on roller benches, and the vibration behavior was characterized by means of experimental modal analysis (EMA) and measurement in operation. A simulation model was build for solutions design: excitation forces were derived from the measured combustion pressure and from a cinematic model of the engine moving parts, whereas structural dynamic response was computed by a Finite Element Model (correlated with EMA). An optimization of muffler design was also performed using transfer matrix models. The implementation of the noise reduction solutions on both prototypes is in progress; a minimum of 3dB noise abatement is expected.

**Monday 09:20-11:00 Room 208**  
**D4a Pavement modelling and measurement techniques**  
**Chair: Paul Donovan, Gaetano Licitra**

**12 Comparison of road and laboratory measurements of tyre/road noise**

*Swieczko-Zurek, Beata (1); Ejsmont, Jerzy (1); Ronowski, Grzegorz (1); Taryma, Stanisław (1)*  
 (1) Technical University of Gdansk, Poland

**ABSTRACT**

Tyre/road noise is one of the major environmental problems related to road traffic. There are several measuring methods of tyre/road noise that may be carried out on the road (for example Coast-down and Close Proximity Method) or in the laboratory (Drum Method). Road measurements are preferred for evaluations of pavement properties while laboratory methods are mostly used to evaluate tyres. One of the biggest problems associated with laboratory methods is to ascertain that tyre interfaces with pavement that has texture, porosity and mechanical impedance the same as with the real road surface. The paper presents results of tests performed by the Close Proximity Method (with test trailer Tiresonic Mk.4) and drum method where very similar or exactly the same surfaces are used. The reported measuring program includes tests performed on an innovative poroelastic road surface called PERS.

**280 Investigating lateral porosity effect on air pumping noise from connected road cavities with CFD simulations**

*Conte, Frédéric (1); Klein, Philippe (1); Bérengier, Michel (1)*  
 (1) IFSTTAR, France

**ABSTRACT**

Several mechanisms induced by the tyre/road interaction contribute to the generation of rolling noise. The road texture has a significant role in this process, together with the possible porosity of the road pavement. The latter may influence the noise sources in the high frequency range in which air pumping is supposed to contribute. Even on dense road surfaces with no vertical porosity, possible air flow allowed by the road texture in the contact patch is equivalent to the effect of a so-called "lateral" porosity which is reckoned to have an influence on the source strength. In this paper, the effect of this lateral porosity is studied with a modelling approach using Computational Fluid Dynamics (CFD). This approach allows the highlighting of some phenomena occurring in the contact patch such as air compression due to the tyre rolling process or air drainage. Simulations are carried out for a smooth tyre and road textures made of more or less connected cavities. A parametric study is presented in the case of a 2D academic configuration to show the influence of air flow resistance in the contact zone on air pumping noise. Finally, air pumping mechanism is simulated for a 3D configuration.

**297 Reduction of vehicle noise at lower speeds due to a porous open-graded asphalt pavement**

*Donavan, Paul*  
 Illingworth & Rodkin, Inc.

**ABSTRACT**

Vehicle noise measurements were made on an arterial roadway in San Rafael, California before and after a 25 mm overlay of open graded asphalt concrete (OGAC). The purpose of these measurements was to document any reduction in vehicle noise due to the overlay on a 0.8 km section of pavement prior to repaving the entire length of the roadway. The posted speed limit along this test section is 56 km/hr. Of particular concern was the reduction of noise produced by medium and heavy duty trucks accessing a quarry. To quantify the noise reduction, statistical isolated pass-by (SIP) measurements were conducted before and after the overlay along with 10-minute Leq's with traffic counts, and on-board sound intensity measurements (OBSI). The SIP measurements indicated a 9.2 dB reduction for light vehicles averaging 64 km/hr, 5.1 dB for heavy trucks under cruise/deceleration averaging 48 km/hr, and 3.1 dB for heavy trucks under acceleration averaging 42 km/hr. The hourly Leq for all vehicles was reduced by 5.0 dB. The OBSI measurements displayed reductions of 3.5 dB implying that porous nature of the OGAC was significantly influencing the measured wayside noise reduction.

**447 Test sections to study the acoustical quality and durability of thin noise reducing asphalt layers**

*Bergiers, Anneleen (1); De Visscher, Joëlle (1); Denolf, Katleen (1); Destrée, Alexandra (1); Vanhooreweder, Barbara (2); Vuye, Cedric (3)*  
 (1) BRRC, Belgium; (2) Flemish Agency Roads and Traffic, Belgium; (3) University Antwerp, Belgium

**ABSTRACT**

Within the context of the European Noise Directive, action plans have been established. Noise reducing road surfaces are seen as a cost-efficient measure for traffic noise abatement. Therefore ten test sections were installed in May 2012 in Belgium, with the objective of integrating noise friendly bituminous wearing courses in the Flemish road surface policy in a later stage. Eight test sections are paved with hot laid, bituminous wearing courses with a thickness of maximum 30 mm and a maximum content of accessible voids of 18 %. The other two sections consist of a double layer porous asphalt (PA) and a stone mastic asphalt (SMA) (reference section). The acoustical quality assessed during measurement campaigns in the first two years after construction is discussed in this paper. Statistical Pass-By (SPB) and Close-ProXimity (CPX) measurements are performed according to ISO 11819 within certain time intervals to follow up the evolution. Also other important factors, like durability, are studied. Resistance to raveling and adhesion to the base course are critical parameters for the lifetime of a thin noise reducing asphalt layer because of the high void content and limited thickness. BRRC measured the raveling resistance on test plates made with the asphalt mixtures sampled at the construction site. Tensile adhesion and shear bond tests were performed on drilled cores to measure the adhesion of the wearing course to the base course. Results of these laboratory raveling and adhesion tests are linked to the evolution on site and to the evolution of the noise measurement results.

- 914 **A study on comparison of noise reduction effect of single-layer drainage asphalt pavement and double-layer drainage asphalt pavement : Part 1 sound power level and frequency characteristic in initial construction**

*Mori, Hisho (1); Ishikawa, Kenichi (1); Ueta, Tomotaka (1); Noguchi, Eiji (1); Yoshida, Motoomi (1); Kokusho, Masami (1); Nagaoka, Hironori (1)*

(1) Oriental Consultants Co., Japan

#### ABSTRACT

This paper describes noise reduction effect of the double-layer drainage asphalt pavement that is one of the measures of road traffic noise. The data used in the study was researched in 1999-2003. The purpose is to study sound power level and the frequency characteristic in initial construction by comparing the single-layer drainage asphalt pavement with double-layer drainage asphalt pavement. Result of the comparison of the two types, it was found that double-layer drainage asphalt pavement have the noise reduction effect, about 3dB at light vehicles and slight effect at heavy vehicles. Peak frequency of the double-layer drainage asphalt pavement is around 500-630Hz. In addition to, in the near 1000Hz, A-weighted power spectrum of double-layer drainage asphalt pavement is lower than that of single-layer drainage asphalt pavement by 7dB.

**Monday 09:20-10:40 Room 207**

**R1 Underwater acoustics**

**Chair: Alec Duncan**

- 114 **AQUO Project – Modelling of ships as noise source for use in an underwater noise footprint assessment tool**

*Audoly, Christian (1); Rousset, Céline (1); Leissing, Thomas (1)*  
(1) DCNS Research, France

#### ABSTRACT

Recent researches outline the need to mitigate underwater noise footprint due to shipping, in order to prevent negative impact on marine life. Within this context, the final goal of the European AQUO project ([www.aquo.eu](http://www.aquo.eu)), which started in October 2012 for 3 years, is to provide to policy makers practical guidelines, in order to mitigate underwater noise impacts of shipping noise on marine life. Those guidelines will be based on solutions regarding ship design, including propeller and cavitation noise as well as solutions related to shipping control and regulation. In a first part, this paper will give an overview of the project. In a second part, we'll focus on the introduction of the ship as a noise source in a noise map prediction model. Underwater radiated noise of different categories of ships is represented in a parametric form along frequency, speed and ship size. For that purpose, using available experimental data, a new method is introduced to derive parametric models, based on the decomposition of total radiated noise into three components (machinery noise, propeller noise, and cavitation noise). Each component is defined by a specific "pattern" accounting for the variation of noise with frequency and ship speed. In the last part of the paper, these models are used to determine noise footprint indicators on a test case, and the influence of taking into account or not the horizontal directivity of the noise sources is studied.

- 401 **Ambient noise forward prediction from measured characteristics and high resolution modeling**

*Eller, Anthony I (1); Heaney, Kevin D (1)*  
(1) Oasis, Inc., USA

#### ABSTRACT

An analysis of temporal statistics of ocean ambient noise level time series data is used to determine basic characteristics such as the coherence time of noise level, the frequency distribution and spectrum of noise level fluctuations, and the expected duration of noise excursions from the mean. Conclusions are drawn from this analysis about the effective design of noise surveys and about noise exposure times to marine mammals. Simple formulas are presented to describe forward projection of noise levels in the near term future based on first- and second-order Markovian processes. In addition detailed propagation modeling of the noise from discrete shipping, coupled with appropriate source motion models, is used to support noise forward prediction.

- 888 **Shipping noise impacts on marine life**

*Cato, Douglas H*  
DSTO & University of Sydney, Australia

#### ABSTRACT

Concerns about the impact of noise of shipping on marine life, has led to the recent publication by the International Maritime Organisation of guidelines for the reduction of noise from commercial shipping. This paper puts the noise from shipping in context with other sounds in the ocean, addresses the potential impact of noise from shipping, the difficulties of assessing the impact and the likely effectiveness of mitigation measures. It draws on underwater noise studies around Australia that included areas of low shipping densities, allowing reliable characterisation of natural ambient noise at frequencies of shipping noise. This low frequency ambient noise has been difficult to determine in the high shipping areas where most ambient noise studies have been made. The paper also draws on studies of the effects of noise on marine mammals. Noise from many distant ships across an ocean basin produces a general nondescript background noise known as "traffic noise" where the contribution of any single ship is not detectable. Noise from a nearby ship reaches higher levels than traffic noise but is present for short times and close distances. Noise from a close ship can be positive if it causes an animal to move away and avoid collision.

- 765 **Directionality and coherence of underwater noise and their impact on sonar array performance**

*Zhang, Zhi Yong*  
DSTO, Australia

#### ABSTRACT

Fundamentally, sonar detection depends on extraction of the target signal from underwater noise by spatial and temporal processing of the received inputs. Spatial processing involves coherently adding, with appropriate weighting and phasing, the inputs from distributed sensor array elements to extract the more directional (more correlated) signal from the less directional (less correlated) noise. Knowledge and understanding of the directionality and coherence characteristics of underwater noise is therefore important for

the optimum design, operation, and performance assessment of sonar arrays. This paper reviews ambient noise directionality measurements in both deep and shallow waters, with particular emphasis on the medium frequencies where sea surface-generated noise dominates. We discuss the effects of the environmental propagation conditions on the level and directionality of the ambient noise. The noise directionality patterns are interpreted in terms of sound propagation characteristics influenced by sound speed profiles, surface ducts, surface and bottom reflections, internal waves, and range-dependent bathymetries. We also illustrate the effect of noise directionality on spatial processing gain by considering the response of simple sonar arrays.

**Monday 09:40-11:00 Room 206**  
**T4a Noise and health- overall effects and**  
**susceptible groups**  
**Chair: Irene van Kamp, Stephen Stansfeld**

**867 Daytime and night-time aircraft noise and cardiovascular disease near Heathrow airport in London**

*Hansell, Anna (1); Blangiardo, Marta (1); Fortunato, Lea (1); Floud, Sarah (1); De Hoogh, Kees (1); Fecho, Daniela (1); Ghosh, Rebecca E (1); Lazlo, Helga E (1); Pearson, Claire (1); Beale, Linda (1); Beevers, Sean (1); Gulliver, John (1); Best, Nicky (1); Richardson, Sylvia (1); Elliott, Paul (1)*  
 (1) Imperial College London, UK

**ABSTRACT**

Background. Few studies have investigated associations of aircraft noise with cardiovascular health. We investigated this in areas exposed to noise from London Heathrow airport. Methods. A small area study was conducted in 12,110 census output areas covering 3.6 million residents. Risks for hospital admissions and mortality in 2001-05 were assessed in relation to aircraft noise in 2001, adjusted for relevant confounders. Night (Lnight) and daytime (LAeq,16h) aircraft noise were assessed separately. Results. Higher aircraft noise was associated with higher relative risks for hospital admissions and mortality from stroke, coronary heart disease (CHD) and cardiovascular disease. Risk estimates were higher for night-time than daytime noise. Adjusted risks were highest for stroke, with RR 1.29 [95% CI 1.14 to 1.46] for Lnight and RR 1.08 [95% CI 1.02 to 1.14] for LAeq,16h for >55dB vs. <50dB. All linear dose-response relationships were statistically significant for hospital admissions but not for mortality, except for CHD and LAeq,16h. Discussion. This research attracted a high level of policy interest. However, the impact of this and other recent papers on policy decisions such as increased airport capacity in England is currently unclear. Priority areas for follow-up health research into aircraft noise need to be considered.

**352 Traffic noise in relation to self-reported mental health**

*Turunen, Anu W (1); Yli-Tuomi, Tarja (1); Tiittanen, Pekka (1); Halonen, Jaana (2); Männistö, Satu (1); Lanki, Timo (1)*  
 (1) National Institute for Health and Welfare, Finland; (2) Finnish Institute of Occupational Health, Finland

**ABSTRACT**

Noise can cause physiological and psychological stress. Our aim was to study whether outdoor traffic noise levels in Finland are associated with self-reported mental health. Data from the FINRISK 2002 and FINRISK 2007 studies regarding Helsinki, Vantaa, and Turku (n=4,167) were used. Data on the current use of sleep medication, sedatives, and antidepressants, feelings of depression, and doctor-diagnosed depression and other psychiatric illnesses within the past 12 months were obtained from a self-administered questionnaire. Noise (Lden) at the most exposed facades of the residential buildings was modelled using Nordic prediction method and ESRI ArcMap 10 software. Poisson regression models to calculate relative risks (RR) were stratified by sex and adjusted for age, marital status, education, occupation, neighbourhood income, smoking, alcohol consumption, physical activity, BMI, chronic disease, and exposure to traffic-related air pollution. Among those exposed to ≥55 dB, the RR estimates for psychotropic medication use and the prevalence of depression and other mental illnesses were statistically non-significant and varied between 0.86 and 2.02 (men) and 0.74 and 1.05 (women) when compared with the lowest exposure category (<45 dB). Outdoor traffic noise levels in urban areas in southern and south-western Finland were not associated with decreased self-reported mental health.

**508 Noise sensitivity modulates the auditory-cortex discrimination of sound feature changes**

*Heinonen-Guzejev, Marja (1); Klyuchko, Marina (1); Heikkilä, Kauko (1); Spinosa, Vittoria (1); Tervaniemi, Mari (1); Brattico, Elvira (2)*  
 (1) University of Helsinki, Finland; (2) University of Helsinki & Aalto University, Finland

**ABSTRACT**

Noise sensitivity refers to physiological and psychological internal states of any individual, which increase the degree of reactivity to noise. There are only few studies on the neural mechanisms underlying noise sensitivity. Mismatch negativity (MMN) is a component of the auditory event-related potential (ERP), generated in the supratemporal lobe of the brain, that is elicited by any discriminable change in some repetitive aspect of the ongoing auditory stimulation. In this study, we recruited 61 healthy adult subjects (age range 19-46 years) and measured their MMN to several sound feature changes inserted in a music-like sequence and administered the noise sensitivity questionnaire. With the help of this method we studied how the neural discrimination of sound changes (as indexed by MMN) is associated with noise sensitivity (as indexed by the questionnaire). The results showed that noise sensitivity had an influence on MMN to sound changes in timbre, with lower MMN responses in individuals with high noise-sensitivity scores than in those with low noise-sensitivity scores. According to the literature available this is the first study on this topic.



**712 Four electrophysiological studies into noise sensitivity**

*Shepherd, Daniel (1); Hautus, Michael J (1); Lee, Jenny (1); Mulgrave, Joe (1)*  
(1) Auckland University of Technology, New Zealand

**ABSTRACT**

Noise sensitivity is present in many clinical populations, describes approximately 20% of the general population, though little is known about its underlying mechanisms. We present findings from four electrophysiological studies designed to expose possible differences in electrophysiological measures between noise sensitive and noise resistant individuals. Noise sensitivity was estimated using self-report measures, while electrophysiological indices included both cardiac (heart rate, heart rate variability) and electroencephalographic (event-related potentials, alpha persistence) measures. All four studies were designed with reference to pre-existing theoretical frameworks. While the findings from all four studies were not definite enough to decide a likely mechanism, they do suggest that electrophysiological investigation of noise sensitivity is viable and in need of further investigation.

**Monday 11:00-12:20 Room 220**  
**E1 Railway noise and vibration**  
**Chair: James Nelson**

**119 Considering the perception of combined railway noise and vibration as a multidimensional phenomenon**

*Sharp, Calum (1); Woodcock, James (1); Waddington, David (1)*  
(1) University of Salford, UK

**ABSTRACT**

Classical models for predicting annoyance due to combined noise and vibration have typically taken the form of a summation of the magnitudes of the individual stimuli. In this paper, the perception of combined railway noise and vibration will be investigated as a complex multidimensional phenomenon. In a laboratory study, 30 subjects were exposed to 10 combined railway noise and vibration stimuli and asked to make paired comparison judgements of annoyance and judgements of pairwise dissimilarity. A multidimensional scaling analysis on the results revealed a perceptual space of 4 dimensions. Correlations between these perceptual dimensions and objective parameters of the noise and vibration signals were then tested in an attempt to find which, if any, noise and vibration parameters may be related to these perceptual dimensions. Once correlating parameters were found, a multiple regression model was developed to predict total annoyance due to combined railway noise and vibration as a function of these parameters. The final multidimensional regression model has a very strong and significant correlation coefficient (0.99, significant at the 0.001 level) and is able to accurately predict total annoyance as a function of spectral characteristics of the noise and vibration stimuli and the duration of the combined stimulus.

**653 Railway vibration reduction using impact dampers**

*Yang, Wonseok (1); Ahn, Sangkeun (1); Koh, Hyo-In (2); Park, Junhong (1)*  
(1) Hanyang University, South Korea; (2) Korea Railroad Research Institute, South Korea

**ABSTRACT**

The use of impact dampers for reducing railway vibration induced from moving wheel loads and consequent noise generation is presented. The impact dampers for efficient reduction of impact vibration induced by moving loads were designed and verified using simple dynamic models. To test the performance of the impact dampers, the vibration of a simplified beam attached with various impact dampers was measured. The performance of the impact damper on reducing the transient vibration of railway is investigated. The effects of clearance and mass ratio on vibration reduction was analyzed. The numerical solutions using finite element method were verified using the experimental results to find the vibration reduction mechanism. The result was utilized to reduce rolling noise radiation from moving trains.

**43 Exhaust noise control case study for 2800 class locomotive**

*Croft, Briony (1); Brown, Stephen (2); Miller, Aaron (2); Parker, Andrew (2)*  
(1) SLR Consulting Canada Ltd, Canada; (2) SLR Consulting Australia Pty Ltd, Australia

**ABSTRACT**

In NSW, Environment Protection Authority Licences for railway systems activities define noise limits for locomotives applying for permission to operate on the network. This paper describes a case study involving one particular locomotive class (the 2800 class) that had been refused permission to operate in NSW on the basis of low-frequency noise emissions. This paper describes investigations into the locomotive noise and muffler performance, and the steps taken to re-design the muffler to optimise its performance. The objective was to reduce low frequency noise emissions to comply with the EPA licence requirements. The project achieved a reduction in overall Lmax noise levels of up to 5 dB in the highest engine notch settings. The low frequency benefit (in the 25 Hz and 50 Hz one-third octave frequency bands) was of the order of 8 dB. The locomotive class has subsequently been granted approval to operate in NSW.

**541 Railway-noise reduction effect and aged deterioration properties of softer rail pad**

*Saito, Hidetoshi (1); Ninomiya, Masaki (1); Shimizu, Kenta (1); Takeda, Yoji (1); Sato, Daigo (2)*  
(1) West Japan Railway, Japan; (2) Railway Technical Research Institute, Japan

**ABSTRACT**

To lower the elastic rigidity of the track is known as one of the countermeasures against railway-noise. In this study, a field test in which the standard rail pads were replaced by the softer rail pads were conducted in order to evaluate the railway-noise reduction effect of the softer rail pads. In addition, the noise measurements were conducted in another field where the softer rail pads were installed at several periods up to 60

months and the material properties of some of the installed rail pads were measured. As the results, the relationship between railway-noise reduction effect and the aged deterioration properties of the softer rail pads was evaluated quantitatively.

**Monday 11:20-12:40 Room 219**  
**P1a Vibration and Shock**  
**Chair: Len Koss, Vincent Rouillard**

**46 Vibration of a curved subsea pipeline due to internal slug flow**

*Reda, Ahmed M (1); Forbes, Gareth L (2); McKee, Kristoffer K (2); Howard, Ian M (2)*  
 (1) Curtin University, Australia, Qatar Petroleum, Doha, Qatar;  
 (2) Curtin University, Australia

**ABSTRACT**

Subsea oil and gas pipelines undergo vibration due to "slug" flow within the internal fluid contents of the pipeline. This slug flow is generated by the differences in density of the internal fluid. It acts as a traversing force along the length of the pipeline and causes structural vibration of unsupported pipeline spans. The resulting vibration of the pipeline may cause high cycle fatigue due to these fluctuating forces. Previous modelling of a moving slug within pipelines has been undertaken for straight pipe span sections. As unsupported pipeline spans are often curved, understanding the impact this curvature has on the traversing fluid load is important. This paper presents a Finite Element model to investigate the effect pipeline curvature has on the slug flow induced forces, resulting in vibration and hence possible fatigue damage to the pipeline structure. Furthermore, the paper presents a technique for using commercial finite element packages for analysing the dynamic response of curved beams to time variant moving loads.

**75 Analysis on propulsion shafting coupled torsional-longitudinal vibration under different applied loads**

*Huang, Qianwen (1); Liu, Jia (1); Zhang, Cong (2); Yan, Xinping (2)*  
 (1) Wuhan University of Technology, China; (2) Wuhan University of Technology, China, Key Laboratory of Marine Power Engineering and Technology Ministry of Transportation, China

**ABSTRACT**

With the improvement of the requirements of large ships to ship economy, the coupling dynamics problem of the ship propulsion shafting is particularly prominent. Theoretical method for propulsion shafting coupled vibration needs to be solved to improve the reliability of the propulsion shafting and raise the sailing performance of the ship. This paper mainly studies on the coupled torsional-longitudinal dynamics analytical theory and numerical simulation of the propulsion shafting. Different kinds of incentives can cause different kinds of coupling responses. The changes of displacement and rotation angle caused by coupled torsional- longitudinal vibration of the propulsion shafting is studied by the finite element method. Through comprehensive analysis for the coupling response of the propulsion shafting under the condition of different applied loads individually and

simultaneously, the research reveals the dynamics mechanism of coupled torsional-longitudinal vibration and puts forward the theoretical guidance for coupled torsional-longitudinal vibration of the propulsion shafting.

**122 Investigations of eddy current vibration damping**

*Ruber, Karel (1); Kanapathipillai, Sangarapillai (1); Randall, Robert Bond (1)*  
 (1) UNSW Australia, Australia

**ABSTRACT**

Eddy currents are generated in electrically conductive materials such as copper in response to a moving magnetic field and they generate forces in the opposite direction of the relative movement of the magnetic field to the conductive material. Those forces have been used for braking applications and are proportional to the relative velocity between the conductive material and the magnetic field, similar to viscous damping forces in vibration attenuation applications. This paper investigates various geometrical configurations of magnet and copper assemblies with the purpose of quantifying and maximising the eddy current forces. The effects of air gaps, magnetic field strength, orientation and surface area are investigated with Finite Element Analysis (FEA) and validated with measurements.

**299 Footfall vibration analysis of a high precision manufacturing facility**

*Gaekwad, Jason (1); Lee, Yong Keat (1); Mackenzie, Neil (1)*  
 (1) Aurecon, Australia

**ABSTRACT**

High tech manufacturing facilities often have specific requirements regarding vibration of floor structures to ensure precision manufacturing is not compromised by vibration induced displacement of components. This paper outlines the design methodology used to mitigate footfall-induced vibration in one such proposed facility. The vibration design process involved an on-site assessment of a similar existing building within the facility to determine the response of typical spans (elevated or on grade) to footfall excitation. Finite element modelling and analyses of proposed constructions were then conducted. The results of this study allowed for floor constructions meeting the specified ASHRAE Vibration Criteria to be accurately determined and priced during the concept stage of the project.

**Monday 11:00-12:40 Room 218**  
**L1b Active control of sound**  
**Chair: Bosun Xie, Kean Chen**

**281 Individual Error Signal Design in Narrowband Active Noise Control Systems**

*Chang, Cheng-Yuan (1); Kuo, Sen M (1)*  
 (1) Chung Yuan Christian University, Taiwan

**ABSTRACT**

A narrowband active noise control (NANC) system is often applied to reduce undesired noise with multiple tones whose frequencies are close. Generally, an NANC system uses a single

error signal to update a bank of adaptive filters configured in direct/parallel or parallel form. This work proposes a delayless filterbank to participate the frequency components of the error signal into individual error signals with the same frequencies components of the input signals to update the corresponding adaptive filters. A new adaptive algorithm based on the optimized performance index for the enhanced NANC system is also developed. Theoretical analysis is performed to demonstrate the increased convergence speed. Computer simulations are conducted to verify the analysis results and demonstrate the improved performance of the proposed NANC system.

### 355 Mitigation of indoor low-frequency noise using single channel active noise control system

*Kaneuchi, Ken (1); Nishimura, Koichi (1); Matsui, Toshihito (2)*  
(1) Osaka Gas Co., Japan; (2) Hokkaido University, Japan

#### ABSTRACT

In an enclosed space such as a residential space, noise transmitted from outside is amplified at the resonant frequency of the indoor space. The resonant frequency of a residential space is generally close to the low frequency sound of 200 Hz or less. In this study, a single channel active noise control system that has only one secondary source was evaluated experimentally for mitigating low frequency resonance. A standing wave that causes resonance was canceled out by the one secondary source. The similar results were also obtained by numerical simulation utilizing the boundary element method. The simulation is used for arranging an optimal position of active noise control system. From this study, it was confirmed that the single channel active noise control system can mitigate indoor low frequency noise on loops of standing wave efficiently.

### 715 Noise reduction through active noise control using stereophonic sound for increasing quiet zone

*Min, Dongki (1); Kim, Junejong (1); Nam, Sangwon (1); Park, Junhong (1)*  
(1) Hanyang University, South Korea

#### ABSTRACT

The low frequency impact noise generated during machine operation is difficult to control by conventional active noise control. The Active Noise Control (ANC) is a destructive interference technic of noise source and control sound by generating anti-phase control sound. Its efficiency is limited to small space near the error microphones. At different locations, the noise level may increase due to control sounds. In this study, the ANC method using stereophonic sound was investigated to reduce interior low frequency noise and increase the quiet zone. The Distance Based Amplitude Panning (DBAP) algorithm based on the distance between the virtual sound source and the speaker was used to create a virtual sound source by adjusting the volume proportions of multi speakers respectively. The 3-Dimensional sound ANC system was able to change the position of virtual control source using DBAP algorithm. The quiet zone was formed using fixed multi speaker system for various locations of noise sources.

### 54 Hybrid active noise barrier with sound masking

*Wang, Xun (1); Koba, Yosuke (1); Ishikawa, Satoshi (1); Kijimoto, Shinya (1)*  
(1) Kyushu University, Japan

#### ABSTRACT

In this paper, a hybrid active noise barrier (ANB) with sound masking capability is considered. To protect the speech privacy, several sound masking techniques have been developed. However, these sound masking techniques based on the superposition of the masker and original sound will lead to increase in the loudness of the sound after masking. Against this problem, this paper proposes a soundproof system which combines an ANB with a sound masking system. The ANB applies a new type of hybrid active noise control (ANC) system, which can reduce the noise diffraction and the noise propagated to the ear positions of the people behind the ANB simultaneously, to attenuate the conversation sound. Consequently, the required volume of the masker sound will decrease because of the smaller loudness of the original conversation sound in the control area. The sound masking system applies a method which can generate masker based on the frequency properties of the original sound. Several simulations are carried out to investigate the sound attenuation and sound masking performance of this system, and the results show that comparing with the traditional sound masking system, the proposed system needs smaller masker sound to achieve the sound masking effect.

### 410 A power constrained algorithm for multi-zone sound reproduction

*Liao, Xiangning (1); Zheng, Sifa (1); Peng, Bo (1); Lian, Xiaomin (1)*  
(1) Tsinghua University, China

#### ABSTRACT

In the process of multi-zone sound reproduction, large output power may be required because of the non-robust for the reproduction system, which will cause loudspeaker failure. To overcome this problem, Least Squares matching approach mostly be adopted to limit total output power. But this method may not assure every loudspeaker power is within the limit. So a power constrained optimization algorithm is proposed to make every loudspeaker power being constrained. Considering power constraint for multi-zone sound reproduction as a convex optimization problem, the primal-dual interior point algorithm is introduced. The simulation performance of reproducing multi-zone sound field in the reverberant room is shown to reach the goal of single power constraint. Therefore, each loudspeaker signal can be realized while minimizing the error between the reproductive and desired sound field.

**Monday 11:20-12:40 Room 217**  
**V1a Metrology - calibration and realisation of standards**  
**Chair: Doug Manvell, Longbiao He**

**648 Influence of ground-shield configuration in reciprocity calibration of laboratory standard microphones**

*Olsen, Erling Sandermann (1); Carlsen, Henrik (1)*  
 (1) Brüel & Kjær, Denmark

**ABSTRACT**

The open-circuit sensitivity of condenser microphones, and in particular Laboratory Standard (LS) and Working Standard (WS) microphones, depend on the mechanical ground-shield configuration of the preamplifier. Therefore, the mechanical ground-shield configurations of preamplifiers for LS and WS microphones are defined in the IEC 61094 standard series. The sensitivity, dynamic range and acoustic impedance of the microphone loaded by a preamplifier also depend on the electrical configuration of the shield and the preamplifier's input impedance. Minimizing the load on the microphone is generally preferable. This is achieved with "driven" shield where the shield is driven with the microphone output signal. Recently, it has been shown that adaptors used for free-field reciprocity calibration of WS3 microphones with the driven shield configuration may present a too high load to the preamplifier type traditionally used. In this paper, it is showed that a simple modification of the preamplifier can eliminate this problem, even for adaptors that present a rather extreme load to the preamplifier. The ground-shield configuration and the electrical configuration of the shield is discussed, both in the case of ideal and non-ideal electrical conditions, and in the context of reciprocity calibration of microphones and the 61094 standard series.

**172 Realization of Air-borne Sound pressure unit with LDA technique by Spectrum and autocorrelation method in a travelling wave tube**

*He, Longbiao (1); Feng, Xiujuan (1); Yang, Ping (1); Niu, Feng (1); Zhong, Bo (1)*  
 (1) National Institute of Metrology, China

**ABSTRACT**

To realize the sound pressure unit directly, the method of sound pressure measurement based on acoustic particle velocity with LDA technique was described. In order to get a simple acoustic field, a travelling wave tube was designed. The sound pressure distribution obtained by microphone along the tube was measured. The result showed the acoustic field inside the tube could be considered as travelling wave. The air-borne sound pressure is equal to the product of the air density, sound speed and the particle velocity. The laser Doppler Anemometry was used to measure the particle velocity in the acoustic field. The modulated doppler signal was obtained by TSI laser doppler system and the doppler signal was processed by autocorrelation method and spectrum analysis method. With the spectral analysis of doppler signal, the particle vibration velocity was obtained with the Bessel function analysis and the velocity can also be calculated based on the time of characteristic values of the correlation function. The comparison of sound pressure measured by microphone and

the value deduced from the velocity measured by laser Doppler system shows that they have good agreement and the deviation is less than 0.5 dB.

**6 Noise dosimeter microphones: an evaluation of the measurement reliability**

*Bondarenco, David Bello*  
 Total Safety Ltda., Brazil

**ABSTRACT**

One of the most practically useful equipment on acoustics is the sound exposure meter, commonly known as noise dosimeter, widely spread on the industry to estimate potential hearing loss of the workers. Despite its importance, the noise dosimeter is much underestimated, having generally lower quality components when compared to other equipment of acoustics metrology field, i.e. sound level meters, modular measuring systems, etc. This fact is remarkable when looking at microphones, main item of any acoustics measuring chain. The microphones used in almost all the noise dosimeters are not standardized despite the common sense that to assure measurement reliability, microphones should meet international manufacturing and testing standards. The present noise-dosimeter standards are not conclusive about the right acoustic field to which microphones for this task should be constructed. For those reasons, the frequency response on free-field, diffuse-field and pressure-field of a population of noise dosimeter's microphones of a worldly well-known brand will be determined and compared to present applicable international standards to evaluate the actual reliability of the measures produced by this kind of equipment.

**1022 Experimental determination of the difference between free-field and pressure sensitivity levels of half inch laboratory standard microphones**

*Bacelar Milhomem, Thiago Antônio (1); Martins Defilippo Soares, Zemar (1); Machado Da Rosa Albuquerque, Lucas (1)*  
 (1) Inmetro, Brazil

**ABSTRACT**

According to the definitions of free-field and pressure sensitivities of a microphone, the two sensitivities will differ from each other because the effects of diffraction and reflection. According to the free-field receiving characteristics of a microphone the difference between of the pressure and the free-field sensitivity is determined not only by the scattering, but also by the relation between the acoustic impedance of the microphone and the radiation impedance. This paper will present a study of the technical specification IEC TS 61094-7 which gives a polynomial function for the difference between free-field and pressure sensitivity levels of laboratory standard microphones, it will present the results of experimental determination for half inch laboratory standards microphones and it will compare the experimental result with the result obtained according to IEC TS 61094-7.

**Monday 11:00-12:20 Room 216**  
**C1b Aeroacoustics**  
**Chair: Con Doolan**

**573 Benchmark study of numerical solvers for the prediction of interior noise transmission excited by A-pillar vortex**

*Cho, Munhwan (1); Kim, Hyoung Gun (1); Oh, Chisung (1); Ih, Kang Duck (1); Khondge, Ashok (2); Mendonça, Fred (3); Lim, Jongyun (4); Choi, Eui-Sung (5); Ganty, Bastien (6); Hallez, Raphael (7)*

(1) Hyundai Motor Group, South Korea; (2) ANSYS Inc., India; (3) CD-adapco, UK; (4) ESI Korea, South Korea; (5) Exa Korea Inc., South Korea; (6) Free Field Technology, Belgium; (7) Siemens PLM, Belgium

**ABSTRACT**

Wind noise in road vehicles is being made much quieter to satisfy customers' demands for comfortable driving environments. The interaction between outside flows and exterior surfaces at the front and sides of a vehicle forms a strong swirling fluid structure called A-pillar vortex which is one of the most crucial wind noise sources. The geometrical characteristics of the A-pillar can determine the size or strength of the vortex structure. It is tremendously time-intensive and costly to change the shape of the A-pillar if it cannot be modified in the early development stage. For early determination of its shape, a reliable numerical methodology to predict vehicle interior noise due to the A-pillar vortex should be applied. This can be very challenging because the numerical method should simulate the complicated fluid behaviors as noise sources and the structural motions acting as transmission and propagation paths with acceptable precision. In this study, various numerical solvers are validated as the predictive tool of the interior transmitted noise in a simplified vehicle model. The solvers examined in the open benchmark study use various computational fluid and vibro-acoustic methods. It is shown that most of the software has prediction ability enough to industrial purposes.

**584 Characterization of an Aeroacoustic Wind Tunnel Facility**

*Pascioni, Kyle (1); Reger, Robert (1); Edstrand, Adam (1); Cattafesta, Louis (1)*

(1) Florida State University, USA

**ABSTRACT**

The Florida State Aeroacoustic Tunnel (FSAT) is an open-circuit anechoic wind tunnel designed for low subsonic aerodynamic noise studies. Nominal flow speeds in the test section range from 5-75 m/s and are achieved using a 450-hp centrifugal blower. The test section, with dimensions 0.914×1.219×3.048 m (H×W×L), can take the form of an open-jet or closed-wall configuration. A 250 Hz anechoic chamber (2.7×4.5×4.8 m) surrounds the test section. Flow non-uniformity and turbulence intensity are measured to be <1% and <0.12%, respectively, for both test section configurations at all flow speeds. To enhance acoustic quality, an inlet silencer is placed upstream at the entrance of the tunnel, while a metal perforate liner is used over the entire length of the diffuser. Additionally, a swiveling jet collector rotates ±10 degrees for lifting bodies that deflect the freestream jet. Depending on frequency, background noise levels are found to scale with Mach number between the fifth

and eighth power, and are 80 dBA at Mach 0.17. The major noise sources are determined to be the first set of turning vanes, jet collector, and the fan/motor. Reduction techniques of these noise sources are proposed and will be considered in future work.

**338 Characteristics of turbulent noise from backward-curved centrifugal fan with rectangular casing**

*Hayashi, Hidechito (1); Aramaki, Takuma (2); Shirahama, Seiji (2); Oda, Ippei (2); Okumura, Tetsuya (1)*

(1) Nagasaki University, Japan; (2) Panasonic Ecology Systems Co, Japan

**ABSTRACT**

The backward-curved centrifugal fan with rectangular casing is used to the air conditioners and the air cleaners that is required the compact and flexible design. We have studied the fan with rectangular casing by experiments and numerical simulation. It is pointed out that the performance of the fan with the rectangular casing is better than that with scroll casing at the large flow rate. The turbulent noise consists of the three frequency ranges, low frequency range under 800Hz, middle frequency range 1200-2700Hz and high frequency range 2700-4000Hz, that have the different noise source. The low frequency range is generated from the impeller, the middle frequency range is mainly generated from the casing wall and the high frequency range is in relating to the flow above the shroud. The secondary flow near the shroud causes the large turbulence and generates the high frequency and large turbulent noise. We proposed the obstacle to reduce the noise level, and then the noise level of high frequency is reduced about 5 dB.

**707 On the reduction of the engine and aerodynamic noise of aircraft**

*Campos, L M B C*

Técnico, U.Lisboa, Portugal

**ABSTRACT**

Air traffic is growing at a steady rate of to 7% per year in most regions of the world, implying a doubling every 10-25 years. This requires major advances in aircraft noise reduction at airports, just not to increase the noise exposure due to the increased number of aircraft movements. In fact it can be expected, as a consequence of increased opposition to noise by near airport residents, that the overall noise exposure will have to be reduced by bans, curfews, fines, and other means and limitations, unless significantly quieter aircraft operations are achieved. The ultimate solution is aircraft operations inaudible outside the airport perimeter, or noise levels below road traffic and other existing local noise sources. These substantial noise reductions cannot come at the expense of a degradation of cruise efficiency, that would affect not just economics and travel time, but would increase fuel consumption and emission of pollutants on a global scale. The paper reviews the: (i) current knowledge of the aircraft noise sources; (ii) the sound propagation in the atmosphere and ground effects that determine the noise annoyance of near-airport residents; (iii) the noise mitigation measures that can be applied to current and future aircraft; (iv) the prospects of evolutionary and novel aircraft designs towards quieter aircraft in the near term and eventually to operations inaudible outside the airport perimeter.

**Monday 11:00-11:40 Room 215**  
**A1b Education - outreach to community**  
**Chair: Courtney Burroughs, Marion Burgess**

**185 Common failings of inter-disciplinary studies on noise and the potential solutions**

*McLaren, Stuart J (1); Page, Wyatt H (1)*  
 (1) Massey University, New Zealand

**ABSTRACT**

Inter-disciplinary research has been published on the adverse effects of noise in health, education and other areas. These studies often produce findings that on close examination are ambiguous; display flawed methodology and conclusions not supported by the measurements. This paper highlights common anomalies and errors in noise assessment which have passed through the peer-review process to publication in journals. Often ambiguity in the findings is the result of using incorrect notation and terminology, combined with a poor understanding of appropriate noise descriptors. It is common practice to perform the statistical analysis on the sound levels in decibels. But this leads to an underestimation of the effect because adverse health effects of noise typically display a dose response to the product of the sound pressure squared and time. Methodologies are often described without reference to best practice or existing standards that typically describe in detail robust measurement procedures. There is a need to educate researchers involved in noise studies about the need for competency in noise measurement and assessment. It also highlights to journal editorial staff about the need to include in their peer review process someone with appropriate expertise in noise.

**398 Web-based calculators for transportation noise and vibration**

*Smith, Michael (1); Chiles, Stephen (2)*  
 (1) URS, New Zealand; (2) NZ Transport Agency, New Zealand

**ABSTRACT**

The NZ Transport Agency has developed a number of on-line calculators for road-traffic noise and construction noise and vibration. These tools allow members of the public, project managers, and contractors to perform calculations that would typically be the domain of an acoustics specialist. The calculators use recognised methods (CRTN, BS 5228) applying the simplifications necessary for a 2-dimensional model. This paper discusses the benefits of empowering non-specialists to perform acoustical calculations, as well as identifying where oversimplification can lead to invalid conclusions. The New Zealand implementation will be presented as a case study, providing lessons learnt from the five years of development.

**Monday 11:40-12:40 Room 215**  
**A2a Education- to the profession**  
**Chair: Courtney Burroughs, Marion Burgess**

**930 Post baccalaureate professional development in noise control engineering**

*Holger, David K*  
 Iowa State University, USA

**ABSTRACT**

Professional development opportunities for practicing engineers are an important element of noise control engineering education. An effective and efficient approach to providing these opportunities involves leveraging development and delivery of formal professional master's programs, graduate certificates, formal coursework, and non-credit workshops and short courses. Typical audiences for these offerings include practicing engineers with substantial undergraduate background in noise control engineering, practicing engineers who lack fundamental background in noise control engineering, and other professionals who need background information on noise control engineering because of their related work in consulting, government, or management roles. Courses and other programmatic elements can be developed to utilize educational technology, simulations, and distance delivery via the internet to a variety of audiences including on-campus students, off-campus students, and students who receive materials via multiple modes. Leveraging the development of various elements enables efficient and cost effective delivery of educational programs to the often small and specialized interest audiences

**162 Expanding the horizon of machinery noise source control via a dedicated short course on gear dynamics and noise**

*Singh, Rajendra*  
 Ohio State University, USA

**ABSTRACT**

The dedicated 4-day short course on gear dynamics and noise (taught by the author and his colleague Donald Houser) is intended for designers and engineers involved in the analysis, manufacture, design specification, or utilization of gear systems. Over the past 35 years more than 1800 engineers from over 355 companies around the world have attended this short course. Industries that have found this course helpful include the automotive, transportation, wind-energy, process machinery, aircraft, appliance, and general manufacturing. The course covers the fundamentals of gearing kinematics, gear dynamics, source mechanisms governing major gear whine and rattle noise problems, structural paths with focus on bearings, noise and vibration measurements and diagnostics. A popular feature of this course is the interspersing of demonstrations with lectures; this makes the course appealing to both gear designers and noise (or measurement) specialists. Yet another novel approach is the workshop on "real life" gear noise and dynamics problems. This workshop allows the instructors and participants to interact and discuss case histories presented by attendees. A round table discussion on the last day is utilized to foster interactive problem solving, modeling and measurement discussions. Finally, issues posed by attendees have led to fundamental studies and graduate theses.

**950 Extending the scope of urban sound planning by education and research**

*Scheuren, Joachim (1); Kropp, Wolfgang (2); Forssen, Jens (2)*  
(1) Müller-BBM, Germany; (2) Chalmers University of Gothenburg, Sweden

**ABSTRACT**

Based on continuous research work as well as on growing demands of all involved it is widely agreed today that acoustic comfort in cities should aim for more than just preventing and controlling given noise. However, in practice this typically fails because of two dilemmas: Acoustical aspects are considered too late and with a limited scope only, limited to make other non-acoustic planning acoustically acceptable. This then prevents any approaches to plan and go for desired sound scenarios from being applied. The European Integrated Training Network SONORUS tries to overcome this restriction by application oriented research, exemplary application to test sites and – above all – by education. Nine partners from all over Europe, coordinated by Chalmers University of Gothenburg, work together to educate 14 young re- searchers in urban sound planning. Apart from complementing available tools for practical application and testing these tools in case studies provided by five associated European cities, the basic idea of the project is to supply the researchers with all skills enabling them to acoustically contribute with competence to a holistic urban planning process. It is hoped that the concrete availability of their respective competence will help to extend the scope of Urban Sound planning in practice.

**Monday 11:20-12:00 Room 214**  
**H1b Urban sound propagation**  
**Chair: Timothy Van Renterghem**

**546 Use of traffic modeling and geographic information systems to evaluate noise reduction policies in urban environments: case study in Bogota - Colombia**

*Paez, Daniel (1); Caviedes, Alvaro (1)*  
(1) Uniandes, Colombia

**ABSTRACT**

In order to support policy development and evaluation at Los Andes University in Colombia we developed the Bogota Geographic Noise Model (BGNM). This model, based on a transport model and a geographic information system, estimates sound pressures caused by transportation. The model determines areas of the city where legal limits for noise levels are exceeded. Using the BGNM it was found that over 90% of important facilities in Bogotá, such as schools and hospitals, do not have an acceptable noise quality according to current local regulations. In order to address this problem, reducing speed limits and restricting heavy vehicle traffic in the vicinity of key hospitals is being considered. In this paper we present results from further developments to the BGNM in order to evaluate, in 5 specific locations, the proposed traffic measures. To achieve this the further development of the model included additional capabilities to consider a 3D city (building heights and terrain elevation) as well as a traffic-modeling module. Results from this investigation suggest that the new capabilities of BGNM allow better understanding

of noise conditions and a more effective and efficient way to develop scenarios.

**141 Assessment of noise pollution sourced from entertainment places in Antalya, Turkey**

*Sari, Deniz (1); Ozkurt, Nesimi (1); Hamamci, Samet Feyyaz (1); Ece, Mustafa (2); Yalcindag, Nazli (2); Akdag, Ali (3); Akdag, Nese (4)*  
(1) Environment and Cleaner Production Institute, Turkey; (2) Antalya Metropolitan Municipality, Turkey; (3) HIDROTEK Engineering Co.Ltd., Turkey; (4) Yıldız Technical University, Turkey

**ABSTRACT**

Noise pollution with the increased entertainment facilities especially in the touristic cities, has been turned out to be one of the major problems that impact the quality of life all over the world. Antalya is the most prominent tourism center in Turkey with its historical places, beaches and crowded entertainment areas. Entertainment life in Antalya is more dynamic and versatile than an usual touristic city with beaches parties, hotel discos, wedding ceremonies and night clubs. Emphasis in this paper is placed on conducting computer simulation using the SoundPLAN 7.3 to assess the noise exposure levels sourced by above 600 entertainment facilities such as discos, bars and pubs etc. in the city center of Antalya. The levels of entertainment noise exposure in the city was calculated according to the European Noise Directive. Almost all of the entertainment places located at the sea side, therefore the most affected population from the entertainment noise live close to these regions. Our results show that nearly 29,000 households during daytime and 10,500 households at night-time were exposed to 50 dB(A) or higher entertainment noises in Antalya. In other words, 3% of the resident population is potentially threatened by high noise levels which may cause to several illness such as hypertension, sleep disturbances etc.

**Monday 11:20-12:40 Room 213**  
**Q2b Numerical methods in vibro-acoustics**  
**Chair: Franck Sgard, Matthias Klaerner**

**718 A review of the coupling parameter of the Burton and Miller boundary element method**

*Marburg, Steffen*  
UniBw, Germany

**ABSTRACT**

The phenomenon of irregular frequencies or spurious modes in boundary element techniques for acoustic problems has been well investigated and a number of methods have been presented to overcome this problem. The most popular methods seem to be the Combined Helmholtz Integral Equation Formulation (CHIEF) and the Burton and Miller formulation. This contribution deals with the latter and its only parameter, i.e. the so-called coupling parameter. It is known for more than four decades that this parameter must be complex for radiation from rigid bodies with particle velocity prescribed. During the 1980ies, a number of authors proposed the value of  $i/k$ . This value is proving to be an excellent choice for the high frequency limit. However, it turned out that the optimal choice of the coupling parameter depends on a few more parameters including the harmonic time dependence and the formulation

of the integral equation itself. This paper discusses these influences for a specific EAA benchmark case which has only recently been proposed, i.e. the radiator.

**100 A comparison of numerical methods for the large-scale modelling of acoustic coupled fluid-structure interactions of double-walled cylindrical shells**

*Peters, Herwig (1); Wilkes, Daniel Ryan (2)*

(1) UNSW Australia, Australia; (2) Curtin University, Australia

**ABSTRACT**

This paper presents a comparison of numerical methods used to model large scale acoustic coupled fluid-structure interaction (FSI) problems for single and double-walled cylindrical shells. The finite element method (FEM) is used to model the structure while the fast multipole boundary element method (FMBEM) is used to model the fluid domain and both models are coupled on the shared boundary surface to allow for the FSI, yielding a coupled FEM-FMBEM formulation. At suitably high frequencies the statistical energy analysis (SEA) method may instead be used to model both the complete fluid domain and the structure. The FEM- FMBEM and SEA models are compared for two structural configurations. The first involves a single-walled cylindrical shell while the second case involves a double-walled cylindrical shell, where two cylindrical shells of different radii encapsulate an interior body of water. The SEA model is seen to provide substantially faster solution times at high frequencies, while yielding similar results to the FEM-FMBEM model.

**103 Prediction of the radiated sound power from a fluid-loaded finite cylinder using the surface contribution method**

*Liu, Daipei (1); Peters, Herwig (1); Kessissoglou, Nicole (1); Marburg, Steffen (2)*

(1) UNSW Australia, Australia; (2) Universität der Bundeswehr München, Germany

**ABSTRACT**

Based on acoustic radiation modes, the surface contribution method has been developed to predict the surface contributions to the radiated sound power from a vibrating structure. In this work, the surface contribution method is used to identify the sound field on a vibrating structure submerged in a heavy fluid. It was recently found that surface contribution method was not able to predict the surface contributions at low frequencies when the structural wavenumber is higher than the acoustic wavenumber. In this paper, the acoustic radiation efficiencies calculated for different numbers of integration points are compared and used to compute the surface contributions to the radiated sound power. The radiated sound power obtained from both the surface contribution and the active intensity methods are compared. Numerical results for a fully coupled finite element/boundary element model of a cylindrical shell with hemispherical end closures submerged in water show that the surface contribution method can also be successfully applied at low frequencies.

**858 Implementation aspects of the Boundary Element Method including viscous and thermal losses**

*Cutanda Henriquez, Vicente (1); Juhl, Peter (1)*

(1) University of Southern Denmark, Denmark

**ABSTRACT**

The implementation of viscous and thermal losses using the Boundary Element Method (BEM) is based on the Kirchhoff's dispersion relation and has been tested in previous work using analytical test cases and comparison with measurements. Numerical methods that can simulate sound fields in fluids including losses are particularly interesting whenever small cavities and narrow passages are present, as is the case with many acoustic devices such as transducers and small audio appliances. The present paper describes current work aimed at improving the method by addressing some specific issues related with mesh definition, geometrical singularities and treatment of closed cavities. These issues are specific of the BEM with losses. Using examples, some strategies are presented that can alleviate shortcomings and improve performance.

**Monday 11:20-12:20 Room 212  
B4b Machinery N&V - Plant  
Chair: Zhuang Li, Colin Tickell**

**90 Noise Control for Fluid Power Systems**

*Li, Binghui (1); Moore, Simon (2)*

(1) SLR Consulting Australia Pty Ltd, Australia; (2) AECOM Australia Pty Ltd, Australia

**ABSTRACT**

Pressure pulsation, created by the operation of hydraulic pumps in a fluid power system, is one of the primary causes of noise issues from hydraulic machinery. The wave energy resulting from such pulsation propagates in both the wall and the fluid of the flow pipes associated with the fluid power systems, inducing fluid\_borne vibration of the pipes and the consequent noise radiated from the pipes. The pressure pulsation can be controlled using many available techniques, including the design of quiet fluid power pumps, active control (e.g. by implementing fluid wave actuators) and passive control treatments (e.g. by installing pulsation suppressor/dampener). This paper presents a case study of noise control for a series of marine hydraulic mooring winch systems installed on a marine barge, which emit excessive noise levels during operation. The installation of passive pulsation suppressors was proposed as the most practical solution to control pulsation from the fluid power units and the consequent excessive noise radiation from the flow pipes, considering a number of factors such as cost, implementation schedule and complexity, as well as intrusion to the system.

**436 Acoustic and Vibration Stability Analysis of Furnace System in Supercritical Boiler**

*Kwon, Hyuk-Min (1); Cho, Chi-Hoon (1); Kim, Heui-Won (1)*

(1) Hyundai Heavy Industries Co., South Korea

**ABSTRACT**

The furnace of supercritical boiler is tall and flexible because it consists of thousands of tubes connected with thin plates each



other. So the furnace has additional outfitting structure to resist internal combustion turbulent flow, external wind load and earthquake forces. It is difficult to evaluate the dynamic characteristics of the furnace in the design stage due to structure complexity. The evaluation procedure for dynamic characteristics of the furnace was proposed in this paper based on CFD, acoustic resonance calculation and transient forced vibration analysis considering the temperature change of furnace inside. The transient CFD analysis of the furnace combustion has been carried out to obtain the fluctuating pressure which was good agreement with acoustic mode of the furnace. The transient forced vibration analysis has been performed considering combustion fluctuation pressure, which was evaluated with allowable vibration limit. The proposed evaluation procedure has been applied to HHI's supercritical power plant project.

**713 Minimising the cost of noise control in the coal seam gas industry by selection of noise treatments for gas wells using engineering optimisation**

*Davis, David James*  
URS, Australia

**ABSTRACT**

Reducing costs is an important consideration when designing gas field facilities. The cost of noise mitigation treatments to the power units and pumps at well-heads can be a significant proportion of capital expenditure, and opportunities to reduce these costs are usually welcomed. The assessment and management of environmental noise impact from land-based gas fields is somewhat unique because of the large number of noise sources distributed over a very large area, often with many noise receptors interspersed between the wells and with most receptors receiving noise simultaneously from many wells from different directions. With such complexity, it can be difficult to select and design noise control treatment for the noise sources located at the wells in a cost-effective manner. It would be advantageous to have a calculation tool that could select appropriate noise treatments for each noise source at each well so that the environmental noise targets are achieved at each receptor while simultaneously ensuring that the cost-effectiveness of the noise mitigation program is maximised. This paper demonstrates an example of using three different optimisation techniques to minimise the cost of the overall noise control treatment scheme for the major noise sources located at coal seam gas wells.

**Monday 11:20-12:20 Room 211**  
**N3 Green sustainable buildings**  
**Chair: Jeffrey Fullerton**

**836 The challenge of meeting both acoustic and thermal comfort in 21st century school classrooms**

*Campbell, Colin (1); Svensson, Carsten (1); Nilsson, Erling (1)*  
(1) Saint-Gobain Ecophon AB, Sweden

**ABSTRACT**

The benefits of "thermal mass" in stabilizing temperature for thermal comfort and reducing building energy consumption for sustainable green buildings are well documented. However, when exposing the concrete soffit for thermal purposes it is then not possible to have a fully covered sound absorbing

suspended ceiling in classrooms for acoustic comfort. In turn, this potentially compromises the achievement of good acoustic comfort while still utilizing the thermal mass of the exposed soffit. For this paper we measured a classroom configuration with free hanging sound absorbing units and wall absorbers instead of a fully covering traditional suspended ceiling. We looked into solving the low frequency imbalance - a potential negative consequence of not having a full suspended ceiling - with an enclosed void which can trap the low frequency sound (125Hz) which can build up and interfere with the important speech frequencies. We looked at the challenge of optimizing the acoustic coverage range without affecting the thermal comfort. We also wanted to improve the balance of the potentially negative low frequencies to achieve good speech communication and acoustic comfort for all students and teachers, while also providing an inclusive acoustic environment for sensitive listeners.

**697 Noise associated with the ground water systems serving residential geothermal heat pumps**

*Fullerton, Jeffrey L*  
Acentech, USA

**ABSTRACT**

Geothermal heat pumps are an energy efficient option for many residences as an alternative to more conventional gas or oil fueled residential HVAC systems. This paper continues discussions about the noise and vibration issues from these residential geothermal systems that have been presented in prior papers by this author. In this paper, the noise contributions of two components of the ground water system will be discussed. First, the paper will discuss the influence of noise from the control system that regulates the ground water flow. A comparison of the noises from a simple pressure switch system versus a variable speed controller will be discussed. Second, the ground water system includes zone control valves to manage the water flow for the different systems. These valves can contribute to the noise generated by the system when it operates. Two types of valves will be discussed, which have dramatically different designs and different sound emissions. The paper concludes with recommendations for achieving a low noise ground water system to serve the geothermal heat pumps.

**862 Acoustical investigation of open-plan offices in green building: Simulation experiment**

*Nazli, Che Din (1); Nurul Amira, Abd Jalil (1); Nila Inangda, Keumala (1); Asrul Sani, Razak (1)*  
(1) University of Malaya, Malaysia

**ABSTRACT**

The authors have previously reported on the measurement results from the investigation and evaluation done on the acoustical performance of open-plan offices in green buildings in Malaysia. This research uses the results from field measurements for verification on the optimum modeling process for two existing open-plan office in term of calculation time and accuracy of the simulation. Two models of open-plan office layout were constructed in four different level of model detailing utilizing 3D modeling tool. Using ODEON Room Acoustic Simulation Software, the authors examined the effects of the geometrical properties to identify the appropriate model setting for further simulation process. The simulated results of

two acoustical parameters; reverberation time (RT) and speech transmission index (STI) for each model setup are then compared between each other, and further compared with field measurement results. The study concludes that the modeling process in term of number of surfaces is affecting the acoustical parameters. The discrepancy of simulated RT and STI data between model setup will be discussed.

**Monday 11:20-12:40 Room 210**  
**N8b Room acoustics**  
**Chair: Toru Otsuru, Takeshi Okuzono**

**840 Room impulse response measurement with a spherical microphone array, application to room and building acoustics**

*Barré, Sébastien (1); Döbler, Dirk (1); Meyer, Andy (1)*  
 (1) Gfai e.V., Germany

**ABSTRACT**

Room impulse response measurement using deterministic signals like sine sweeps is a well-established method to obtain objective parameters that describe the acoustic field in 3-dimensional space. Combined with conventional delay-and-sum beamforming, it becomes a very powerful tool offering precise information about the behaviour of acoustic waves inside or between rooms. More precisely, the use of a transparent array allows us to process the microphone's signals directly by spectral division, a linear deconvolution method, and to analyze the resulting room impulse responses through beamforming. This permits a precise localization of the direct sound and the early reflections over time and space. Additionally, the high signal-to-noise ratio and decorrelation properties offered by the method permit to highlight leakage and airborne sound transmission paths between rooms. Finally, the repeatability of the method allows for a comparison of measurements of various room configurations, for example in the case of acoustic treatment and optimization.

**601 Influence of time-varying talker directivity on the calculation of speech transmission index from speech in a room acoustical context**

*Opsata, Adam (1); Cabrera, Densil (1); Yadav, Manuj (1)*  
 (1) University of Sydney, Australia

**ABSTRACT**

Standard calculations of the Speech Transmission Index (STI) are most frequently determined using specialised test signals, but methods have also been developed that estimate an STI value by using real speech as the stimulus signal. However, these methods have previously been studied in highly controlled scenarios, and have rarely been tested using real human talkers in real acoustical environments. We conducted a test to study how the natural movements of real talkers within an actual room environment affects the calculation of speech-based STI, by comparing results to those produced by a stationary head and torso simulator. In addition to the challenge of analysing a non-ideally modulated test signal, using a human talker introduces time variance in the transfer function from reference microphone to receiving microphone (due to incidental body movements and time-varying directivity). This paper examines the extent of this effect using a 130 m<sup>3</sup> room with long and short reverberation times.

**425 Validation of lateral fraction results in room acoustic measurements**

*Protheroe, Daniel (1); Day, Christopher (1)*  
 (1) Marshall Day Acoustics, New Zealand

**ABSTRACT**

The early lateral energy fraction (LF) is one of the most important acoustic descriptors of concert hall sound. This paper describes a procedure for validating LF measurements of halls. The measurement of LF can be problematic due to uncertainties with calibrating, aligning and aiming two microphones of different sensitivities and directivity patterns. The validity and reproducibility of measured LF values needs to be established. A series of simulated sound fields consisting of the direct sound and a single reflection in an anechoic chamber were used to validate LF measurement systems. The reflection was varied in angle and level, and the measured LF values were compared with the known or calculated values. Two commercially available measurement systems were validated and the measured results were generally within one JND of the calculated values.

**274 Sound source localization accuracy of ambisonic microphone in anechoic conditions**

*Malecki, Pawel*  
 AGH University of Science and Technology in Krakow, Poland

**ABSTRACT**

The paper presents results of determination of sound source localization based on signals measured by first-order ambisonic microphone. The experiment consisted in recording the test signals with the 3D microphone positioned in the axis of the turntable in the anechoic chamber. The spherical coordinates of the sound intensity vector were calculated and compared to actual values resulting from the geometry of the system. Accuracy of the localization of the sound source depending on the frequencies, the time constant and the parameters of the signal recording was presented. The obtained results show the effectiveness of the sound source localization using first order ambisonic microphone in laboratory conditions.

**Monday 11:00-12:40 Room 209**  
**D2a Vehicle noise vibration and harshness (NVH)**  
**Chair: Joseph Lai, Zhichao Hou**

**399 Structural transfer path analysis of automobile tire/road noise**

*Yu, Xiongying (1); Pang, Jian (2); Min, Fujiang (1); Wen, Wei (1); Gong, Shichao (3)*  
 (1) Changan Auto Global R&D Center, China, State Key Laboratory of Vehicle NVH and Safety Technology; (2) Changan Auto Global R&D Center, China, State Key Laboratory of Vehicle NVH and Safety Technology; (3) Changan Auto Global R&D Center, State Key Laboratory of Vehicle NVH and Safety Technology

**ABSTRACT**

With refinement of powertrain, tire/road induced noise has become an important parameter within vehicle development. It

is necessary to reveal the transfer characteristics of tire/road noise for suppressing it. This paper presents an experimental analysis of the structural-borne contribution of noise and vibration for a vehicle driving on a coarse road, using a simplified transfer path analysis method (TPA). The simplified TPA method is used to identify the major noise transfer paths of tire/road noise based on subjective evaluation and objective measurement, which is fast and cost-saving compared with conventional TPA method. The vehicle tire/road noise is analyzed by the simplified TPA method, which shows the rear suspensions are the major contribution components. A TPA model for the rear suspension noise and vibration is built up and the transfer path testing is carried out. The comparison of measured and recalculated interior sound pressure level shows a good correlation. The results show Z- direction of the torsion beam axle and Z- direction of the left shock absorber are significant contribution paths to the interior noise. To improve the tire/ road noise and not to sacrifice the side effects such as handling and durability, the torsion beam axle structure is modified.

**539 Measurement of the distributed dynamic stiffness of seats under compression to analyze dynamic characteristic of seats**

*Kim, Deokman (1); Min, Kyongwon (1); Park, Hyunkyu (2); Park, Junhong (1)*  
(1) Hanyang University, South Korea; (2) Hyundai•Kia Motors, South Korea

**ABSTRACT**

Supporting stiffness of seats is an important component affecting dynamic characteristics cognized by a passenger. To analyze dynamic characteristic of a seat for vehicles operating on various road conditions, the seat vibration from road irregularity should be understood and compared. In this study, the seat is analyzed as distributed supporting system. The dynamic stiffness is measured using masses on elastic foundation. The deflection of the seat under compression is analyzed using simple numerical model and used in understanding dynamic coupling between arrayed masses. The characteristic of the seats is analyzed by measuring distributed dynamic stiffness. The influence of seat cover, elastic support and flexible polyurethane foam on the measured stiffness was analyzed. The equivalent dynamic stiffness when larger dummy model is used in measurements is compared to the distributed stiffnesses

**582 Development of an adaptive composite leaf spring**

*John, Sebastian (1); Dannemann, Martin (1); Kostka, Pawel (1); Ehlig, Jana (1); Modler, Niels (1)*  
(1) TU Dresden, Germany

**ABSTRACT**

As suspension of vehicles is generally designed for maximum load, its driving performance for light loaded cases is poor. Additionally, a hard suspension leads to dynamic peak loads on the vehicle structure and freight resulting in an increased noise level. Hence especially in trucks adjustable pneumatically driven suspension systems are commonly used. However, these systems are high maintenance and expensive compared to classic metallic leaf springs. Within the research of the collaborative research centre (SFB) 639 an innovative adaptive lightweight suspension system consisting of glass

fibre-reinforced polypropylene (GF/PP) leaf spring elements is designed. Via a component integrated hydraulic system different levels of stiffness can be applied to the spring element depending on the loaded mass and road properties in order to reduce accelerations of the load platform and vibration peaks of the freight. Especially when transporting loose freight a reduction of mass acceleration is a basic possibility to reduce noise emission. Through a detailed multi-body simulation of a demonstrator vehicle, reduced amplitudes of platform acceleration and dynamic wheel loads were determined when using the novel suspension system. Considering multiple operation conditions, the ascertained results indicate a significant reduction of noise emission.

**598 Study on the vertical vibration of an occupant - seat cushion system**

*Hou, Zhichao*  
Tsinghua University, China

**ABSTRACT**

Dynamic interaction between a human body and the seat cushion was addressed, aiming at seat design for better NVH performance of a passenger vehicle. Referring to DIN EN ISO 3386-1 and previously researches, static and dynamic tests were conducted on polyurethane foams typically used as vehicle seat cushions. A one-dimensional stress strain relation was derived based on the measured data, in which the nonlinear elastic behavior of the foam material is regarded as piecewise linear in terms of the static strain while the viscoelastic property is described using a fractional derivative. A model was then established with some simplification to reflect the interaction in the vertical direction between a foam cushion and a seated occupant, where the seated human body was depicted by a lumped parameter model. Apparent mass of the system was calculated using the model, which were validated by experiments with or without seat cushion. The influence of the foam cushion is thus demonstrated on the vertical vibration of the occupant, which will be helpful to vehicle seat design.

**669 Tire/road contact modeling for the in-vehicle noise prediction**

*Vuj, Trong Dai (1); Yin, Hai Ping (2); Duhamel, Denis (2); Gaudin, Arnaud (3); Abbadi, Zouhir (3)*  
(1) ENPC, France, PSA, France; (2) ENPC, France; (3) PSA, France

**ABSTRACT**

A numerical model for the contact between a wheel-air-tire system and a road surface is presented. The forces calculated at the center of wheel are to be used in a full numerical model of a vehicle for the in-vehicle noise prediction. The tire/road contact modeling is a difficult task because of the complex structure of the tire and the roughness of the road surface. Two numerical approaches are compared to each other in the present study: the first one solves directly the dynamic equation and the second one uses the static contact force to calculate the vibration of the tire. The numerical results of the forces at the wheel center have been compared to those of measurements conducted by PSA Peugeot Citroën. The comparison shows good agreement in the low frequency range up to 230Hz.

**Monday 11:20-12:40 Room 208**  
**D4b Pavement modelling and measurement techniques**  
**Chair: Paul Donovan, Gaetano Licitra**

- 915 **A study on comparison of noise reduction effect of single-layer drainage asphalt pavement and double-layer drainage asphalt pavement: Part 2 long-term change of sound power level and frequency characteristic**

*Ueta, Tomotaka (1); Ishikawa, Kenichi (1); Mori, Hisho (1); Noguchi, Eiji (1); Yoshida, Motoomi (1); Kokusho, Masami (1); Nagaoka, Hironori (1)*

(1) Oriental Consultants Co., Japan

**ABSTRACT**

Using data identical to where described in "Part 1 Sound Power Level and Frequency Characteristics in Initial Construction", The purpose is to study long-term change of sound power level and the frequency characteristic by comparing the single-layer drainage asphalt pavement and double-layer drainage asphalt pavement. It is found that sound power level is calculated, by  $6.9\log(y+1)$  [ $y$  is equal to years after construction] at light vehicles,  $3.0\log(y+1)$  at heavy vehicles. A comparison of initial construction and 70 months after construction for the frequency, A-weighted power spectrum increase uniformly in full range at single-layer drainage asphalt pavement, and increase slightly near the peak frequency at double-layer drainage asphalt pavement. In addition to, equivalent continuous A-weighted sound pressure level of double-layer drainage asphalt pavement is lower than that of single-layer drainage pavement by 2.0-2.5dB.

- 603 **Effect of road surfaces on road traffic noise on the public roads of Japan - An investigation based on tyre/road noise measurement**

*Koike, Hiroshi (1); Ito, Akiyoshi (1)*

(1) Japan Automobile Research Institute, Japan

**ABSTRACT**

Tyre/road noise measurements on public roads were conducted in order to investigate the effect of road surface condition on vehicle pass-by noise on public road of Japan. Since applying the CPX method to evaluate public road of Japan must be subject to domestic regulations and is considered to pose some safety risks, a quasi-CPX method was employed after its vehicle noise evaluation validity had been confirmed by road tests on a test track. The tyre/road noise measurements by the method on public roads were performed on 2 routes including 3 types of road surfaces -- dense asphalt (DAC), porous asphalt (PAC), and double layer porous asphalt concrete (DLPAC) surfaces. As a result, it was confirmed that the level of tyre/road noise of each road surface type spreads to the range of 4 to 9dB, and that the spread of DLPAC pavement seems to be wider than other surface types.

- 692 **Project ROSANNE: Rolling resistance, Skid resistance, and Noise Emission measurement standards for road surfaces**

*Haider, Manfred (1); Conter, Marco (1); Wehr, Reinhard (1); Sandberg, Ulf (2); Anfosso, Fabienne (3)*

(1) AIT, Austria; (2) VTI, Sweden; (3) IFSTTAR, France

**ABSTRACT**

ROSANNE is a collaborative project in the Seventh EU Framework Programme which aims at developing/harmonising measurement methods for skid resistance, noise emission and rolling resistance of road pavements as a preparation for standardization. To achieve this, the project will follow the recommendations of key predecessor projects as well as consider ongoing work in CEN and ISO. The project will develop and improve standards in the field of working group CEN/TC 227/WG 5. For the pavement influence on road traffic noise emission the main objective is to consider the existing measurement methods of SPB (ISO 11819-1) (1) and CPX (ISO/DIS 11819-2) (2) to provide a stable and reliable harmonised method for pavement noise emission properties. The project will validate these methods and a combination of them, incorporate correction mechanisms for temperature influence and investigate its potential use for noise immission calculation methods like the one proposed by the CNOSSOS-EU project (3). It will also explore the potential for recent developments in the measurement of surface texture to deliver parameters that better reflect the physical process of tyre/road interaction and that may improve our understanding of how the texture influences noise emission. The present paper summarizes the project status after the first nine project months.

- 825 **SPB and CPX results of rubberized surfaces in the Italian urban and extra-urban context**

*Licitra, Gaetano (1); Teti, Luca (1); Cerchiai, Mauro (2); Ascari, Elena (3); Chetoni, Marco (1)*

(1) I.P.C.F.-C.N.R., Italy; (2) S.A.F. A.V.L.-A.R.P.A.T., Italy; (3) I.D.A.S.C.-C.N.R., Italy

**ABSTRACT**

Road traffic is the main noise source in urban context and a road surface with low emission characteristics is one of the most applied solutions for noise mitigation actions. Road pavement incorporating rubber (also known as rubberized surface) is a solution often applied all over the world and it has the great environmental benefit of recycling the scrap tires. In Italy the rubberized technologies have been introduced quite recently and some experimental installations have been acoustically studied in the last years. These experimental surfaces have been laid on extra-urban road and exposed to the wear due to the real traffic, in order to verify the time durability of the noise mitigation action too. In this work, data obtained from both Close Proximity method and Statistical Pass-By measurement sessions carried out on some rubberized experimental surfaces are shown. Results show clearly that the rubberized surface can be an efficient mitigation action also in the Italian context. Anyway, in some cases here analyzed the lowering of the emission level was almost negligible and this could be blamed to binding technical skills required by the rubberized surface technology but not perfectly complied during the installation.

**Monday 11:20-13:00 Room 207**  
**R3a Underwater noise and its control**  
**Chair: Paul Croaker**

**62 LES-based Numerical Analysis of Surface-Pressure Fluctuations and Unsteady Thrust of a Marine Propeller**

*Tian, Jin (1); Yang, Haosen (1); Zhang, Zhenguo (1); Yuan, Guoqing (1); Rao, Zhiqiang (1); Hua, Hongxing (1)*  
 (1) Shanghai Jiao Tong University, China

**ABSTRACT**

Fluctuating forces induced by a rotating marine propeller are major sources exciting the hull vibration which radiates unwanted underwater noise. To attain a better understanding of the fundamental nature of these excitation sources, a numerical study of blade surface-pressure fluctuations and unsteady thrusts of a marine propeller is performed. A computational model based on large eddy simulation (LES) with moving mesh technique is developed. Considering both of the uniform and non-uniform inflow conditions, the hydrodynamics performances including (i) the spatial variation of the vortex structure; (ii) fluctuating forces acting on the propeller blades; and (iii) the unsteady propeller thrust are obtained in time and frequency domains with reasonable accuracy. The correlation of the vortex structures to pressure fluctuations is evaluated through visualizing the pressure distribution on the blades. The spectral characteristics of the blade surface-pressure and the unsteady thrust are then analyzed and compared for the two different inflow conditions. Numerical results show that clear peak frequencies of the surface-pressure spectrum are related to the harmonics of shaft frequency, and inflow uniformness significantly affects the unsteady thrust spectrum.

**225 LDV-based vibration measurement of a stiffened plate covered by a rubber coating with multi-layered periodic porous in air**

*Huang, Xiuchang (1); Zhu, Dawei (1); Tian, Jin (1); Hua, Hongxing (1)*  
 (1) Shanghai Jiao Tong University, China

**ABSTRACT**

To control underwater acoustic radiation of ships and protect against detection, coatings are attached to the vibrating wet surface of the hulls. Coatings with different pores or scatterers enclosed will attenuate vibration and suppress sound radiation with different mechanisms. However, there are very few experimental studies concerning vibration measurement of a coated structure in water, mainly due to the water environment. A compromised way to reveal the attenuation mechanism is to measure the vibration in an anechoic chamber. A stiffened plate covered by a rubber coating with multi-layered periodic porous is measured by a LDV scanning system in this study, which is aimed to minimize added mass effect of contact measurement. Comparative measurements on bare stiffened plate and stiffened plate covered with solid rubber are also carried out. Vibration transmission from the stiffened plate to the coatings as well as vibration modes on the radiating surface for the three tested objects is obtained. The vibration and sound attenuation mechanism of the proposed rubber coating is unveiled.

**284 Adulteration of underwater acoustic measurements**

*Schael, Stefan*  
 WTD 71 Germany

**ABSTRACT**

The influence of the marine environment caused by radiated sound of ships has become in the focus of research and surveillance programs. Besides the underwater acoustic surveillance measures to control the underwater noise contribution of ships shall be initiated. Identified as a prerequisite, a standard for measurement has to be issued. In a joint working group, within the ISO (International Organization for Standardization) efforts and demands are announced to establish standardization for ship measurements. This paper will describe underwater range facilities in northern Europe owned by the government and operated by the MoD. The experiences depict the difficulties of reproducibility and comparability according to procedures, environmental effects and range equipment.

**437 Numerical Study on Non-Cavitating Noise of Marine Propeller**

*Jang, Ji-Sung (1); Kim, Hyung-Taek (1); Joo, Won-Ho (1)*  
 (1) Hyundai Heavy Industries Co., South Korea

**ABSTRACT**

Blade Passing Frequency (BPF) noise of a fan or a propeller comprises of the thickness and loading noises. In general, the loading noise is regarded as the main noise source in non-cavitating condition because the thickness noise decreases rapidly with respect to distance from the noise source. In this study, underwater radiated noise for the model scaled propeller is calculated by the rotating dipole formulation coupled with acoustic finite element method which considers the loading noise with reflection surfaces in frequency domain. The CFD analysis is used to calculate blade surface pressures for obtaining the noise source. The wall effect is considered to carry out the noise analysis in the same condition as the water tunnel experiment. The noise predictions are conducted under without and with wake conditions to observe effects of inflow velocity and unsteady loading on the radiated noise, respectively. The both numerical results are in good agreements with experimental results. Based on these results, the prediction method can be used to design a low noise propeller and predict underwater radiated noise including the effect of acoustic reflection by a hull structure.

**590 Optimisation applied to composite marine propeller noise**

*Mulcahy, N Lex (1); Croaker, Paul (1); McGuckin, Damian G (2); Brandner, Paul A (3); Kessissoglou, Nicole (4)*  
 (1) UNSW, Australia & Pacific ESI, Australia; (2) Pacific ESI, Australia; (3) University of Tasmania, Australia; (4) UNSW, Australia

**ABSTRACT**

In the design of maritime vessels, the reduction of noise and vibration is of primary importance for the comfort and safety of passengers and crew, the reliable operation of sensitive instruments on research vessels and the acoustic signature of military vessels. One of the main sources of noise and vibration is the propeller. Shape-adaptive structures, which adapt their

shape to changes in their operating conditions, have a number of applications including marine propellers. Previous studies of shape-adaptive propellers have concentrated on maximising the efficiency of the propeller, either in a ship's disturbed wake flow or at off-design conditions. In the present work, a method is developed to determine whether propellers with flexible composite blades can be designed to radiate less underwater noise than equivalent rigid propellers. An optimisation procedure, which adjusts the composite material properties in order to minimise the radiated sound, is applied. The core of the procedure is the radiated sound computation, which processes the results of a transient hydroelastic analysis to compute the sound power on a porous surface that surrounds and translates with the propeller. The results of a computation for a flexible propeller are compared to those of a rigid counterpart.

**Monday 11:20-12:20 Room 206**  
**T4b Noise and health- overall effects and**  
**susceptible groups**  
**Chair: Stephen Stansfeld, Irene van Kamp**

**32 Non-specific physical symptoms and related functioning in people with self-reported noise sensitivity**

*Baliatsas, Christos (1); Van Kamp, Irene (2); Hooiveld, Mariette (3); Yzermans, Joris (3); Lebre, Erik (1)*  
 (1) University Utrecht, The Netherlands, RIVM, The Netherlands; (2) RIVM, The Netherlands; (3) NIVEL, The Netherlands

**ABSTRACT**

There is not much epidemiological evidence on the symptomatic profile, functional status and illness behavior of people with increased sensitivity to noise. An epidemiological study combining self-administered questionnaires and electronic medical records of non-specific physical symptoms (NSPS) registered by general practitioners (GP) allows such investigation. The study sample consisted of 5933 participants, drawn from 21 practices within the Dutch Primary Care Database. Among participants, 722 (12.5%) responded "absolutely agree" to the statement "I am sensitive to noise". Compared to the rest of the sample, the noise sensitive group reported significantly higher scores on number and duration of self-reported NSPS and indicators of functional impairment and illness behavior. There was also a higher prevalence of GP-registered NSPS among noise sensitive respondents. Results remained consistent after adjustment for demographic characteristics and GP-registered morbidity. Noise sensitivity was strongly associated with various other sensitivities such as those to chemical substances, odors and electromagnetic fields. Individuals with high levels of noise sensitivity share characteristics similar to those of people with other self-reported sensitivities. These findings add to the notion that different types of sensitivities might share a common (psycho) physiological basis.

**913 What factors are associated with noise sensitivity in the UK population?**

*Clark, Charlotte (1); Smuk, Mel (1); Stansfeld, Stephen (1); Van De Kerckhove, Rik (2); Notley, Hilary (2)*  
 (1) Queen Mary University of London, UK; (2) Defra, United Kingdom

**ABSTRACT**

This paper explores whether certain sub-groups of the UK population are more or less noise sensitive, using the 2012 National Noise Attitude Survey (NNAS 2012) dataset. NNAS 2012 was a community questionnaire survey of 2747 respondents in the UK, which measured attitudes to environmental noise. Data relating to a range of sociodemographic, dwelling, and geographic factors was also collected. Respondents rated how sensitive they were to noise on a seven-point scale ranging from 'not at all sensitive' to 'very sensitive'. Linear effect coding regression analyses were used to develop multivariable models of associations with noise sensitivity. A range of noise sensitivities were reported by the respondents (median = 4). Overall, noise sensitivity was more strongly associated with sociodemographic factors than with dwelling or geographic factors. Age; gender, homeownership, children, employment status, social class, and interviewer rating of hearing problems were associated with noise sensitivity after adjustment for dwelling and geographic factors. The analyses suggest that certain sub-groups of the population may be more or less noise sensitive compared with the UK population as a whole. The policy implications of these findings will be discussed.

**1009 Influence of visual factors on noise annoyance evaluation caused by road traffic noise in indoor environment**

*Ma, Hui (1); Nie, Wenjing (1)*  
 (1) Tianjin University, China

**ABSTRACT**

Through laboratory experiments the variation of noise annoyance caused by road traffic noise with LAeq.20sec of 35, 45, 55 and 65dB under different visual conditions in study and living rooms was explored. The experimental result shows that in the indoor environment the influence of brightness perception on noise annoyance caused by road traffic noise was more obvious, and the effect of color perception on noise annoyance evaluation was not significant though color and brightness had an interaction effect on noise annoyance evaluation. Therefore, both improving the lighting conditions and creating a reasonable combination of color and brightness condition was helpful for the noise control in the indoor environment.

**Monday 13:40-15:20 Room 220**  
**K2a Applying building envelop design for noise mitigation**  
**Chair: Maurice Yeung, Shiu-keung Tang**

**1 Noise Control Potential of Vacuum Isolation Panels**

*Walters, Sheldon (1); Dance, Stephen (2)*  
 (1) Australia; (2) LSBU, UK

**ABSTRACT**

In the field of noise control, a commonly evoked acoustic principle is that of sound isolation through the use of massive materials. This paper explores the potential of a vacuum to provide noise control measures. The primary aim is to quantify the relationship between the acoustic attenuation potential of a custom built Vacuum Isolation Panel and a degree of vacuum. Through doing so, this research provides an understanding of the magnitude of physical forces such designs would need to endure to offer any perceivable level of noise reduction. This in turn provides valuable data for future feasibility studies into the design and commercial viability of product development this area. The results showed that the relationship between the quantities is exponential, but only begins to be perceivable above a 90% vacuum level and thereby, 90% mechanical load.

**207 Investigations on road noise level spatial variability within a specially designed acoustic balcony**

*Naish, Daniel A (1); Tan, Andy C C (1); Demirbilek, F Nur (1)*  
 (1) Queensland University of Technology, Australia

**ABSTRACT**

An investigation into the spatial distribution of road traffic noise levels on a balcony is conducted. A balcony constructed to a special acoustic design due to its elevation above an 8 lane motorway is selected for detailed measurements. The as-constructed balcony design includes solid parapets, side walls, ceiling shields and highly absorptive material placed on the ceiling. Road traffic noise measurements are conducted spatially using a five channel acoustic analyzer, where four microphones are located at various positions within the balcony space and one microphone placed outside the parapet at a reference position. Spatial distributions in both vertical and horizontal planes are measured. A theoretical model and prediction configuration is presented that assesses the acoustic performance of the balcony under existing traffic flow conditions. The prediction model implements a combined direct path, specular reflection path and diffuse reflection path utilizing image source and radiosity techniques. Results obtained from the prediction model are presented and compared to the measurement results. The predictions are found to correlate well with measurements with some minor differences that are explained. It is determined that the prediction methodology is acceptable to assess a wider range of street and balcony configuration scenarios.

**333 Prediction method of insertion loss of detached houses against road traffic noise based on a point sound source model- Prediction formula considering the heights of buildings and a prediction point**

*Fujimoto, Kazutoshi (1); Tominaga, Toru (1); Morita, Kengo (1); Hirata, Tomoko (1)*  
 (1) Kyushu University, Japan

**ABSTRACT**

In the Environmental Quality Standards for Noise in Japan (EQS) revised in 1998, the problem of environmental noise at areas facing roads is evaluated by obtaining the numbers and the rates of buildings at which noise levels exceed the standard value. The Standards allow for the estimation of noise levels, instead of requiring actual measurements, in cases where taking the actual measurements would be difficult. In order to estimate noise levels, to grasp insertion loss of buildings in an evaluated area is needed. Based on the above background, the authors proposed F2012a which can predict insertion loss of detached houses against road traffic noise based on a point sound source model. However, F2012a confines the heights of buildings and a prediction point to 10m and 1.2m above the ground, respectively. To expand these heights, this paper propose an extension formula of F2012 which can be applied to the condition when the height of buildings is less than 10m and a prediction point is lower than buildings. The validity of the proposed formula is verified through the experiments. This extended F2012 is adapted into ASJ RTN-Model 2013, a new version of ASJ RTN-Model, and applicable to the evaluation of EQS.

**334 The sound transmission loss across ventilation window under active noise cancellation**

*Tang, Shiu Keung (1); Tong, Yean-ghing (2); Tsui, Kwong-lam (3)*  
 (1) Hong Kong Polytechnic University, Hong Kong; (2) Universiti Tun Hussein Onn, Malaysia; (3) The Hong Kong Polytechnic University, China

**ABSTRACT**

An experimental investigation on the use of active noise cancellation to improve the sound transmission loss across a ventilation window was carried out in this study. This experiment series was conducted inside a building acoustic test chamber consisted of two isolated rooms. One of these rooms was reverberant and was used as the receiver room, while the other was made semi-anechoic and it was where the sound source was located. The ventilation window was installed on a brick wall separating these two rooms. Active control with one reference signal, one error microphone and maximum three secondary sources was implemented using the EZ-ANC II MIMO controller. Six well separated microphones which spanned over the whole volume of the receiver room were used to capture the average sound pressure level inside the receiver room. The average sound pressure levels in the receiver room with and without the active control were used to describe the improvement of sound transmission loss by the active control. Among the various control combinations tested, sound transmission loss improvement was found at frequencies below 550Hz. The highest improvement was ~5dB and was found at ~200 Hz. The improvement decreased as frequency increases in general, but there was a dip at ~300 Hz. This dip was believed to be due to a longitudinal resonance in the ventilation window cavity.

**349 Numerical analysis of sound insulation performance of double-layer wall with vibration absorbers using FDTD method**

*Lin, Shuo-Yen (1); Shinichi, Sakamoto (2)*

(1) Graduate School, the University of Tokyo; (2) Institute of Industrial Science, the University of Tokyo

**ABSTRACT**

For investigating the detail effects of the vibration absorbers in the cavity of the double-layer wall (DLW), a vibro-acoustic numerical model was developed and the behavior of the system was simulated by the finite-difference time-domain method (FDTD method). By comparing the results for various cases, the mechanism of the vibration absorber in the DLW and the effects of the location side and the distribution patterns of the vibration absorbers on the sound insulation performance of the DLW had been confirmed. The deterioration of the sound insulation performance of the DLW due to the mass-air-mass resonance can be improved by the vibration control. In spite of that, setting the vibration absorbers in the cavity causes the movement of the original resonance to the other frequency band and the occurrence of the second resonance. The problems can be dissolved by the sound absorption of the damping material in the vibration absorber. In the investigation, the changes of the sound insulation performance are low correlated with the conditions of the different location side and distribution patterns of the vibration absorbers in the DLW.

**Monday 13:40-15:00 Room 219**  
**P1b Vibration and Shock**  
**Chair: Len Koss, Vincent Rouillard**

**455 Transient response of complex stiffness system using a green function from the Hilbert Transform and the steady space technic.**

*Bae, Seung-Hoon (1); Jeong, Wei Bong (1); Cho, Jin-Rae (1)*

(1) Pusan National University, South Korea

**ABSTRACT**

Transient response of complex stiffness system using a green function from the Hilbert Transform and the Steady Space Technic. The characteristics of damped structures which are designed to reduce the strength of vibrations and shock are expressed in complex stiffness. It is not easy to solve second-order differential equations which have complex stiffness because of the governing equation's singular points that cause time solution divergence. To solve this problem, free vibrations of these systems was obtained theoretically by the Hilbert Transform and the Steady Space Technic in which singular points are avoided and provides green function of the convolution integral. The result that are calculated by the numerical integration process for transient responses show accurate amplitude and phase differences. Therefore, it is suggested that this method provides an accurate way to estimate the maximum amplitude of time responses.

**623 Defect size estimation and analysis of the path of rolling elements in defective bearings with respect to the operational speed**

*Moazenahmadi, Alireza (1); Petersen, Dick (1); Howard, Carl (1); Sawalhi, Nader (1)*

(1) University of Adelaide, Australia

**ABSTRACT**

This paper investigates and explains the path of a rolling element in the defect zone and the nature of the entry and exit events of the two main features that appear in the vibration signal of a defective bearing. Vibration response and contact forces between the rolling elements and bearing raceways are simulated and compared with the measured vibration signals. Assumptions used in previous defect size estimation methods in describing the path of the rolling elements in the defect zone, are investigated and some discrepancies are identified. These analyses are essential to develop defect size estimation algorithms. Therefore, the defect size estimation results of the existing signal processing algorithms often contain significant errors and are biased for different operational speeds. A method to validate the explanations offered by this study for the true path of rolling elements in the defect zone is proposed. This method can be used for defect size estimations for defective bearings. The research shows that this method is more accurate and less biased for speed when compared with existing methods.

**702 In-Situ Assessment of Building Isolation Bearings**

*Mackenzie, Neil (1); Lee, Yong Keat (1); Dawson, Bill (1)*

(1) Aurecon, Australia

**ABSTRACT**

A sustainable future has driven the increase in public transport options within cities, many of which are rail corridors under or alongside sensitive facilities. Urban development above rail corridors has led to revitalisation of precincts such as the Riverbank Precinct in Adelaide. This has been inspired by the development of the Adelaide Convention Centre, constructed in stages over the main rail corridor into Adelaide since about 1985. The current stage sought to retain building vibration isolators, originally installed in 1985, to support the new Plenary Hall. This paper outlines a novel use of contra-rotating rotary electric vibrators, ordinarily used for materials handling applications, to measure the performance of building isolators in-situ. It also provides a method for estimating the life expectancy of bearings (usually specified as to be no less than 50 years). Finally it provides insight into design aspects of floor structures subject to combined harmonic loads (from crowd dance activities) while needing to adequately isolate structure-borne noise.

**619 Free vibration analysis of elastically connected multiple-beams with general boundary conditions using improved Fourier series method**

*Du, Jingtao (1); Xu, Deshui (1); Zhang, Yufei (1); Yang, Tiejun (1); Liu, Zhigang (1)*

(1) Harbin Engineering University, China

**ABSTRACT**

Lots of dynamic systems in science and engineering can be simplified as the elastically connected multiple-beams, such as



carbon nano tubes and pipes. However, in the majority of current study, just translational spring is considered on beam coupling interfaces. As we know that, not only the translation but also the rotational deformation will occur during beam bending problem. In this work, general beam vibration model is established, in which both two types of translational and rotational springs are taken into account for the coupling interface and both ends. An improved Fourier series is employed for the vibration displacement description for each beam, in which the additional terms are introduced to meet the continuity requirement when the constructed expression is used as the admissible functions. Modal parameters can be determined through the application of Rayleigh-Ritz procedure to the system energy formulation. The current model is then validated through the comparison with those from other analytical approach in open literature. The results show that the current model can made efficient and accurate prediction on the modal property of such complex beam system. The effect of rotational spring on the modal characteristics is also emphasized.

**Monday 13:40-15:40 Room 218**  
**L1c Active control of sound**  
**Chair: Bosun Xie, Kean Chen**

**250 Design of Active Noise Control System Applied to Helicopter Cabins**

*Yan, Shenggang (1); Tang, Dakai (2); Zhang, Xiaonei (1); Yu, Haoxin (1)*

(1) Northwestern Polytechnical University, Xi'an, China; (2) Shaanxi Fenghuo Electronics Co. Ltd., China

**ABSTRACT**

The high low-frequency tonal noise in the helicopter cabin has strongly negative influences on safety, personnel mind and body health of the pilots and passengers. In order to control such type of noises, an active noise control (ANC) system is developed for a mock-up of the helicopter cabin. The presented ANC system is divided into three parts: acoustic signal inputs, SMJ320C6415 DSP based active control algorithm implementation, and the generation of secondary sound sources. The main characteristics for the active controller are given by (1) power supply with DC 27V, 500W, (2) 14 error signal channels and 16 secondary signal channels, (3) 2 reference signal channels, and (4) total weight of 15kg (including microphones and speakers). Finally, a series of experiments within a helicopter cabin mock-up are carried out using the designed active control system. It is shown from the experimental results that the active control system can operate smoothly and steadily.

**717 Effect of transducer mismatch on the performance of spherical microphone arrays**

*Rao, Dan*

South China University of Technology, China

**ABSTRACT**

Spherical microphone arrays (SMAs) were widely used in sound field recording, beamforming, etc. for its advantage of high geometrical symmetry. Many factors could affect the performance of SMAs, including transducer errors. In this paper, effect of transducer mismatch in amplitude and phase

on the performance of SMAs was studied through simulation calculation. A SMAs with 64 nearly uniformly distributed transducers was used in the simulation. Beam patterns with and without transducer mismatch errors were calculated, and then the differences between those patterns were compared using beam pattern correlation coefficients as the metric. The simulation and analysis results show that under the condition that the spherical harmonics expansion order is not larger than  $ka$  (the product of wave number and array radius), the correlation coefficient is not less than 0.97 when the max random transducer amplitude error is less than 3dB or the maximum random transducer phase error is less than 10 degree. This result indicates that the performance of SMAs has a good tolerance to transducer mismatch errors when spherical harmonics truncation order is not larger than  $ka$ . While  $ka$  less than truncation order, great errors occur due to low-frequency boost nature of SMAs signal processing.

**351 Active noise control based on state feedback by a concentrated mass model**

*Hisano, Shotaro (1); Ishikawa, Satoshi (1); Kijimoto, Shinya (1); Koba, Yosuke (1)*

(1) Kyushu University, Japan

**ABSTRACT**

We herein propose a new model-based control method, in place of traditional adaptive control, for a low-frequency noise problem in a closed space. The proposed control method is based on state feedback control and a model of the acoustic space obtained by the concentrated mass model. Thus, we can control noise in the entire space. According to the concentrated mass model, the acoustic space is modeled as masses, connecting linear springs, connecting dampers, and base support dampers. Furthermore, a loudspeaker, as a control source, is also modeled by a mass, a spring, and a damper. In the present paper, as a first step, we constructed a coupled analysis model of a one-dimensional sound field and the loudspeaker. We designed the model-based system for the standing sound wave in the low-frequency band. Specifically, we realized a state feedback control system based on a Kalman filter and pole placement. Modal reduction using modal analysis is conducted to reduce the computation time of the controller. Then, we conducted experiments and a numerical simulation of the one-dimensional sound tube to confirm the validity of the analysis model. Moreover, we perform an experiment to control the noise in the sound tube. The noise is reduced around the resonance frequency in the entire space. Therefore, the proposed method is valid for noise control in a closed space.

**1029 Withdrawn2**

*Withdrawn2,*

**ABSTRACT**

*Withdrawn2*

**733 Active noise reduction of a coupled rectangular cavity using active wave control**

*Watanabe, Motoya (1); Iwamoto, Hiroyuki (1); Tanaka, Nobuo (2)*  
(1) Seikei University; (2) Tokyo Metropolitan University

**ABSTRACT**

The objective of this study is to generate a quiet space in a coupled rectangular cavity by suppressing a travelling wave caused by vibration of a flexible panel. Firstly, this study begins with description of an enclosed sound field from a wave point of view by introducing a one-dimensional transfer matrix method for three-dimensional space. Next, a concept of modal coupling method is utilized to model a coupled rectangular cavity. Furthermore, introducing multiple control sound sources in an arbitrary plane in the target space, the control law is derived that eliminates a travelling wave passing through the control plane. Finally, numerical simulations are carried out to demonstrate the validity of the proposed method. As a result, it was clarified that the proposed method enables to generate a quiet space by cancelling transmitted waves.

**904 Active Structural Acoustic Control of Sound Power Radiation from a Soft-Core Sandwich Panel**

*Kiran, Sahu (1); Jukka, Tuhkuri (1)*  
(1) Aalto University, Finland

**ABSTRACT**

In this paper, active control of harmonic sound transmitted through a soft-core sandwich panel is studied. As it has already been shown for the low frequency region, the noise transmission through a soft-core sandwich panel mainly occurs due to the flexural and the dilatational modes [Rimas Vaicaitis, NASA Technical Note, NASA TN D-8516, 1977]. Therefore, in this study, the volume velocity and weighted sum of spatial gradients methods are used to control these modes, and achieve sound attenuation in a broad frequency range. A point force actuator is used as the secondary force to control the radiation modes of the bottom faceplate. Radiated sound power from these two control theories are compared for different values of isotropic loss factor of core. Numerical studies indicate that irrespective of core loss factor weighted sum of spatial gradients method works well in a large frequency band without increasing the radiated sound power unlike the volume velocity method.

**Monday 13:40-15:00 Room 217**  
**V1b Metrology - calibration and realisation of standards**  
**Chair: Doug Manvell, Longbiao He**

**357 First results in the realization of the unit Watt in airborne sound**

*Voelkel, Katharina (1); Bethke, Christian (1); Brezas, Spyros (1); Wittstock, Volker (1)*  
(1) Technische Bundesanstalt Braunschweig, Germany

**ABSTRACT**

Sound power - though a main quantity in acoustics - is not a traceable quantity to this day because a standard device for the

realization of the unit watt has not been developed. Changing this is one goal of a research project funded by the European Metrology Research Programme (EMRP). Basis for the realization of the unit watt in airborne sound is an embedded oscillating solid body whose sound power output can be calculated using Rayleigh's integral with measured velocity distributions on the radiator surface. Ideally, the solid body moves as a rigid unit and acts as a monopole. However, measurements show that a uniform movement of the radiator surface is difficult to achieve. It will be investigated whether such a source can nevertheless be considered as a monopole and at which frequencies. Thus, analyses on the comparability of numerical and analytical data as well as an investigation of the dependency of uncertainties on discretization of the measured radiator surface will be presented. Calculations will be compared to sound powers determined from sound pressure measurements on an enveloping surface for further verification.

**77 Influence of reflecting plane having finite surface density on sound power level of reference sound sources calibrated in hemi free-field**

*Yamada, Keisuke (1); Takahashi, Hironobu (1); Horiuchi, Ryuzo (1)*  
(1) NMIJ/AIST, Japan

**ABSTRACT**

The NMIJ, National Metrology Institute of Japan planned to start calibration service for reference sound sources (RSSs) by 2015 and we have been developing the RSS calibration system in accordance with ISO 6926. In our system, hemi-anechoic environment necessary for the calibration is realized by laying down wooden boards on a wire meshed floor of our anechoic room. In this study, we investigated the influence of such a reflecting plane having finite surface density on sound power level of the RSS theoretically and experimentally. We especially examined sound energy transmission through wooden boards and their vibration caused by the RSS operation. We also experimentally confirmed that our hemi-anechoic environment satisfies an inverse square law of sound intensity within a tolerance in ISO 3745. Furthermore, sound power level of the RSS determined by our system agreed with that by the SP, Technical Research Institute of Sweden within a range of SP's expanded uncertainty. These results show that our hemi-anechoic environment is suitable to determine sound power level of RSSs in accordance with ISO 6926.

**449 Calibration Methodologies and the Accuracy of Acoustic Data**

*Beyers, Craig*  
Air Noise Environment P/L, Australia

**ABSTRACT**

The precision and accuracy of acoustic instrument calibrations is fundamental in ensuring the validity and defensibility of acoustic measurements. The measurement error is additive to the overall uncertainty or error associated with acoustic calculations and modelling techniques, where these rely on measurement data as a source of acoustic data. Therefore, the tolerance of the calibration is a fundamental component in determining the accuracy of all applications that rely on acoustic measurement data. National and International metrology standards define the methodologies adopted in

acoustic calibration. Currently the IEC 61672 standard is adopted for the periodic testing of field instruments. This paper provides an overview of the changes in calibration requirements of the IEC 61672 standard relative to the earlier versions of IEC 61672 and the IEC 652 standard. The paper then explores in more detail from an end user perspective the implications of calibration methodologies and the overall accuracy of acoustic data.

#### 154 The Effect of Wind on Low Frequency Noise

*Lin, I-Chun (1); Hsieh, Yein-Rui (1); Shieh, Ping-Fei (1); Chuang, Hsun-Cheng (1); Chou, Li-Chung (1)*  
(1) Taiwan EPA, Taiwan

##### ABSTRACT

The impact of wind on the measurement of low frequency noise is a topic that is worth researching into. Since the existing "Measuring Method of Environmental Low Frequency Noise" applies only to indoor measurement of low frequency noises (According to the provision of law in our country, low frequency refers to the frequency range of 20Hz ~ 200 Hz), if a petitioner demands measuring the low frequency noise at an outdoor location, there is no method and/or control standard for outdoor measurement of low frequency noise currently available in our country. This paper aims to explore the effect of the windscreen on reducing wind noise. It is hoped that the findings of the study can serve as reference for formulating method and control standard for outdoor measurement of low frequency noise. When conducting noise measurement, if the sensor of the sound meter is affected by the effect of wind force, there is an influence of wind noise on the measurement, particularly at low frequencies (20 Hz ~ 200 Hz). This study aims to explore the effect of wind noise on outdoor noise measurement at low frequencies. Through comparing and probing into the effects of wind noise when using different types of windscreens, we have obtained some noticeable noise reducing results under different wind speeds when using different types of windscreens, which might serve as reference for selecting windscreens when conducting outdoor noise measurement at low frequencies.

**Monday 13:40-15:20 Room 216**  
**C2a Airframe/flow-induced-noise**  
**Chair: Danielle Moreau, Thomas Geyer**

#### 26 Measuring owl flight noise

*Geyer, Thomas (1); Sarradj, Ennes (1); Fritzsche, Christoph (2)*  
(1) BTU Cottbus, Germany; (2) Thuringian State Institute for Environment and Geology, Germany

##### ABSTRACT

It is well known that most genera of owls are able to fly almost silently in order to hunt their prey. However, this knowledge is actually based on very few quantitative studies only. This is especially interesting regarding the fact that, against the background of increasing air traffic, the unique plumage adaptations of the owl responsible for the silent flight are the motivation behind various airframe noise reduction techniques such as serrations or porous trailing edges. Both by reviewing existing data and by means of appropriate experiments, the paper will first illustrate the special feather adaptations of owls and will expand upon their contribution to the silent flight.

Then, following a brief review of existing measurement data on the silent owl flight from past studies, the paper will focus on more recent measurements of the noise generated by gliding owls. Thereby, two different approaches were followed: First, outdoor measurements of the noise emitted by gliding owls were performed using microphone array technology and a high speed camera setup to capture the flight path of the birds. Second, indoor measurements in an aeroacoustic open jet wind tunnel revealed the noise generated by prepared wings as well as their aerodynamic performance in terms of lift and drag forces. In both cases, special attention was paid to the difference between the flight noise of the owl compared to the noise of other, non-silently flying birds.

#### 283 Effects of wing tip shaping on noise generation

*Klei, Christine E (1); Buffo, Rainer M (1); Stumpf, Eike (1)*  
(1) RWTH Aachen University, Germany

##### ABSTRACT

Geometrical shaping of wing tips leads to variations in the axial and tangential velocity components of the developing vortex. This effect is taken as basis for further analyses of a generic wing model with exchangeable tips in a wind tunnel. Flow field measurements using 3C-PIV and acoustic measurements are performed in order to indicate how changes of the wing tip shape affect noise generation caused by different flow development. High-resolution flow field measurements allow for detailed analyses of the vortex structure and distribution around the wing tip region. Furthermore, beamforming methods are used in order to localize the noise source and show the overall noise reduction potential of different wing tip shapes. The combination of PIV and acoustic measurements allows for a better understanding of underlying physical effects and correlations. Analyses of the data prove a variation of both, flow field and noise characteristics, dependent on the geometrical shape of the wing tip.

#### 290 Analysis and Control of Flow-Acoustic Feedback-Loop Interactions in Transitional Airfoils

*Golubev, Vladimir (1); Nguyen, Lap (1); Mankbadi, Reda (2); Roger, Michel (2)*  
(1) Embry-Riddle Aeronautical University, USA; (2) Ecole Centrale de Lyon, France

##### ABSTRACT

Our recent numerical and experimental efforts are reviewed examining flow-acoustic resonant interactions in transitional airfoil boundary layers and means of control of the resulting prominent, tonal trailing-edge noise sources. Experimentally recorded unsteady responses of loaded, transitional NACA0012 airfoil reveal operational regimes characterized by the presence of the shifted ladder-type tonal structures with dual velocity dependence observed in the surface pressure and the acoustic signals. High-fidelity numerical efforts employ a 6th-order Navier-Stokes solver implementing a low-pass filtering of poorly resolved high-frequency solution content to retain numerical accuracy and stability over a range of transitional flow regimes. 2D and 3D (ILES) numerical experiments investigate the behavior of the boundary-layer statistical moments during the transitional flow regimes characterized by the presence of separation regions and the resulting formation of the highly-amplified instability waves scattered into noise at the airfoil trailing edge, thus triggering and sustaining the acoustic

feedback-loop process. The current paper particularly focuses on the sensitivity of the airfoil flow-acoustic interactions (and the resulting acoustic signature) to the upstream flow conditions.

**693 Wind Tunnel Test of Trailing Edge Serrations for the Reduction of Wind Turbine Noise**

*Fischer, Andreas (1); Bertagnolio, Franck (1); Shen, Wen Zhong (1); Madsen, Jesper (2); Madsen, Helge Aagaard (1); Bak, Christian (1); Devenport, William (3); Intaratap, Nanyaporn (4)*  
(1) Technical University of Denmark, Denmark; (2) LM Wind Power A/S, Denmark; (3) Virginia Tech University, USA; (4) Virginia Tech University, USA 3 LM Wind Power A/S, Denmark

**ABSTRACT**

We tested trailing edge serrations for the reduction of the emitted sound from an aerofoil in the aero-acoustic wind tunnel of Virginia Tech University. The aerofoil was developed for the use on the outer part of the blade of a wind turbine. Two different serration geometries were tested. The geometry of the serrations is confidential to LM Wind Power A/S. The far field sound was measured with a microphone array outside the test section. Additionally the aerofoil surface pressure was measured at 62 chordwise positions. The chord based Reynolds number was 1.6 million. The serrations had very small influence on the aerodynamic performance of the aerofoil. At low angles the emitted sound was decreased by up to 8 dB, but the noise reduction became less with increasing angle of attack. At very high angles of attack the emitted sound was increased. The measured far field sound was compared to a modified TNO model using Howe's expression for sound emitted from a serrated edge. The comparison was good for the straight edge configuration, but the noise reduction by a serrated edge was significantly overestimated by the model. The expression for sinusoidal serrations gave better results than the one for saw-tooth serrations.

**684 Influence of Structural Elasticity on Trailing Edge Noise**

*Chen, Li (1); Kessissoglou, Nicole (2)*  
(1) DSTO, Melbourne, Australia; (2) UNSW Australia, Australia

**ABSTRACT**

For an airfoil, a hydrofoil or a control surface in high Reynolds number flow, the noise generated by the turbulent boundary layer is scattered by the trailing edge and then radiated efficiently. This is an important broadband noise problem, particularly at high frequencies. For aeronautical applications, estimations of trailing edge noise are mainly based on the assumption of rigid surfaces. In underwater applications, the foils may no longer be considered as rigid. The trailing edge noise is then the result of the vibro-acoustic coupling of the flow and the foils. In this paper, the influence of structural elasticity on trailing edge noise generation is investigated. The turbulent flow loading on a 2D hydrofoil is modelled using a Reynolds-Averaged-Navier-Stokes based computational fluid dynamics approach. The fluid loading is then applied to the bending wave equation of a thin plate to predict elastic edge noise. Rigid edge noise is also predicted using the flow loading combined with a Green's function. Four different materials are examined in this study.

**Monday 13:40-15:40 Room 215**  
**A2b Education - to the profession**  
**Chair: Courtney Burroughs, Marion Burgess**

**92 European Acoustics Association Schools**

*Maffei, Luigi (1); Vorländer, Michael (2); Jambrošić, Kristian (3)*  
(1) Second University of Napoli, Italy; (2) RWTH Aachen University, Germany; (3) University of Zagreb, Croatia

**ABSTRACT**

European Acoustics Association Schools are an integral part of the Young Acousticians Program of EAA. Meanwhile they consist a) of various "Hot Topic" courses for graduate level and b) of an introductory course "Approaching Acoustics" for undergraduate students. All parts are taught by internationally recognized and distinguished experts in acoustics. The first EAA (Summer) School was held in Ljubljana, Slovenia, in 2010 with short courses on "Soundscapes", "Voice and Musical Acoustics", "Building Acoustics", "Hydroacoustics", "Numerical Methods", "Psychoacoustics" and "Ultrasound". The second EAA (Winter) School was held in Merano, Italy, in 2013 with advanced courses on "Cutting Edge in Spatial Audio", "FEM and BEM", "Synergies between Environmental Noise Control and Soundscape Approach", "Understanding Musical Instruments in Practice", and "Introduction to Aeroacoustics". Furthermore, an undergraduate course "Approaching Acoustics" was attended by 100 students from 18 countries. In the paper, the background and the motivation of this initiative is illustrated. Content, organization and future plans of integration in the European higher education in acoustics are discussed.

**968 Experiences of MOOCs and 25 year short courses for industries**

*Kim, Yang-Hann*  
Korea Advanced Institute of Science and Technology, Republic of Korea

**ABSTRACT**

Recently, the impact of MOOCs (Massive Online Open Courses) is huge not only in terms of its number of registration but also its wide geographical, age, and educational background. This paper introduces the courses that are related with noise/acoustics in MOOCs: its current statistics. KAIST has been offering noise related short course for more than 25 years: one is for modal analysis and another is to introduce the fundamentals of acoustics. This paper attempts to compare the recent MOOCs courses related with noise/acoustics, and others, including the conventional offline short courses: pros and cons.

**235 Audio and Acoustical Response Analysis Environment (AARAE): a tool to support education and research in acoustics**

*Cabrera, Denisil (1); Jimenez, Daniel (1); Martens, William Leigh (1)*  
(1) University of Sydney, Australia

**ABSTRACT**

AARAE is a MATLAB-hosted environment for measurement and analysis of room acoustics and audio systems, designed to support education and research in audio and acoustics. While it

already provides a wide range of test signals, and measurement, processing, and analysis methods, one of its main features is easy extensibility. Students new to signal processing (and MATLAB) can use it from its graphical user interface (without any need to write code), whereas more advanced students can develop implementations of pre-existing or novel measurement, processing and analysis algorithms using templates that allow quick integration of functions into the graphical user interface. AARAE was introduced into acoustics teaching at the University of Sydney in 2014, and it is used in both introductory and advanced units. While most of the code for the current version of AARAE was written by the authors, coursework students have contributed to functions in areas such as speech intelligibility, distortion, reverberation parameters and background noise rating. This paper illustrates how AARAE is used in teaching, highlighting some recent student projects in AARAE. It also illustrates how AARAE has been used to support research and research training.

### 321 Study and practice of joint teaching between ZJU and UWA

*Pan, Jie (1); Stone, Brian (1); Guzzomi, Andrew (1); Sun, Hongmei (1); Zheng, Jing (2); Tong, Yuhui (3); Du, Xuhao (2); Xia, Yinzhu (2)*

(1) The University of Western Australia, Australia; (2) Zhejiang University, China; (3) The University of Western Australia, Australia, Zhejiang University, China

#### ABSTRACT

A joint international unit on dynamics, vibration, and sound was established in early 2014 for engineering students in their penultimate year at Zhejiang University (ZJU), China, and at the University of Western Australia (UWA), Australia. The unit was taught entirely in English. Dynamics and sound topics were taught live to ZJU students and vibration topics live to UWA students. Recordings were uploaded to websites so that students at each university could access the material. A set of quiz questions supplemented each recorded lecture. Tutorials and laboratory practical classes (weighted 15%) were delivered using a combination of live teaching/demonstrations and self-learning via online recordings. A group project (weighted 25%) using receptance encouraged students to self-study three chapters of an e-book on vibration. Additionally, it provided an opportunity for teamwork, internet forum discussion, computer programming, and optimization. Apart from the final exam (weighted 60%)—conducted simultaneously at each university—all assessments were completed online. This paper summarizes some key observations of the effects of various teaching methods on the students' effort and performance at the two universities. In addition, it highlights the need for integrated live lectures, online support, and a variety of practices for effective knowledge and skills transfer.

### 229 The NOISE database and other electronic and web-based tools for researchers and educators

*Beach, Elizabeth Francis (1); Gilliver, Megan (1); Williams, Warwick (1)*

(1) NAL Sydney, Australia

#### ABSTRACT

NAL and the HEARing CRC are increasingly seeking ways i) to translate our hearing loss prevention research findings and ii)

promote noise awareness and hearing health via electronic and online methods. The aim is to translate our research work into tools that are broadly accessible to both researchers and the general public regardless of location. This presentation will discuss some recently developed online initiatives with a focus on the NOISE database project. The NOISE database allows researchers to access and contribute to its collection of 895 noise level measurements obtained at a wide range of different leisure activities in Australia and across the globe. Also included will be an introduction to our 'Know Your Noise' website aimed at young adults. The site allows anyone to learn more about the consequence of their noise exposure through the Noise Risk Calculator and other elements of the site.

### 610 Car mechanic training course and acoustic technique education

*Nakamura, Kinji*

Non-profession engineer, Japan

#### ABSTRACT

This report is showing of one example of the acoustic technique education adopted at the car mechanic training course. The author thinks that the anti-noise is important as one of the work of the car mechanic. In addition, the purpose of it is to urge understanding to a sound phenomenon of the car. For instance, it will lead to technological acquisition of the noise level measurement, frequency analysis, and the evaluation test when how to the frequency component with different exhaust noise to feel it is evaluated by the auditory sensation. This evaluation is an estimate of the magnitude to noisy feeling. The examination sound is an adjacent exhaust noise of the motorcycle and various reproduction sounds from the audio speaker. It is thought that making the student think about the current state and the content of the regulation of the automobile noise based on the above-mentioned experimental result can deepen understanding to the necessity of the noise control, and assumes it to be an outline of this education of giving the chance.

**Monday 13:40-15:20 Room 214**  
**H2a Outdoor sound propagation**  
**Chair: Rob Bullen, Ho-Chul Shin**

### 16 Acoustic Study and Visualization of a complex echo at the Klondike Bluffs, in the Arches National Park, Utha, USA

*Heilmann, Gunnar (1); Navvab, Mojtaba (2); Boeck, Magdalena (1); Vonnheim, Benjamin (1)*

(1) gfaitech, Germany; (2) University of Michigan, USA

#### ABSTRACT

Physical explanations for echoes are widely known. Although measuring an echo with common methods using a single microphone is simple, it does not provide a full description of the behavior of each individual reflection that take part of an echo of this large scale environment without knowledge of the exact topology. The actual directions of each echo remain unknown. Only simulations will provide some understanding but are only as good as the model and all its assumptions. The aim of this paper is to investigate and uncover the participating reflections for an echo and create detailed visualization of the echo reflections scheme. The measured echo was first

discovered by Gunnar Heilmann in September 2009 and was now measured and will be described here for the first time. It is particularly interesting because of its multitude (more than ten reflections) and order of individual echo reflections and its 3D distribution and timing surrounding the receivers' location.

**214 Experimental validation of the modelling of surface roughness effects by an effective impedance**

*Faure, Olivier (1); Gauvreau, Benoit (1); Junker, Fabrice (2); Lafon, Philippe (2)*  
(1) Ifsttar Nantes, France; (2) EDF R&D, France

**ABSTRACT**

Natural grounds can exhibit small geometry irregularities, compared to the wavelength, which are called surface roughness. Using effective impedance is a useful way to model the effects of surface roughness on outdoor sound propagation, particularly in numerical methods as it avoids the meshing of small irregularities. In this paper, firstly an effective impedance model taking into account the surface roughness spectrum of the ground is exposed. Secondly, an experimental campaign of sound pressure measurements above 1/10 scale 2D rough surfaces is presented. The same profile characterized by a gaussian roughness spectrum is designed in two polystyrene boards coated with resin. One board is felt-covered to simulate an absorbing rough surface and the other is left uncovered to simulate a reflective rough surface. Finally, the experimental results are compared to analytical calculations with the effective impedances corresponding to the two experimental rough surfaces, respectively. Those results show good agreement, thus validating the effective impedance approach and allowing more accurate SPL predictions for future impact studies in environmental acoustics.

**340 Field experiment on sound propagation from an elevated directional source**

*Sakamoto, Shinichi (1); Tkanashi, Toshikazu (2); Yokoyama, Sakae (3); Ishii, Hirokazu (4)*  
(1) Institute of Industrial Science, The University of Tokyo, Japan; (2) INC Engineering Co., Ltd., Japan; (3) Kobayasi Institute of Physical Research, Japan; (4) Japan Aerospace Exploration Agency, Japan

**ABSTRACT**

The authors investigate outdoor sound propagation from a directional source by field experiments. Results on ground-to-ground sound propagation are reported in this conference by another paper. In addition to an experimental investigation on ground-to-ground sound propagation from a directional source, in this report, results of an experiment on air-to-ground sound propagation from an elevated directional source lifted by a tethered balloon is described. In this experiment, a horn type loudspeaker was raised at the heights of about 100 and 200 m, and sound propagation characteristics from the source to receivers on the ground were analyzed from impulse responses measured by a swept sine method. As a result of the experimental study, which was made under a meteorologically calm condition, it was confirmed that the sound propagation characteristics can be accurately estimated by considering the directivity characteristics of the sound source in low and middle frequencies, and that they are considerably affected by meteorological effects.

**1034 Withdrawn7**

*Withdrawn7,*

**ABSTRACT**

*Withdrawn7*

**383 Field experiment on ground-to-ground sound propagation from a directional source**

*Takanashi, Toshikazu (1); Sakamoto, Shinichi (2); Yokoyama, Sakae (3); Ishii, Hirokazu (4)*  
(1) INC Engineering Co., Japan; (2) University of Tokyo, Japan; (3) Kobayasi Institute of Physical Research, Japan; (4) Japan Aerospace Exploration Agency, Japan

**ABSTRACT**

When predicting sound propagation in long distance, meteorological effects resulting from wind and temperature should be taken into consideration. Regarding this problem, many studies have been carried out by field measurements, numerical analyses and physical experiments. To predict and assess traffic noise by vehicles, trains and aircrafts, the sound sources are roughly modeled as omnidirectional. In reality, however, the sources have their inherent directivities according to their shapes, and the directivity can affect noise propagation characteristics as well as the meteorological effects. In this study, a field experiment on ground-to-ground long distance sound propagation using an omnidirectional loudspeaker and two types of directional loudspeakers were conducted at a flat field which approximately satisfied hemi-free field condition. To examine the relationship between the directivity effects and the meteorological effects, sound propagation characteristics by an omnidirectional loudspeaker and those by directional loudspeakers were compared. In addition, sound propagation by the omnidirectional point source was analyzed using Crank-Nicholson Parabolic Equation analyses and the experimental results were validated. Consequently, it was confirmed that sound propagation from the directional sources showed the same trend for excess attenuation characteristics as that from the omnidirectional source by considering its directional characteristics.

**Monday 13:40-15:40 Room 213**  
**Q2c Numerical methods in vibro-acoustics**  
**Chair: Vicente Cutanda Henriquez, Daniel Wilkes**

**859 The Adaptive Order FEM approach for vibro-acoustic simulations: a report on a newly implemented technology with application examples demonstrating its superior performance to conventional FEM methods**

*Vansant, Koen (1); Hallez, Raphael (1)*  
(1) Siemens PLM, Belgium

**ABSTRACT**

This paper will discuss a newly implemented Adaptive Order Finite Element Method (FEM AO) and intends to illustrate its superior performance to conventional FEM methods. The power of the new FEM AO technology lies in the adaptive model size, which is accomplished by element order increase (p

refinement) and varies with frequency. This allows to work with an as lean as possible model at each frequency while at the same time guaranteeing the requested accuracy. Three different application examples are provided in which the computational performance of the new FEM AO approach is compared with that of a conventional FEM method. Occasionally the comparison may also include results from advanced Boundary Element Method (BEM) approaches, like the Fast Multipole BEM. In the context of automotive applications, a first case reports on the simulation of acoustic transfer functions for a full vehicle model up to 4 kHz to be used in a transfer path analysis model for prediction of pass-by noise. A second application example concerns the noise radiating from a fan of an aero-engine, including the effects of flow. A third example will illustrate the performance of a computation of the transmission loss for an industrial muffler. The examples show that FEM AO delivers equally accurate results 2 to 20 times faster compared to a conventional FEM and with a more efficient use of in-core memory.

**115 A reduced-order stochastic finite element analysis for structures with uncertainties**

*Yang, Ji (1); Faverjon, Béatrice (2); Peters, Herwig (1); Kessissoglou, Nicole (1)*  
(1) UNSW Australia, Australia; (2) INSA-Lyon, France; UNSW Australia, Australia, UNSW Australia, Australia

**ABSTRACT**

his work examines the effects of uncertain material and geometry properties on the dynamic characteristics of a simply supported plate. The forced responses of the plate are predicted using the polynomial chaos expansion method. The stochastic system equations are transformed to a set of deterministic equations using Galerkin projection. In order to improve the computational efficiency when attempting to examine the structure with many degrees of freedom, the Arnoldi-based Krylov subspace technique is implemented to reduce the number of degrees of freedom in the finite element model, before the polynomial chaos expansion is applied. The combined stochastic finite element analysis and model order reduction technique is shown to provide accurate results with significantly reduced computational effort.

**662 A study of the assumptions used in statistical energy analysis**

*Lafont, Thibault (1); Totaro, Nicolas (2); Le Bot, Alain (3)*  
(1) LTDS, France, LVA, France; (2) LVA, France; (3) LTDS, France

**ABSTRACT**

This paper is a discussion on the coupling strength, the frequency bandwidth and indirect coupling loss factor in statistical energy analysis. The example of coupled oscillators is taken. First, it is shown that the coupling power proportionality is always valid for two coupled oscillators for any strength of coupling as long as the resonant modes are within the frequency band. Then, the case of three coupled oscillators indicated that the apparition of indirect coupling loss factors depends on the coupling strength. Finally, it is shown that modes outside the frequency bandwidth of excitation can lead to invalid the reciprocity relation. Some test cases are presented to illustrate these conclusions.

**658 Modelling the forced response of a stiffened structure**

*Forrest, James*  
DSTO, Australia

**ABSTRACT**

Different analytical approaches can be used to model the forced response of the beam-stiffened plates or shells that are commonly found in many practical structures from ships to aircraft. A popular method is to smear the mass and stiffness properties of the beam stiffeners to give an orthotropic plate or shell. This is simpler than modelling discrete stiffeners. This paper considers the example problem of a cylindrical shell with ring stiffeners. Previous work using periodic structure theory has shown that the calculated wave propagation behaviour in this cylinder using a smeared shell model is different from that with the stiffeners modelled discretely. The current work calculates the forced response of the cylinder using both models and compares the results to determine the range of applicability of the smeared shell approach.

**329 The Numerical Prediction and Features Analysis of Cylindrical Shell Acoustic Radiation Noise**

*Cao, Hongli (1); Fang, Shiliang (1); An, Liang (1)*  
(1) Southeast University, China

**ABSTRACT**

Target feature is important information in underwater target classification. A characteristic analysis in underwater cylindrical shell acoustic radiation noise was studied in this paper based on the finite element/boundary element method (FE/BEM) method. Firstly, the numerical prediction of cylindrical shell acoustic radiation noise based FE/BEM method was verified by the numerical and analytical solutions. The characteristic of acoustic radiation was studied with different cylindrical shell size, material, excitation points, shape, observing position. Simulation results show that the features in acoustic radiation noise were relevant to the medium, radius and shape. The features analysis had some guidance significance with the target identification.

**243 Coupled analysis of two-dimensional acoustic and membrane vibration by concentrated mass model**

*Ishikawa, Satoshi (1); Kijimoto, Shinya (1); Owaki, Ryoma (2); Matsuo, Ataru (1)*  
(1) Kyushu University, Japan; (2) Mitsubishi Electric Corporation, Japan

**ABSTRACT**

In the finite element method of a structural-acoustic coupled analysis, the mass matrix and the stiffness matrix are not symmetrical. Therefore, the modal analysis cannot be applied directly to the coupled problem. In our previous study, a concentrated mass model was proposed to analyze a two-dimensional acoustic analysis. The model consists of the masses, the connecting springs. It is very easy to couple the structure and acoustic field by the concentrate mass model. Furthermore, the mass matrix and the stiffness matrix are symmetrical. In this paper, we propose a concentrated mass model to perform a coupled analysis of a two-dimensional acoustic and a membrane vibration. And we propose a coupling method to arrange of the masses of the air near the membrane. To confirm the validity of the proposed model, the

natural frequency obtained by the concentrated mass model is compared with the natural frequency by the modal coupling method. These results are in good agreement. Therefore, it is concluded that the proposed model is valid for the coupled analysis of an acoustic and a vibration analysis.

**Monday 13:40-15:20 Room 212**

**B2 Machinery N&V - Engines**

**Chair: Zhuang Li**

**71 Experimental Analyses of Vibration and Noise of Faulted Planetary Gearbox**

*Li, Zhuang*

McNeese State University, USA

**ABSTRACT**

Epicyclic gear trains are widely used in various industrial sectors due to their advantages over fixed-axis gears, such as high torque capability, compact size, differential and planetary designs, ease of adjusting gear ratios and even directions of rotation. This research focuses on planetary gearbox whose degree of freedom is one. The geometry and dynamics of the planetary gear train are quite complicated compared with the fixed-axis gear train. In an earlier research, three theoretical models for faulted sun, planet, and ring gears were analyzed and the signature frequencies of the three cases were derived. In this paper, experiments were conducted on a Drivetrain Diagnostics Simulator with various faults of the sun gear in order to verify the previously proposed theoretical models. Both the vibration and noise signals were collected and analyzed using signal processing techniques in the time and frequency domains. The sidebands around gear mesh frequency due to the fault signature frequencies are also discussed accordingly. The signals of healthy and faulted gear trains were also compared carefully. The existence of the signature frequency can be used to detect mechanical defects and prevent catastrophic consequences.

**431 Parametrically Excited Vibration in Rolling Element Bearings**

*Srinath, R (1); Sarkar, A (1); Sekhar, A Seshadri (1)*

(1) IIT Madras, Chennai, India

**ABSTRACT**

A defect-free rolling element bearing has a varying stiffness. The variation of stiffness depends on number of rolling elements, their configuration and cage frequency. The time-varying characteristics of the stiffness results in a parametric excitation. This may lead to instability which is manifested as high vibration levels. An FEM simulation is performed to evaluate stiffness in each configuration of rolling elements and is used to study the variation of direct stiffness and cross coupled stiffness. The obtained stiffness variation is expanded into a Fourier series to form the equation of motion for the bearing vibration. As the stiffness varies with cage frequency, stiffness term in the equation of motion is periodic with parametric excitation. Hence, the equation of motion is a 2-DOF coupled Mathieu equation. Based on Mathieu parameters and cage frequency there exists unstable rpm ranges for a particular bearing. Floquet theory is employed to find out the stable and unstable regions. This involves finding out maximum Floquet exponent using Monodromy matrix. The

results obtained through Floquet theory are in agreement with the numerical solution of the governing equations.

**1031 Withdrawn4**

*Withdrawn4,*

**ABSTRACT**

Withdrawn4

**313 Vibration reduction of brush cutter considering human response characteristic**

*Uemura, Masanori (1); Yoshida, Junji (1); Miyakawa, Shigeru (2); Oono, Teruhito (2); Ishikawa, Daiga (2)*

(1) Osaka Institute of Technology, Japan; (2) Taiseimonac Co., Japan

**ABSTRACT**

Balancing brush cutter was developed to be used safely and easy handling. In this study, we tried to improve the vibration through subjective evaluation tests and the vibration analyses. In the first subjective test, participants evaluated handle vibration feelings of some brush cutters and the frequency characteristic to the vibration feeling was clarified. Subsequently, the handle vibration from 100 to 200 Hz was found to be large and the handle pipe structure had high influence on the large vibration through measurements and analyses of the handle vibration at the operational condition. We then applied several countermeasures including modification of the handle pipe length to reduce the vibration. As a result, the handle vibration of the brush cutter was reduced much and the vibration feeling was improved.

**1027 Coupling analysis of torsional vibration and engine rotational speed control system of marine propulsion shating**

*Yu, Shuwen (1); Liu, Yan (1); Han, Xiao (1); Chen, Meilong (1); Li, Wanyou (1)*

(1) Harbin Engineering University, China

**ABSTRACT**

For general simulation of engine rotational speed control system, the shafting is always assumed to be rigid. The torsional vibration characteristics of the shafting are neglected. The possible relationship between the rotational speed oscillation phenomenon and coupling of the torsional vibration and the engine rotational speed control system will not then be revealed in such simulation. In this paper, by assuming the shafting to be elastic instead of rigid, a coupling simulation model is established. The influenced of different PID control parameters and variation of the propeller damping to the speed-control performance are analysed to illustrate the coupling characteristics of the shafting torsional vibration.



**Monday 13:40-15:20 Room 211**  
**N4a Classroom acoustics**  
**Chair: James Whitlock**

**89 New generation learning environments: creating good acoustic environments - policy to implementation**

*Robinson, Amanda (1); Rose-Munro, Leanne (2)*  
 (1) Marshall Day Acoustics, Australia; (2) Learning Spaces Consultancy

**ABSTRACT**

The introduction of new technologies in schools has resulted in a paradigm shift in the way educational spaces are created and used. Today's learning environments are flexible speaking and listening spaces where collaboration, group work, complex problem solving, digital information gathering and publishing occur. Changes in technology and legislation have highlighted the need for equitable access to learning environments. Good acoustic design is essential. This cross-disciplinary paper co-written by an acoustical engineer and an educator discusses the importance of good acoustic design within new generation learning environments to promote inclusive teaching and learning. This paper argues that design of open plan learning environments in schools and government policy implementation must address issues of acoustic design and noise control in an effort to comply with the Australian Disability Discrimination Act 1992, the Building Code of Australia, the Disability Standards for Education 2005 and Australian Education Bill 2012. Recommendations are provided on policy changes, which will help reinforce this position across all educational spaces, from early learning centres to adult education.

**821 An investigation into the acoustics of an open plan compared to enclosed Kindergarten classroom**

*Mealings, Kiri Trengove (1); Buchholz, Jorg M (2); Demuth, Katherine (1); Dillon, Harvey (3)*  
 (1) Macquarie University, Australia; (2) Macquarie University, Australia; (3) National Acoustics Laboratories, Australia

**ABSTRACT**

Open plan classrooms, where several class bases share the same space, have recently re-emerged in Sydney primary schools. This case study examines the acoustics of a mid-range open plan Kindergarten classroom containing 91 students, compared to an enclosed classroom of 25 students. Ambient noise levels, intrusive noise levels, occupied background noise levels, and teacher's speech levels were recorded in both classrooms during different activities. Room impulse responses using logarithmic sweeps were also recorded in each classroom for different teaching scenarios. From these recordings, signal-to-noise ratios, speech transmission index scores, and reverberation times were calculated. The results revealed much higher intrusive noise levels in the open plan classroom, resulting in signal-to-noise ratios and speech transmission index scores to be well below those recommended in classrooms with students of this age. Reverberation time in the open plan classroom was also outside the recommended level. Additionally, occupied background noise levels in both classroom types were well above recommended levels. These results show the importance of further research into the noise

levels of open plan classrooms to determine if they are suitable learning spaces for young students. The impacts of noise on speech perception, learning, and teacher's vocal health are discussed.

**837 The same reverberation time in two identical rooms does not necessarily mean the same levels of speech clarity and sound levels when we look at impact of different ceiling and wall absorbers.**

*Campbell, Colin (1); Svensson, Carsten (1); Nilsson, Erling (1)*  
 (1) Saint-Gobain Ecophon AB, Sweden

**ABSTRACT**

It is common to only use Reverberation Time (RT) for setting the acoustic conditions in a classroom for teaching and learning activities. To calculate the RT in rooms with ceiling absorption is common but this data can also be misleading. Indeed, we measured the same RT values in two identical rooms with different acoustic treatment, even though the calculations predicted significant differences and interestingly the rooms are also be perceive quite differently in reality. Assuming that the user perceptions are valid, the measured RT data alone leaves us in the dark when seeking to explain the difference in human user perception. Measuring additional room acoustic parameters such as speech clarity and the difference in sound levels, identifies other differences between the two rooms with the same RT and points to why only one of the two rooms seems fit for purpose as a group activity room. We will discuss how to achieve acoustic comfort in classrooms; low RT, low sound levels and high speech clarity. In addition to commonly accepted low RT values we will discuss recommended objective values for good Speech Clarity to support good speech communication activities in typical teaching and learning rooms in real life situations.

**934 Acoustical Quality Assessment of Lecture halls at Lund University, Sweden**

*Said Youssef, Rabab (1); Bard, Delphine (2); A Mahmoud, Abd El Fattah (1); Mkrm Esa, Nahed (3)*  
 (1) National Institute for Standards, Egypt; (2) Lund University, Sweden; (3) Al-Azhar University, Egypt

**ABSTRACT**

Noise control in buildings should aim at reducing disturbances caused by speech noise (i.e., improve speech privacy, speech intelligibility). Room acoustics can be controlled with high room absorption, high screens and bookcases, and sufficient masking sound. This research concerns an important aspect of room acoustic metrology, the ability to quantify the most relevant room acoustic parameters for academic purposes. In this proposed study we will focus on the lecturing rooms of Lund University, of which some have designed quite recently while others were constructed many years ago. As the use of audio-visual equipment as well as the use of enabling techniques for disabled students is continually increasing. Lecture halls, which have not been explicitly designed for the use of such equipment, are being fitted with an assortment of audio-visual fixtures. This can lead to far less environment profoundly impacts the outcome of the learning process it is performance to assess the current state of the situation with respect to the acoustic performance of lecture halls at Lund University.

**192 A pilot study on the influence of language on the results of speech intelligibility tests in classrooms**

*Radosz, Jan (1); Zawieska, Wiktor M (1)*

(1) Central Institute for Labour Protection - National Research Institute, Poland

**ABSTRACT**

Numerous studies have shown that teachers often speak louder in classrooms because of the acoustic properties of the spaces. To improve the acoustics in classrooms, it is necessary to develop relevant acoustic criteria. Existing evaluation scales for parameters of room acoustics have been developed on the basis of studies of adults for a variety of languages (e.g., Dutch and English). One of the issues still not fully recognized is the effect of the respondents' language and age on the results of speech intelligibility tests. This paper presents a pilot study of the speech intelligibility of Polish-speaking children (10-13 years old) in conjunction with parameters of room acoustics. It also compares studies of speech intelligibility for other languages. Our study confirmed a relationship between the results of speech intelligibility tests and speech transmission index STI for classrooms with varied acoustics. It also showed that the results of Polish tests are similar to Anderson's and Jacob's results for English.

**Monday 13:40-15:40 Room 210**  
**N7a Acoustic criteria in regulations and**  
**classification schemes for buildings**  
**Chair: Birgit Rasmussen, John LoVerde**

**971 International proposal for an acoustic classification scheme for dwellings – Background and perspectives**

*Rasmussen, Birgit*

Aalborg University Copenhagen, Denmark

**ABSTRACT**

Acoustic classification schemes specify different quality levels for acoustic conditions. Regulations and classification schemes for dwellings typically include criteria for airborne and impact sound insulation, façade sound insulation and service equipment noise. However, although important for quality of life, information about acoustic conditions is rarely available, neither for new or existing housing. Regulatory acoustic requirements will, if enforced, ensure a corresponding quality for new dwellings, but satisfactory conditions for occupants are not guaranteed. Consequently, several European countries have introduced classification schemes. The schemes typically include four classes. Comparative studies have shown significant discrepancies between countries due to national development of schemes. The diversity is an obstacle for exchange of construction experience for different classes, implying also trade barriers. Thus, a harmonized classification scheme would be useful, and the European COST Action TU0901 "Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions", running 2009-2013 with members from 32 countries, including three overseas countries, had as one of the main objectives preparation of a proposal for a harmonized acoustic classification scheme. The proposal developed has been approved as an ISO/TC43/SC2 work item, and a working group

established. This paper describes the proposal, the background and the perspectives.

**878 A new approach to building acoustics regulation in Canada**

*Zeitler, Berndt (1); Schoenwald, Stefan (2); Quirt, David (3)*

(1) National Research Council, Canada; (2) Empa Swiss Federal Laboratories for Materials Science and Technology, Switzerland; (3) JDQ Acoustics, Canada

**ABSTRACT**

A new approach to the control of sound transmission is among the proposed changes in the 2015 edition of the National Building Code of Canada. The design objective is changing from a minimum STC for the wall or floor/ceiling assembly separating adjacent units to a requirement for the Apparent Sound Transmission Class (ASTC) including flanking. The approach to design is based on combining the ASTM data from conventional laboratory measurement of direct transmission through wall or floor/ceiling assemblies with measurements of flanking transmission conforming to ISO 10848 and predictions using ISO 15712-1. To support the design and regulatory approval process, the National Research Council is preparing a series of reports detailing the design procedure for a broad range of heavy monolithic and lightweight framed constructions, and providing the supporting generic data in form of web-based tools and tables from two decades of research studies in flanking test laboratories.

**731 Heavy/soft impact sound criteria and regulation in Korea**

*Jeong, Jeong Ho*

Republic of Korea

**ABSTRACT**

Most of housings in Korea constructed with reinforced concrete structured high rise apartment. Floor and walls were shared with neighbors and floor impact sound generated on upper floor transmitted into lower unit. Heavy/soft impact sound is become one of social problem. In 2006, heavy/soft impact sound certification system with 4 graded rating systems mandated. 50 dB in Li,Fmax,AW; regulated in KS F 2683-2, is minimum requirement. To establish the rating system, auditory experiments on heavy/soft impact sound and field measurements were conducted. In this paper, auditory experiment results and Korean floor impact sound isolation performance certification system will be introduced.

**978 Classification scheme of floor impact sounds with the standard rubber ball in dwellings**

*Sato, Hiroshi (1); Yoshimura, Junichi (2)*

(1) National Institute of Advanced Industrial Science and Technology, Japan; (2) Kobayasi institute of Physical Research, Japan

**ABSTRACT**

This study presents results of subjective judgments to simulated floor impact sound to create classification scheme of heavy weight impact sound with standardized rubber ball. The floor impact sound samples were recorded in a wood-frame test house with different floor configurations and were reproduced in an anechoic chamber. Using the relationship

between subjective rating and physical indices, an example of classification scheme for rubber ball impact sound measurement will be presented.

**886 Defining vehicular noise levels to manage risk associated with exterior facade design**

*LoVerde, John J (1); Dong, Wayland (1); Rawlings, Samantha (1)*  
(1) Veneklasen Associates, USA

**ABSTRACT**

Evaluation and mitigation of noise from vehicular sources is common as a building design criterion. In the United States of America (USA), it has been part of U.S. Department of Housing and Urban Development (HUD) multifamily building design requirements since the 1970s. It is included in numerous state and local planning requirements, and also has recently been added to various Green Building Design Standards, including school and healthcare facility design guidelines. In California, the building codes include mitigation of traffic noise sources for all multifamily and most commercial projects. These criteria specify an allowable noise level, but do not provide a method for defining this level given the statistical variations. For sources with large variations, the method of defining the level can greatly affect the building façade design and the occupant experience. Further, it may be necessary to determine this level from relatively brief measurements. This paper examines the factors that should be considered when defining the exterior noise from vehicular sources. Methods for predicting the noise level using data are evaluated, and minimum survey requirements to determine specific exterior noise parameters are suggested.

**938 How to modify a tested fire-rated wall to improve its sound transmission rating, while maintaining its official fire-rated qualification**

*Forester, Harold*  
Forester Controls, Canada

**ABSTRACT**

Local regulatory agencies generally require wall designs that meet specific fire ratings. acoustical consultants also have to select designs that have appropriate sound transmission properties. While most standard designs have been independently tested for both their fire and sound transmission ratings, many specialized wall designs have been tested only for sound transmission or fire resistance, but not for both. Shaft walls and walls that provide exceptionally high sound transmission loss often fit into these categories. To overcome this limitation, select a wall design that is close to the desired configuration that has been tested to the required fire rating. Then proceed to modify that design to improve its sound transmission rating, while respecting the Underwriters Laboratories design guidelines for fire ratings. For example, the UL guidelines permit the spacing between wall elements and the number of layers and thickness of gypsum board to be increased without affecting the tested fire rating. These modifications will significantly increase the sound transmission ratings. The paper presents specific examples.

**Monday 13:40-15:40 Room 209**  
**D2b Vehicle noise vibration and harshness (NVH)**  
**Chair: Joseph Lai, Paul Kennings**

**247 The Influence of Vibrations on Vehicle Occupant Fatigue**

*Azizan, Mohd Amzar (1); Fard, Mohammad (1)*  
(1) RMIT University, Australia

**ABSTRACT**

The attempts to summarize the knowledge about the human body's response to vibration, merely by introducing a physical or empirical model do not reflect a modern understanding of the effects of vibration on body comfort or fatigue. Several studies have demonstrated that fatigue leads to impairment of the ability to perform tasks. Although the performance of vehicle drivers under fatigue conditions has been investigated in many types of environments, there is insufficient research about the effects of vibration on levels of mental alertness in seated drivers. The formulation of drowsiness caused by vibration in the vehicle is complex due to several confounding factors such as vehicle interior noise and traffic control. However, understanding the effects of only vibration on drowsiness can provide significant knowledge to predict and prevent the vehicle occupant (driver) drowsiness. Hence, we investigated the relationship between whole body vibration and human drowsiness. A human vibration test setup was designed for this study. Three conditions were selected for these studies which are no-vibration condition, low frequency sinusoidal vibration and low frequency random vibration. For vibration condition, volunteers were exposed to multi-axial vibration at a frequency between 1- 15 Hz with the transmitted vibration at 0.3 m/s<sup>2</sup> rms for 20 minutes. Changes in drowsiness level during vibration exposure were measured by recording brainwave activities along the scalp. Two brainwave spectrums (Beta wave and Theta wave) were considered for analysis. Exposure to vibration was found to be correlated with a reduction in alertness. Combined decrease in beta wave and increase in theta wave activity caused by vibrations were found to be statistically significant in sinusoidal and random vibration ( $p < 0.05$ ). However, the effect of sinusoidal vibration is more pronounced compared to random vibration.

**201 Automobile Power-train—Coupling Vibration Analysis on Vehicle System**

*Ding, Heng (1); Zhang, Weihua (1); Chen, Wuwei (1); Shi, Peicheng (2)*  
(1) Hefei University of Technology, China; (2) Anhui Polytechnic University, China

**ABSTRACT**

Engine is one of the main vibration sources, and it has a big impact on the vibration characteristics of the car. Reasonable design of suspension system can obviously reduce the vibration of automobile powertrain and the body. Aiming at the vehicle vibration induced by automobile engine, the powertrain mounting system is put into the environment of vehicle to study its coupling vibration characteristics. A multi-body dynamic model including powertrain, vehicle, body and suspension system is established to carry out the simulation calculation, then analyze the vibration transmissibility and the

coupling vibration between powertrain and vehicle. The research shows that there is difference in vibration characteristics between vehicle model and six-degree-of-freedom model of mounting system. After optimizing the parameters of mounting system, the vibration transmissibility has significantly reduced, thus the vibration reduction effect has been effectively improved.

### 319 Developing Powertrain Mounting Systems in the Virtual Engineering World Using a Full Vehicle NVH Simulator

*Kennings, Paul (1); Layfield, Jonathan (1); Tarabra, Marco (1); Fothergill, David (2); Syred, Frank (3); Franks, Graham (3)*  
(1) Bentley Motors, UK; (2) DJ Fothergill Consulting, UK; (3) Sound & Vibration Technology, UK

#### ABSTRACT

At Bentley Motors, the development approach for powertrain mounts has ramped up in recent years, from Hardware based test comparisons in the early years through to our CAE based development with "Physical Simulation". This latest technique, known as the Full Vehicle NVH Simulator (FVS), allows the engineering team to physically evaluate a laboratory based vehicle with high correlation to the vehicle on road – this creates a realistic and useable link between objective data and subjective feel. The tool is powerful in that it allows the team to achieve the required attribute balance between ride comfort and powertrain NVH. Advances made towards Bentley's carbon footprint, like variable displacement engines (selectively reducing the number of active cylinders during operation), adds to the challenges of this attribute balance. This change results in lower firing orders at which mount isolation is required, making spectral tuning of the mount stiffness more challenging owing to the lower frequency nature of this operating range. The physical simulation technique which has been used for powertrain mounts development within Bentley has become a business advantage owing to the reduced number of prototypes required for testing and, therefore, reduced product development costs with accurate predictions ahead of design freeze.

### 293 The Transmission of Vibration at Various Locations on Vehicle Seat to Seated Occupant Body

*Ittianuwat, Ratchaphon (1); Fard, Mohammad (1); Kato, Kazuhito (2)*  
(1) RMIT University, Australia; (2) NHK Spring Co., Ltd, Japan

#### ABSTRACT

Previous research showed that vehicle seat has generally three fundamental vibration mode shapes (lateral, fore-aft, and twisting) in the frequency range below 80 Hz which is well within human perception to vibration. However, the effects of seat structural dynamics on the vibration comfort may not be captured properly by current ISO 2631-1 (1997) suggested measurement locations. Therefore, this study evaluated the current center measurement locations on seat surfaces (seat cushion and seatback foams) in assessing transmission of vibration of the occupied vehicle seat. Vibration transmissibility from vibration platform to occupant body was measured at ten different locations between human body and seat surfaces, and nine different locations on seat frame. The vehicle seat was excited in multi-direction (fore-aft, lateral, and vertical) with random vibration of 1.0 m/s<sup>2</sup> r.m.s. for each axis over the frequency range 1 - 100 Hz. The results showed that the

transmission of vibration from vehicle seat structure to human body varies with vibration mode shapes. The transmissibility was greatest at the top measurement location on the seatback surface in y-axis when seat structure undergoes lateral and twisting vibration mode shape. The transmissibility was greatest at the top measurement location on the seatback in x-axis when seat structure undergoes fore-aft vibration mode shape. The variations in transmissibility with modes of vibration and with location of measurements suggest that more than one measurement location is required to evaluate the transmissibility of vehicle seat.

### 345 Study on startup transient vibration of a vehicle with 3-cylinder engine

*Fu, Jianghua (1); Pang, Jian (1); Hu, Chengtai (1); Xu, Xiaomin (1); Deng, Renwei (1); Kuang, Xiaohong (1)*  
(1) Changan Auto Global R&D Center, China, State Key laboratory of Vehicle NVH and Safety Technology, China

#### ABSTRACT

The vibration of 3-cylinder engine is bigger than the 4-cylinder engine with the same engine displacement. The startup processing is studied in order to control the shake level when the engine is started. Excitation characteristics of the 3-cylinder engine is analyzed and a CAE model to analyze the startup shake is established which is verified by the test data. The possible impact factors of the startup vibration are studied and the key control methods are provided, which are applied to an case and successful results are obtained. The results show that the powerplant mounting system has a great influence on the startup vibration of the vehicle with 3-cylinder engine. Aligning the modal frequency distribution between the 3-cylinder engine mounting system and the cranking speed of the start motor, the vehicle transient shake at startup can be effectively controlled. The paper also provides a CAE simulation method which is successfully used to predict the startup shake, which provide a guideline for powerplant mounting system design at early stage of the vehicle development.

### 302 Road noise sensitivity analysis with respect to suspension geometry

*Kosaka, Fumihiko (1); Mizuno, Hiroaki (1); Inoue, Tsuyoshi (2); Takagi, Kentaro (2)*  
(1) Mitsubishi Motors Corporation, Japan; (2) Nagoya University, Japan

#### ABSTRACT

In the vehicle development, the importance of reducing road noise is increasing because of the increasing popularity of quiet electric vehicle. The suspension plays an important role on the mechanism of the structure born road noise. As the countermeasure for reducing road noise, low stiffness suspension bush is often used from the point of view of vibration insulation. However, in general, to use the low stiffness suspension bush makes the driving stability worse. From such reason, it has been difficult to achieve the compatibility between NVH and driving stability at high quality. Therefore, the other ways are required for reducing the road noise. As one of the ways, the road noise reduction by the suspension geometry is presented in this paper. In order to find the suspension geometry which reduces the road noise, the sensitivity analysis is used. For the sensitivity analysis with respect to the position of the suspension arm connecting

points, the suspension model is simplified. The arms are modeled as rigid links whereas the vehicle body, tire and shock absorber are modeled as a modal model. The suspension geometry which reduces the road noise is obtained with the sensitivity analysis.

**Monday 13:40-15:20 Room 208**  
**D4c Pavement modelling and measurement techniques**  
**Chair: Paul Donovan, Gaetano Licitra**

**76 Assessing the acoustic properties of audio-tactile road markings**

*Goubert, Luc (1); Debroux, Philippe (1); Gail, Annette (2); Zöller, Marek (2); De Clerck, Kristof (3); Verleyen, Lenert (3)*  
 (1) BRRC, Belgium; (2) FRTA, Belgium; (3) BAST, Germany

**ABSTRACT**

Structured road markings are becoming popular as edge line on high speed roads, ensuring night time visibility (retroreflection) during rain. These markings are often also "audio-tactile": vehicles (un)intentionally driving over it may produce much more tyre/road sound, which may be observed in the vehicle but also in the vicinity. The sound increase inside the car can be considered as a positive side effect, as it alarms the driver and may be very helpful for the prevention of "doze off" traffic accidents. The sound increase perceived outside the car however, may have a positive aspect as it can warn people on the emergency lane about the approaching vehicle, but it may as well annoy people living around. A method for the assessment of the acoustic properties of audio-tactile markings has been developed. It is mainly based on the "Close Proximity" (CPX) method, an ISO method intended for the acoustic assessment of pavements. The results of measurement campaigns with CPX trailers in Belgium and Germany according to a specially designed procedure are presented. The feasibility of the method is discussed. The research has been carried out in the frame of the standardization activities of the CEN working group CEN/TC226/WG2 "Horizontal signalization".

**104 ODSURF: Optimized low noise urban road surfaces**

*Béregier, Michel (1); Gusia, Peter Johann (2)*  
 (1) IFSTTAR, France; (2) BAST, Germany

**ABSTRACT**

Based on results from the former project "Prediction and Propagation of Rolling Noise" developed in the framework of the German-French cooperation and during which an optimal low noise texture of dense road surface has been designed, ODSurf, financed by the French Environmental Agency and the German Federal Highway Research Institute is mainly devoted to the implementation of new technologies and materials particularly adapted for urban situations in terms of noise abatement to comply the European noise regulation. Different new solutions have been investigated. To achieve our objectives, we improved and/or developed new predicting models and experimental techniques. A particular attention has been paid on the consequences of texture, horn effect and air pumping modifications on tire-road noise emission. Theoretical approaches and new optimized road pavement designing have been carried out in parallel. Furthermore, the improvement of

"conventional" wearing courses has been pursued in order to supply to end-users a complete set of low-noise solutions adapted to their own situations. First validation results are presented. Further, these new optimized pavements will be introduced in the common DEUFRABASE, previously implemented for suburban configurations, which will be completed and extended to urban situations.

**272 On the sound absorption coefficient of porous asphalt pavements for oblique incident sound waves**

*Bezemer-Krijnen, Marieke (1); Wijnant, Ysbrand H (1); De Boer, Andre (1); Bekke, Dirk A (2)*  
 (1) University of Twente, The Netherlands; (2) Apollo Tyres Global R&D, The Netherlands

**ABSTRACT**

A rolling tyre radiates noise in all directions. Conventional measurement techniques for the sound absorption of road surfaces, however, only give the absorption coefficient for normal incidence. The absorption coefficient for oblique incidence is often computed assuming a locally reacting surface. In this paper, a measurement technique is described with which it is possible to perform in situ sound absorption measurements for oblique incidence. The measurements are performed with a small 3D microphone array. The theory behind the measurement technique is based on the local plane wave assumption. In this paper, an approach is proposed to determine whether a surface behaves as a locally reacting surface or as a non-locally reacting surface, which is an important characteristic for optimising the noise absorption properties of asphalt pavements and for modelling techniques. Preliminary measurements at various angles of incidence are performed to demonstrate this approach as well as measurements of the absorption coefficient at normal incidence to validate the microphone array technique with impedance tube measurements.

**512 Influence of surface textures of road markings on tyre/road marking noise**

*Gail, Annette (1); Bartolomaeus, Wolfram (1); Zöller, Marek (1)*  
 (1) Federal Highway Research Institute, Germany

**ABSTRACT**

Road markings are an essential component of a safe road. In particular, the optical guidance at night and under wet conditions rates high. Special surface textures of road markings can enhance the nighttime visibility during wetness, but they can lead on the other hand to noise emission during passages of vehicles and thus annoy residents. In the present study the tyre/road marking noise is analysed based on two different measurement methods for traffic noise: Several different road markings with increased nighttime visibility during wetness were overrun and the noise was determined by controlled coast-by measurements as well as close-proximity measurements. For both measuring methods the averaged A-weighted sound pressure levels were determined and an analysis of the third octave spectra was performed in order to identify annoying tonal components. The results of both measurement methods were compared with each other. Limitations of the individual measurement methods were overcome by combining the data. Properties of road marking noise depending on the texture of the marking are discussed in relation to those of road surface noise. The results will help

specifying road marking texture types that ensure less annoyance and at the same time good visibility at wetness and night-time.

**412 Comparative assessment for low-noise pavements by means of the ISO 11819 and the OBSI**

*Buret, Marc (1); McIntosh, James (1); Simpson, Cassandra (1)*  
(1) VicRoads, Victoria, Australia

**ABSTRACT**

In 2013, VicRoads initiated an acoustic test program for low-noise road surfaces. The program aims to assess the acoustic performance and maintenance requirements for different types of pavement surfaces over a period of at least five years. Seven different products were laid on a single section of roadway on the Mornington Peninsula Freeway in Victoria, Australia. Acoustic tests have then been carried out at regular intervals following three different methods: Statistical Pass-By (ISO 11819-1), Close Proximity Method (ISO/DIS 11819-2) and On-Board Sound Intensity method (AASHTO TP 76-10). Results from these tests are presented here. The measured performance of the different pavement is discussed and an insight is given into the comparison of the different test methods.

**Monday 13:40-15:40 Room 207**  
**R2 Underwater noise measurement**  
**Chair: Paul Dylejko**

**39 Patch near-field acoustical holography based on vector hydrophone array**

*Hu, Bo (1); Yang, Desen (1); Shi, Shengguo (1); Shi, Jie (1); Sun, Yu (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

Near-field acoustical holography is a powerful tool for identifying noise sources from partially known sound pressure field. Patch near-field acoustical holography (PNAH) is related to the partially measured pressure on the hologram surface in terms of sampling and bandlimiting matrices, which cost more in computation. PNAH procedure based on measuring of vector hydrophone array is described, including the mathematical formulation. The measurement array can be smaller than the source, thus the practicability and efficiency of this technology is greatly enhanced. Then an experiment has been carried out with vector hydrophone array. The experimental results have illustrated the high performance of PNAH and the advantages of a vector hydrophone array in an underwater near-field measurement.

**236 Using low cost single-board microcontrollers to record underwater acoustical data**

*Travaglione, Ben (1); Munyard, Andrew (1); Matthews, David (1)*  
(1) DSTO, Australia

**ABSTRACT**

Over recent years there has been a rapid increase in the availability of single-board microcontrollers. In this paper we

review three such microcontrollers; the Arduino Mega2560, the Raspberry Pi and the Beaglebone Black. We show how these devices can be used to produce low cost, low power, deployable, configurable at-sea measurement systems. We also highlight the advantages and disadvantages of each type of single-board microcontroller. We show how these devices can be configured to acquire either digital or analog data from a variety of sensors, as well as process, store and transmit the results. We present some results of high sample rate analog recordings which have been obtained at a fraction of the cost of the more common commercial alternatives. We also highlight some of the pitfalls associated with using these leading-edge devices.

**760 Marine Soundscape Ecology**

*Sydney, Harris (1); Radford, Craig (1)*  
(1) University of Auckland, New Zealand

**ABSTRACT**

In the face of accelerated climate change, monitoring biodiversity has become a critical task for ecologists. Habitat loss is occurring at an alarming rate both in terrestrial and marine ecosystems, resulting in endangerment and extinction of species up to 1,000 times faster than natural rates. However, traditional biodiversity measurements are logistically and financially difficult, making biodiversity monitoring a challenging obstacle to conservation efforts. In terrestrial environments, "Soundscape Ecology" has recently emerged as a potential solution to these problems, providing a mechanism for measuring biodiversity at various temporal and spatial scales using acoustic signatures. Several acoustic diversity indices have proven to be useful indicators of biodiversity in a variety of landscapes. Thus far, this technique has not been extended to marine environments. What is known is that different marine habitats have distinct sound signatures both in temperate and tropical waters. For example, studies have shown that temperate reefs from within a marine reserve have a different spectral signature compared to reefs outside the reserve. Also, a fringing reef from a tropical island has a different spectral signature to those of the lagoon and back reefs. Here we highlight the research potential for using acoustics to monitor marine biodiversity and what is required for this field to progress.

**793 Characterising the acoustic footprint of Australia's new research vessel RV Investigator**

*Kloser, Rudy (1); Martin, Tara (1); Sherlock, Matt (1)*  
(1) CSIRO, Australia

**ABSTRACT**

The RV Investigator is Australia's new noise quietened Marine National Facility (MNF) vessel built to comply with the DNV silent-R specification. This radiated noise specification was based on the ICES 209 CRR specification designed with the main goal of minimising vessel avoidance for fisheries surveys. Noise quietening was specified for RV Investigator to improve the acoustic detection of instruments and reduce the vessel's noise footprint on the environment for research activities. Traditionally DC propulsion motors are used to achieve radiated noise compliance; in this case AC propulsion motors have been used. Initial noise measurements show the RV Investigator is 20 dB (factor of 100) quieter than the previous MNF vessel, RV Southern Surveyor which will significantly improve acoustic

instrument performance. The new acoustic systems on the RV Investigator range from sub-bottom profilers, Doppler current profilers, multi-frequency and multi-beam water-column echo-sounders and low to mid frequency multi-beam bathymetry echo-sounders.

**964 Modeling ocean noise on the global scale**

*Porter, Michael B (1); Henderson, Laurel J (1)*

(1) Heat, Light, and Sound Research, USA

**ABSTRACT**

In recent years there has been a much greater interest in understanding noise in the ocean. In Europe this interest is tied to the Marine Strategy Framework Directive, which seeks to maintain 'good environmental status' with specific attention to sound. In the U.S. a similar commitment was made to evaluate and improve tools for assessing the impacts of human-induced noise in the ocean. In earlier work we did extensive modeling of soundscapes in the U.S. EEZ to understand the various layers of sound. Pile driving, seismic surveys, shipping, and sonar exercises were all considered. In this work, we are extending this modeling to the global scale. The global scale presents unique and interesting challenges in terms of the computational modeling. We discuss the approach and present preliminary results characterizing the global soundscape.

**990 A modelling approach to spatial extrapolation of ocean ambient noise measurements**

*Heaney, Kevin D*

OASIS Inc, Fairfax Station USA

**ABSTRACT**

With the growing understanding that anthropogenic ocean noise can have potential harmful impacts on the ocean ecosystem, many national environmental agencies are beginning to grapple with the task of assessing the levels of ambient noise in their regional waters and an understanding of these impacts. The challenge facing national regulatory agencies, in particular European Union Member States, which are now required to come up with a plan for assessing the environmental health of their waters, is to use limited resources intelligently to estimate the overall impact of man-made sounds. In this paper, we present an efficient modeling approach for low-frequency sound and a way forward for incorporating measurements into an environmental assessment framework.

**Monday 13:40-15:20 Room 206**

**S1a Soundscape and its diversity in history and culture**

**Chair: Koji Nagahata**

**1028 Withdrawn1**

*Withdrawn1,*

**ABSTRACT**

Withdrawn1

**778 Soundscape Study of Urban Public Spaces along the Sea Shore**

*Kabilan, Tharangini (1); Mohan, Anjana (1); Jeyachandran, Keerthika (1); Ramasamy, Kalaiselvi (2)*

(1) Rajalakshmi School of Architecture, India; (2) School of Planning and Architecture – Vijayawada, India

**ABSTRACT**

The cities are profound with variety of sounds that keeps fluctuating at different time intervals. However one restless source lying on the border of Chennai city, India is the wave sound of Marina Beach. It is one of the important urban public spaces that attract number of visitors every day. To carry out the soundscape study of Marina Beach, a stretch perpendicular to the sea comprising of three levels – the Traffic road, a linear double rowed vendor shops and the seashore is chosen. Sound walk followed by a questionnaire study is carried out at each level to investigate the transition of sound along the stretch. Psycho-physical data analyses of verbal descriptions expressed by respondents at each level are observed to be different. The Leq levels are found to be varying throughout the day and found to record the values of about 70 – 80 dB(A) at peak hours, measured using Norsonic sound level meter type 118. The role of vendor shops in providing acoustical aid to the transition from traffic noise to wave sound was mapped for the stretch. Based on the subjective surveys few recommendations are discussed in the full paper to improve the soundscape of the seashore.

**920 The Urban Park Soundscape in Mountainous Cities:A case study in Chongqing**

*Li, Heng (1); Xie, Hui (1); Kang, Jian (2)*

(1) Chongqing University, China; (2) Sheffield University, UK

**ABSTRACT**

As a typical mountainous city, undulating terrain in Chongqing creates a unique urban structure, and the richness of urban park soundscapes is enhanced as well. In this paper, one urban park, named 'ShaPing Park', was selected for the field measurement and questionnaire survey. Approximately 10 receiver points were arranged, with the consideration of both elevations and functional zones. The recreation zone and quiet zone were generally dominated by low frequency sounds, whereas the middle frequency sounds were more significant at the activity zone. Some special sounds, such as whipping tops, were observed in the park. People singing (65.1%) was the most annoying sound due to its unpleasantness. 57.2% of the respondents considered the acoustic environment as severely or relatively noisy, but only 44.5% of the interviewees regarded it comfortable or relatively comfortable. 'Sound level' (57.1%) and 'personal interests' (49.2%) were recognized as the major factors influencing personal sound preference, and the appropriate improvements of acoustical environment were identified as the priority in the studied urban park.

**629 Analysis of soundscape of selected urban public places and its impact on their assessment by users**

*Kamenicky, Matej*

Czech Technical University, Czech Republic

**ABSTRACT**

This paper describes an ongoing research project concerning the soundscape of urban public spaces and the relevance to architectural quality of particular public spaces and their overall assessment by users. Described here is the methodology of data gathering and analysis that was carried out last year in Prague, Split and Ljubljana. In addition, partial and expected results and possible further applications will be discussed. The topic of the research is the effect of sound environment on perceived quality of a given public space by the inhabitants and the dependant factors that influence these relations. The research is focused on selected public spaces representing different typological categories in cities of different geographical location and their users' cultural background. Examined cities will represent regions of central Europe, south Europe and north east Australia.

1036 **Withdrawn9**

*Withdrawn9,*

**ABSTRACT**

Withdrawn9

**Monday 15:40-17:00 Room 220**

**K2b Applying building envelop design for noise mitigation**

**Chair: Maurice Yeung, Shiu-keung Tang**

**427 Tackling Traffic Noise Through Plenum Windows – An Application in Hong Kong**

*Yeung, Maurice (1); N G, Isaac (1); Lam, John (1); Tang, Shiu Keung (2); Lo, David (3); Yeung, David (4)*

(1) Assessment and Noise Group, Environmental Protection Department, The Hong Kong Special Administrative Region Government People's Republic of China; (2) Department of Building Services Engineering The Hong Kong Polytechnic University Hong Kong People's Republic of China; (3) Hong Kong Housing Authority The Hong Kong Special Administration Region Government People's Republic of China; (4) Environ Corporation, Hong Kong

**ABSTRACT**

Hong Kong is a very small but hyper-dense city with over 7 million living in 1,100 sq km in which 85% of land is hilly area. Like other metropolitan cities, Hong Kong is facing significant road traffic noise problems. The Government of Hong Kong is committed to addressing road traffic noise problems and has adopted proactive actions like preventing the problems through land use planning and environmental impact assessment process for new roads, implementation of appropriate mitigation measures on existing roads etc. In most cases, measures like roadside barriers / enclosures would be required. However, the majority of residents live in high-rise buildings and such compact urban forms setting would easily be

susceptible to road traffic noise problem. To make Hong Kong a livable place with a good acoustic environment, examining other measures on building façade design is necessary. This paper will discuss on the actual application and in-situ tests conducted for plenum type windows in its application at a housing development next to a heavily trafficked road. With careful design and use of absorptive materials, a noise reduction of up to 8 dB(A) can be achieved without compromising sufficient air ventilations meeting local regulations.

**504 Design for noise mitigation measures for public housing developments in Hong Kong**

*Lo, David (1); Yim, Stephen (1); Leung, Kenneth (1)*

(1) Hong Kong Housing Authority, Hong Kong

**ABSTRACT**

Hong Kong is renowned for its high density living where we commonly find residential developments, including public housing developments, located close to roads with heavy traffic. To protect the residents from noise nuisance, the Hong Kong Housing Authority (HKHA) has applied a series of noise mitigation measures including low noise road surfacing, noise enclosures/barriers, building setback, orientation and vertical fins etc., to reduce the noise impact. Where the impact is found too severe for the above noise mitigation measures to be adequate, we need to develop more innovative building design to improve the building efficiency and enhance the built environment. In this paper, we share our experience in the research and development of innovative building design to mitigate noise problems. We also give an account on how the noise challenges are tackled in recent projects by making use of the above measures plus innovative designs such as acoustic balcony and acoustic window.

**709 Investigation of sound insulation for a Supply Air Window – field measurements and occupant response**

*Søndergaard, Lars Sommer (1); Legarth, Søren Vase (1)*

(1) DELTA, Denmark

**ABSTRACT**

The Danish Environmental Protection Agency's guideline from 2007 "Noise from roads" introduces noise limits with open windows for certain situations. With a moderate/high outdoor noise level from traffic, railway or industry these noise limits cannot be complied with for regular windows, but requires windows with better sound insulation in open position. The window investigated in this project is a double window construction consisting of an outer part, with a top hung vent in the lower part of the window, and an inner part, with a bottom hung vent in the upper part of the window. The first parts of the project consisted primarily of laboratory measurements investigating the influence of different combinations of e.g. dimensions, opening area and the use of absorbing material. In the second part of the project the window type were installed in 14 flats exposed to approximately 71 dB noise levels from road and railroad traffic. Measurements were performed satisfying the indoor noise limits. The measurements were followed by a questionnaire. The occupants generally responded that the windows allowed them opportunity to have open windows without being especially annoyed by the noise; however other functionalities of the windows were not always acceptable.



**714 Cost reduction of noise treatments in the oil & gas industry - design of noise mitigation for gas compressor stations using engineering optimisation**

*Davis, David James*  
URS, Australia

**ABSTRACT**

The capital cost of noise control treatments for land-based gas compressor stations can be significant. Field gas compression facilities can have many noise sources including compressors, fan coolers, power generators or transformers, pipes and valves, flares and so on. Some coal seam gas field facilities can also have co-located water treatment plant or water transfer pumps. Environmental noise computer modelling predictions can estimate the component contribution noise emissions from each individual noise source at each affected receiver. Using these data, an experienced practitioner can estimate a scheme of noise level reductions for each source so that the noise emissions of the entire site comply with the overall environmental noise targets at the receptors. However it is not straightforward to select and design the noise control treatments for all of the individual noise sources with the explicit goal of minimising the total capital cost for the overall noise mitigation program. This paper provides an example of minimising the cost of noise control treatments required for a coal seam methane gas field compression station using two different engineering optimisation techniques.

**Monday 15:40-18:00 Room 219**  
**T1 Reaction to aircraft noise**  
**Chair: Truls Gjestland, Femke Gelderblom**

**580 The economic value of aircraft noise effects: a UK perspective**

*Sanchez, Diana (1); Berry, Bernard (2); Knowles, Andy (1)*  
(1) Anderson Acoustics, UK; (2) BEL - Environmental, UK.

**ABSTRACT**

The quantification of the effects of aircraft noise on health and quality of life and the associated monetisation of those effects has taken on significance as a major field of study with important implications in policy making and business management. Good quality studies have been conducted in this matter. Although these studies have enriched the understanding of the magnitude and complexity of this matter, several gaps remain, challenging decision making on aircraft noise management at macro and micro levels. This paper is part of a series of papers on understanding and communicating the exposure to, and impacts from aviation noise and developing a balanced scorecard for informed decision-making. In particular, this paper aims to provide an overview of the most up to date and robust monetisation methodologies and the context for its application to UK aviation policy. It presents some estimates for London Airports to show the change in the cost of aircraft noise effects on health and annoyance over 5 years. We suggest a set of principles and a process that can guide monetisation efforts of aircraft noise effects. We argue that monetary values should be considered as indicative and should only be used to understand trends rather than quantify the effects in an absolute sense.

**967 Continuous Descent Approach (CDA) compared to Regular Descent Procedures: Less Annoying?**

*White, Kim (1); Arntzen, Michael (2); Bronkhorst, Adelbert (3); Meeter, Martijn (4)*

(1) National Aerospace Laboratory NLR, The Netherlands / VU University Amsterdam, The Netherlands; (2) National Aerospace Laboratory NLR, The Netherlands / TU Delft, The Netherlands; (3) TNO, The Netherlands / VU University Amsterdam, The Netherlands; (4) VU University Amsterdam, The Netherlands

**ABSTRACT**

Annoyance reactions to different types of landing procedures were addressed in a controlled laboratory setting using a Virtual Community Noise Simulator (VCNS) with a head mounted display. Participants, standing on a virtual countryside road, experienced four types of descent flyovers by an A330 aircraft: a regular descent flyover at 2000ft and CDAs at respectively 3000, 4000 and 5000ft. These types of landing procedures are representative of flights approaching Amsterdam Airport Schiphol (AAS) in the Netherlands. Sound recordings for the VCNS were made on a countryside road and adjusted to match the indicated altitudes. After each flyover, participants were asked to rate their noise annoyance during the previous minute. Preliminary results showed that the 3000ft CDA was rated as the most annoying, followed by the ratings of the regular landing procedure and higher CDAs. These results could indicate that a CDA procedure, despite having lower L<sub>Amax</sub> and similar SEL levels, may still reach higher annoyance ratings due to longer flyover durations.

**106 The impact of civil versus military aircraft noise on noise annoyance**

*Gelderblom, Femke B (1); Gjestland, Truls (1); Granøien, Idar L N (1); Taraldsen, Gunnar (1)*  
(1) SINTEF, Norway

**ABSTRACT**

The noise characteristics of civil and military aircraft operations differ significantly. For example, the difference in flyover noise from a fighter aircraft and jet plane is easily heard. Civil traffic also tends to be spread out relatively evenly over a day, whereas military training operations can often be characterized by short periods of high activity followed by long periods of comparative silence. Such clearly noticeable differences are disregarded in commonly used noise dose indicators, but may be expected to significantly affect noise annoyance levels within a community. Therefore, an attitudinal survey was conducted by means of telephone interviews in the vicinity of the airports of the Norwegian cities Trondheim and Bodø. While those living near Trondheim's airport are predominantly exposed to noise from civil air traffic, Bodø has a runway that is shared by the city's civil airport and a military airbase. The focus of the study was not on demographic factors, which is typical for an attitudinal study, but instead on acoustical and operational aspects. This study is part of an ongoing research project with the aim of explaining why observed dose-response relationships differ widely from one community to the next.

**335 Stated choice valuation of aircraft noise and other environmental externalities at Bangkok Suvarnabhumi Airport**

*Cheramakara, Narudh (1); Bristow, Abigail (1); Budd, Lucy (1); Zanni, Alberto (1)*  
(1) Loughborough University, UK

**ABSTRACT**

Aircraft noise and other environmental externality effects have gained significant public attention in Thailand since Bangkok's Suvarnabhumi Airport opened in 2006. Residential areas around the airport are expanding rapidly and local residents are protesting about the noise and air pollution from the airport. This study employed Stated Choice to elicit willingness-to-pay (WTP) values to reduce aircraft noise and air pollution. The novelty of the research arises from the fact that it explores monetary values of externalities not only for those who suffer from the pollution (residents) but also those who have some responsibility for the externalities that are created (i.e. air passengers). Results indicate that passengers and residents have different priorities in terms of aviation externalities. As might be anticipated, residents place a higher value on aircraft noise nuisance than passengers at 104.76 USD and 70.63 USD per year respectively to halve aircraft noise levels. In terms of air pollution, passengers had a higher WTP at 151.18 USD against residents' WTP of 86.52 USD per year to halve local air pollution created by aircraft. Passengers are willing to pay 41.69 USD per year to offset carbon emissions. The study found that aviation growth at Suvarnabhumi was underestimated and there is an urgent need to implement environmental mitigation policies to address the issue.

**645 The next generation of supplementary aviation noise metrics and their use in managing aviation noise.**

*Porter, Nicole (1); Knowles, Andy (1); Fisher, Nick (2); Southgate, Dave (3)*  
(1) Anderson Acoustics, UK; (2) Department of Infrastructure and Regional Development, Australia; (3) Independent Consultant, Australia

**ABSTRACT**

Successful aviation noise management and sustainable airport development relies on describing noise exposure effectively, understanding its impacts, and communicating these effectively. We need the right tools to describe noise and its impacts in a meaningful way. Furthermore, decision makers need a balanced scorecard to make informed decisions based on the outcomes from an appropriate suite of analysis tools. This paper summarizes our previous work which examined the limitations of traditional noise contours for describing noise exposure based on long-term averages and considered a more targeted contour based on shorter-term noise measures. It looks at supplementary ways of describing the physical exposure to aircraft noise events including those developed in Australia in 2000. These are revisited and we will show in our presentation, by using recent case examples, how we have applied and/or refined them using GIS techniques. We also highlight key information from our companion paper on aircraft noise effects on health and its monetization. All these elements are required for effective management of aviation noise.

**622 New insights into perception of aircraft and community noise events**

*Adams, Keith*  
B&K EMS, Australia

**ABSTRACT**

The current practice of basing all noise monitoring on A-weighted day/night levels has often been criticised. Questions as to what is really happening in the "noisescape" have been raised, with consequences for managing complaints and future planning. At the same time, some permanent noise monitoring terminals are now available to record simultaneously A-weighted, C-weighted, Z-weighted, stationary loudness, non-stationary loudness, and effective perceived noise levels of noise events. These data, together with other available functions in permanent monitors such as dominant pitch, frequency percentile measures and neural network source characterisation, provide useful resolutions of the more complex events that are not purely due to aircraft. The collection of two years of continuous records of all of these parameters with audio, from a modified permanent airport noise monitor, that is exposed to a variety of community, traffic and aircraft sounds, provides a valuable data set for further study. In particular, event-threshold parameters, maximum levels and exposure levels based on the perception metrics, in comparison with the common A-weighted metrics, have been obtained. Together with recordings from some other sites, new insights into what is really happening in noise events are presented.

**242 Relaxations of operating restrictions on Noise and resident's reaction at Narita International Airport**

*Ogata, Saburo (1); Shinohara, Naoaki (2)*  
(1) Narita International Airport Corporation, Japan; (2) Narita International Airport Promotion Foundation, Japan

**ABSTRACT**

At Narita International Airport, air traffic movements have been controlled under various noise related operating restrictions as well as to conform to agreements with residents around airport so as to minimize noise impact because the airport is located inland. In response to needs for airport capacity expansion, Narita International Airport Corporation and Ministry of Transport have had to relax some such restrictions to ensure safety and to improve operating efficiency. This paper makes a brief review of noise mitigation measures at Narita, describes measures to cope with relaxation and resident's reactions like noise complaints and examines the effectiveness of the relaxation. Especially, it speaks about current situation after the enforcement of night curfew relaxation, which came into operation since March 31 last year.

**Monday 16:00-18:00 Room 218**  
**L2 Signal processing for active control**  
**Chair: Jing Lu, Teik Lim**

**249 Multivariable control of tonal disturbances using minimization of the maximum error signal through adaptive error signal weighting**

*Cheer, Jordan (1); Daley, Steve (1)*  
 (1) Institute of Sound and Vibration Research, UK

**ABSTRACT**

In many multichannel active noise and vibration control systems the controller is adapted to minimize the 2-norm of the error signals. This may, however, lead to a large spatial variance in the residual error. A method of achieving a more uniformly controlled error field using a weighted squared error strategy has previously been proposed, although the presented method of defining the error weighting parameters results in a very slow convergence rate. This convergence rate limitation has been overcome by the minimax algorithm which minimizes, in a least-squares sense, the maximum error signal at each iteration. However, due to the inherent switching in this algorithm, for fast convergence speeds it suffers from significant misadjustment and in a tonal control problem this introduces additional unwanted spectral components. In this paper an alternative method of minimizing the maximum error signal is proposed which uses an adaptive error-weighting matrix that is bounded and so avoids the slow convergence speeds previously reported. It is also shown that the proposed algorithm does not suffer from the same misadjustment problems shown by the minimax algorithm. The details of the proposed method are first outlined and then its performance is compared to the previously proposed methods through a series of time-domain simulations employing measurements of a physical system.

**526 Adapting an MSE controller for active noise control to nonstationary noise statistics**

*Barkefors, Annea (1); Sternad, Mikael (1)*  
 (1) Uppsala University, Sweden

**ABSTRACT**

In feedforward active noise control, a primary noise signal is used to generate control signals via a set of loudspeakers. In problems where many loudspeakers are used, it becomes difficult to adjust the controller filters to fast changing spectral properties of broadband primary noise signals. Many parameters then need to be readjusted simultaneously, which limits the tracking performance of e.g. filtered-x LMS adaptation algorithms. Here we propose and evaluate two feedforward control methods based on linear quadratic gaussian control that adapt to the often time-varying statistical properties of the feedforward noise signal, in a partly indirect adaptive design. For both proposed methods, the time is divided in batches and the control laws are updated for each time batch based on repeated estimates of the noise statistics. In the first method, the estimates of the noise statistics are incorporated into the controller, which is updated for each batch, whereas in the second method the controller is kept constant and a predictor for the noise is updated. The first method seems promising, and shows a gain in attenuation of about 5 dB over a controller that disregards the feedforward

noise statistics. The second method, however, shows no such advantage.

**615 Adaptive feedback noise control with leaky FeLMS algorithm**

*Chen, Kai (1); Paurobally, Roshun (2); Pan, Jie (2); Qiu, Xiaojun (1)*

(1) Key Laboratory of Modern Acoustics and Institute of Acoustics, Nanjing University; (2) School of Mechanical and Chemical Engineering, the University of Western Australia

**ABSTRACT**

In this paper, an adaptive feedback control algorithm for ANC (Active Noise Control) with leaky FeLMS (Filtered-error Least Mean Square) algorithm is proposed. A shaping function is used in the updating equation, which selects the frequency band of the noise attenuation for the ANC system. Compared with the adaptive feedback ANC structure based on traditional FxLMS (Filtered-x Least Mean Square) algorithm, the effects of the proposed algorithm are focused only on the selected band and interference from other frequency bands, which can induce instability, can be reduced significantly. The RF is only applied on the updating process for the coefficients of the control filter rather, so the proposed algorithm does not introduce any extra delay. In this paper, the proposed algorithm is analyzed and it is proven to be suitable for applications where broadband noise is present, but the targeted band is limited to a narrow band.

**157 A modified frequency domain adaptive filter for active noise control**

*Lu, Jing (1); Nirong, Li (1); Ning, Han (2)*  
 (1) Nanjing University, China; (2) Southeast University, China

**ABSTRACT**

Frequency domain adaptive filter has potential benefits of fast convergence and low computational load, which make it attractive in the application of active noise control. However, it has been noticed that the commonly used normalized frequency domain block LMS algorithm faces the problem of deterioration of steady-state behavior when the whole control system is noncausal or the adaptive filter is of deficient length. In this paper, an efficient modification of the frequency domain block LMS algorithm is described, and it can be theoretically proven that the proposed algorithm can unconditionally converge to the optimal Wiener solution. Moreover, the convergence behavior is also discussed. The experiment in a short duct active noise control system clearly demonstrates the superiority of the proposed algorithm.

**61 Active sound design for a passenger car based on adaptive order filter**

*Lee, Sang Kwon (1); Lee, Seung Min (1); Kang, In Deuk (1); Shin, TaeJin (1)*  
 (1) Inha University, South Korea

**ABSTRACT**

The paper presents an adaptive order filter for the sound design of a passenger car. The engine speed is calculated by using the pulse signal detected at engine speed sensor such as cam shaft position sensor (CSPS) or engine ignition position sensor (EIPS). Nowadays, the pulse signal of engine speed is delivered to the engine management control unit (ECU) system.

The ECU supplies the engine speed data to the display throughout a high speed gateway. The ANC system can also use this data for the generation of reference signal. Most of reference signals used for the noise control of an engine are the sine wave at the instant frequency (rpm/60). This sine wave is discretely changed with the increment of engine speed but not continuous. Therefore, the ANC system using this reference cannot work when the engine speed is changed rapidly from 1000rpm to 6000rpm but work well at the fixed rpm. In this paper new adaptive order filter (AOF) for the ANC system of interior noise of a car is proposed. The new algorithm uses the continuous reference signal instead of the sine wave. This ANC system is also applied for the active sound design (ASD). The AOF is very excellent algorithm for the ASD of a vehicle.

**303 Active control of vehicle powertrain noise using inverse model LMS algorithm**

*Sun, Guohua (1); Feng, Tao (1); Li, Mingfeng (1); Xu, Ji (1); Lim, Teik C (1)*

(1) University of Cincinnati, USA

**ABSTRACT**

Current active noise control (ANC) technology cannot yield a balanced performance over broad frequency range when applied to powertrain noise control. It is because most of these ANC systems are configured with the traditional filtered-x least mean squares (FXLMS) algorithm with an inherent limitation in the frequency-dependent convergence behavior. In particular, the phase delay of the secondary path in the FXLMS algorithm will significantly affect the convergence speed and thus lead to a relatively poor tracking ability for the transient event. In this study, a novel inverse model least mean square (IMLMS) algorithm is proposed for active powertrain noise control system with an enhanced convergence speed in order to better track the variation of noise signatures due to unavoidable change in the engine speed. The IMLMS algorithm is realized by utilizing the inverse model of the secondary path to minimize the effect of its dynamics on algorithm's convergence to gain a significant improvement in the convergence speed and tracking ability. Numerical simulation using measured powertrain noise responses is also performed to demonstrate the effectiveness of the proposed algorithm. Results show obvious improvement in the convergence speed and appreciable noise reductions over a broad engine rotational speed range.

**Monday 15:40-17:20 Room 217**

**T8b Sound quality**

**Chair: Klaus Genuit, Roland Sottek**

**49 Noise Reduction Measures of Noisy Kitchen Devices and Evidence of their Improvement by an Objective Analysis of Spontaneous EEG Measurements**

*Fischer, Martin (1); Spessert, Bruno M (1); Emmerich, Edeltraut (2)*

(1) Ernst-Abbe-University of Applied Sciences Jena, Germany;  
(2) Jena University Hospital, Germany

**ABSTRACT**

In modern life, influence of noise becomes more and more important. Especially at home, Europeans desire a quieter kitchen. In general small, electromotive-driven appliances and in particular blenders can generate inconvenient home noise

emission. Noise excitations of these devices were diagnosed experimentally. On this, constructions were applied to modify noise emission. The modified noise emissions were compared in terms of sound power level and psychoacoustic parameters like loudness, sharpness and roughness. In order to analyze objectively the psycho-physiological stress caused by these noises, a spontaneous EEG experiment was conducted. "Original noise" of the device and modified "optimized noises" were taken as experimental stimuli. Impact of the noises on psycho-physiological stress of experimental subjects (n = 20) were measured by spontaneous EEG. Through power density distribution, evidence on significant differences between "original noise" and "optimized noises" were found. The power density distributions of the "optimized noises" as compared to the "original noise" come closer to the distribution when subjects are relaxed-awake. This showed that the modifications have been successful as measured through an objective mean.

**120 The influence of the sensation of rhythm on comfort and productivity**

*Yamaguchi, Masao (1); Hanawa, Kazuto (1); Toi, Takeshi (1)*

(1) Chuo University, Japan

**ABSTRACT**

Recently, an evaluation of stress and comfort by using physiological information has been being researched as a quantitative and objective evaluation method. Moreover, sounds which improve productivity introduced into an environment where people work are in demand. In this research, first, to investigate comfortable rhythmical sounds, we conducted a sound quality evaluation, by a subjective evaluation as well as the objective evaluation that used heart rate and salivary amylase. We prepared two sounds: rhythmical sounds which were a metronome sound and an operation sound emitted by a multifunctional peripheral (MFP). From these results, it may be stated that subjects felt more comfortable when they heard a rhythmical sound whose rhythm was a little slower than their heart rate. Moreover, it may be stated that it is possible to evaluate the influence of the sensation of rhythm on comfort by using heart rate and salivary amylase. In the second evaluation, the subjects calculated two-digit number additions, with the presentation of the metronome sound and the operation sound emitted by the MFP used in the first evaluation. Consequently, the number of calculations per minute increased when they heard a rhythmical sound whose rhythm was a little faster than their heart rates.

**681 Effect on car interior sound quality according to the variation of noisy components of tire-pattern noise**

*Shin, Sung-Hwan (1); Hashimoto, Takeo (2); Hatano, Shigeko (2)*  
(1) Kookmin University, Korea; (2) Seikei University, Japan

**ABSTRACT**

A tire noise is one of the important noise sources of vehicle. Especially, it becomes more dominant one for motor-driven vehicle such as electric or hybrid vehicle. The purpose of this study is to grasp the effects of the variation of noise components of tire-pattern noise on car interior sound quality. To this end, tire noises were recorded with a compact car but with different types of tire pattern. Noisy components of each tire noise were indicated and then the noisy components were modified with their peak level, half-power bandwidth, and

position on frequency domain. By employing subjective listening tests whose target was to evaluate the extent of annoyance of the modified noises, the change tendency of annoyance according to the variation of the noisy components was investigated and an index was proposed that could estimate and predict the annoyance of tire-pattern noise. In addition, it was known that energy ratio of a noisy component to background noise in the frequency range that the noisy component exists was one of the important descriptors representing the annoyance of tire-pattern noise.

### 393 Stereo or binaural headphones for sound location

*Cohen, Graeme J*  
Valve Research Pty. Ltd., Australia

#### ABSTRACT

Stereo sound is reproduced over two spaced apart loudspeakers. When headphones are used in place of loudspeakers the stereophonic space is incorrectly reproduced. Stereo headphones could arguably be called binaural headphones, that is the left sound source being heard in the left earphone only. In a live situation of sound the human head hears the sound with both ears. When using headphones and two microphones the sound is different and may not have accurate location in space. By using a cross feed of sound, left to right and right to left, and using suitable compensation and delay, it can be shown that a natural and accurate location of sound source, music, noise etc. may be accomplished. A cross feed system has been developed using previous work, with references. A sound source and delay system has been developed to give a measure of the source using headphones. This technique can be used for use with microphones and recording media, using headphones as a human interface. This is used, with two sound level meters, and computers, for accurate sound source position by using controlled cross feed, amplitude, delay etc. within the frequency band measured. Headphones being used as a live check of the recording.

### 182 Rhythmic constant pitch time stretching for digital audio

*Trevorrow, Brendan*  
University of Southern Queensland, Australia

#### ABSTRACT

Constant pitch time stretching is not uncommon in audio editing software, however several issues arise when it is used on musical recordings, most notably the doubling and skipping of rhythmic transients. This paper examines three signal processing algorithms which are commonly used to provide constant pitch time stretching: these are SOLA (Synchronous Overlap and Add), TD-PSOLA (Time Domain Pitch Synchronous Overlap and Add), and Phase Vocoder. Enhancements to the SOLA and TD-PSOLA algorithms are provided which may make them more suited to rhythmic music. It is found that each of these three algorithms introduce audible artifacts in the time stretched waveform, the severity of these side effects and what causes them is also discussed.

## Monday 16:00-18:00 Room 216 C2b Airframe/flow-induced-noise Chair: Danielle Moreau, Thomas Geyer

### 57 Estimation of pressure fluctuations in a turbulent boundary layer based on vibro-elastic models

*MacGillivray, Ian (1); Skvortsov, Alex (1)*  
(1) DSTO, Australia

#### ABSTRACT

A simple, but scientifically rigorous, framework is proposed for estimation of effectiveness of elastic materials for the reduction of pressure fluctuations. The framework employs the intrinsic correspondence between a transformation of vorticity perturbations into acoustic waves at the elastic boundary and the conversion of transverse (shear) waves to radiated longitudinal (pressure) waves. The case of a significantly subsonic wall flow (such as a turbulent boundary layer) is considered and the relative effect of elastic boundaries on the turbulent pressure fluctuations is estimated. The framework does not allow calculation of the absolute radiation levels, but is reasonably straightforward to implement in comparison to full-scale CFD and aero-elasticity models, and is not computationally intensive. The proposed approach enables rapid estimation of numerous 'what-if' scenarios that become important for design of new vibro-absorbing materials and for prototyping studies.

### 84 The effect of flow on the natural frequencies of a flexible plate

*Peters, Herwig (1); Chen, Li (2); Kessissoglou, Nicole (1)*  
(1) UNSW Australia, Australia; (2) DSTO, Australia

#### ABSTRACT

Vorticity induced vibrations (VIV) are caused by alternating vortices downstream of a structure, which result in a lift force acting on the structure perpendicular to the direction of the mean flow. This oscillating lift force excites vibrations of the flexible structure. When the vortex shedding frequency coincides with a natural frequency of the system, the structure vibrates at large transverse displacement amplitudes. These resonances occur at the natural frequencies of the overall system and are usually very different from the natural frequencies of the structure in vacuo or in a static fluid, which makes the prediction of the VIV resonances difficult. In this work, harmonic and transient simulations are used to predict the natural frequencies of a flexible plate in vacuo, in a static fluid, and in fluid flow. The results illustrate the effect of stationary and flowing water on the natural frequencies of a steel plate.

### 269 Attenuation of acoustic resonances in an inclined open cavity using Micro Perforated Panels

*Gonzalez Diaz, Cristobal (1); Ortiz, Santiago (1); Cobo, Pedro (1)*  
(1) Consejo Superior de Investigaciones Científicas, Spain

#### ABSTRACT

Airframe noise is equal to or louder than engine noise during the landing approach of a commercial aircraft. Cavity noise is one of the most important airframe noises. When airflow passes over an open cavity, due to vortex shedding at the

upstream edge of the cavity and the geometry of the cavity, high-level aero-acoustic noise may be generated. When the incident acoustic waves produced by the airflow couples with the acoustic cavity resonances intensive tones are generated in and around the cavity at resonant discrete frequencies. Sound radiation due to the acoustic cavity resonances in an open cavity could be achieved by passive means such as lining the walls with absorbent materials. Porous and fibrous materials are used where there is no airflow. However, in presence of airflow, Micro Perforated Panels (MPP) and Porous metals are employed instead. This paper presents experimental and simulated results of the attenuation of acoustic cavity resonance tones in and around of an open cavity without and with inclined walls with lined Micro Perforated Panels.

**325 The flow-induced noise of square finite wall-mounted cylinders in different boundary layers.**

*Porteous, Ric (1); Moreau, Danielle (1); Doolan, Con J (1); Prime, Zebb (1)*

(1) University of Adelaide, Australia

**ABSTRACT**

The noise generated by a finite wall-mounted cylinder (FWMC) in cross-flow is relevant to a range of applications including aircraft landing gear, heat exchangers and automobile appendages. The noise generation characteristics and mechanisms of these objects depend primarily on the aspect ratio (ratio of length to width,  $L/W$ ) and the height of the incoming boundary layer,  $\delta$ . This paper presents acoustic and wake measurements for six square FWMC's in two different turbulent boundary layers. The aspect ratio of the cylinders ranged from  $1.94 < L/W < 13.75$  and the boundary layer heights were  $\delta/W = 1.2$  and  $2.4$ . The periodic wake and far-field acoustic characteristics of the cylinders were measured simultaneously using hotwire anemometry and a single microphone. The results show that increasing the boundary layer height increases the overall noise for  $L/W \leq 8.8$  but reduces the overall noise level for  $L/W > 8.8$ .

**407 Effects of Hydrodynamic and Acoustic Pressure Fluctuations on Transmitted Sound in Wavenumber-Frequency Domain**

*Okutsu, Yasuhiko (1); Hamamoto, Naoki (1)*

(1) Mitsubishi Motors Corporation, Japan

**ABSTRACT**

To control flow induced noise such as vehicle interior noise is very important for product development. In transmitted sound induced by flow field, a near acoustic field has to be considered. In this study, the wavenumber-frequency spectrum method was applied to the flow field around a square cylinder placed near a flat plate in order to examine pressure fluctuations in the near acoustic field. Since pressure fluctuations there contain both acoustic and hydrodynamic fluctuations, to deal with transmitted sound, both pressure fluctuations and structural bending waves have to be considered in this study. The flow field has been investigated by applying Computational Fluid Dynamics (CFD) based on the Lattice Boltzmann Method (LBM). The wavenumber-frequency spectrum was calculated by pressure fluctuations from CFD results. Thus, pressure field were investigated in wavenumber domain, and pressure fluctuations which contribute effectively to radiate the transmitted sound were extracted from all of

them. As a result, it is concluded that the wavenumber-frequency spectrum method is useful to analyze flow induced noise such as vehicle interior noise.

**710 Self-noise prediction of a sharp-edged strut using a quasi-periodic CFD-BEM technique**

*Karimi, Mahmoud (1); Croaker, Paul (1); Kessissoglou, Nicole (1); Doolan, Con J (2); Marburg, Steffen (3)*

(1) UNSW Australia, Australia; (2) University of Adelaide, Australia; (3) Universität der Bundeswehr München Werner, Germany.

**ABSTRACT**

The self-noise generated by a sharp-edged strut immersed in low Mach number flow is predicted using a hybrid computational fluid dynamics (CFD) - boundary element method (BEM) technique. The fluctuating flow field is obtained using an incompressible CFD solver. A high-order reconstruction scheme is used to extract acoustic sources based on Lighthill's analogy from the flow field data. Acoustic waves generated by these flow noise sources propagate to and are scattered by the trailing edge of the strut. A BEM model of the sharp-edged strut, based on the Burton-Miller formulation, is used to predict the scattered sound pressure. A quasi-periodic technique is implemented in the BEM model so that the sound generated by the entire span of the strut can be predicted by modelling only a small spanwise segment. The results from the hybrid CFD-BEM technique are presented for turbulent flow past a sharp-edged strut, with Reynolds number based on chord  $Re_c = 2.0 \times 10^5$  and Mach number  $M = 0.044$ . The computed aerodynamic and acoustic results are compared with experimental data obtained using the anechoic wind tunnel at the University of Adelaide.

**Monday 16:00-17:40 Room 215**  
**U1 Technical expertise in noise assessment**  
**and management**  
**Chair: Pam Gunn, Emma Shanks**

**268 Discussion on noise control at workplaces**

*Pääkkönen, Rauno (1); Saine, Kari (2); Seppänen, Saara (3); Ollila, Tapani (1)*

(1) Finnish Institute of Occupational Health, Finland; (2) Finnish Institute of Occupational Health Oy, Finland; (3) Tampere University of Technology, Finland

**ABSTRACT**

In Finland noise exposure and hearing losses remain about the same level although it is said that the work is changing rapidly towards office work. The persons at productive workplaces say often that it is not possible any more reduce noise exposure. Have the workplaces have done all that is possible especially concerning technical noise control possibilities? The measurement technology has improved significantly over the last 20 years. Also, construction technology and structures have improved. Is the productivity, efficiency and machine technology more important than human health? Many organizations state that well-being at work is very important in improving productivity and result of the company. Then it is also said that workers do not care. What are the real possibilities in improving the safety culture and noise control at

workplaces? Are we prisoners of prejudices, is it impossible to use modern technology to reduce noise at workplaces.

- 565 **Comparative study of the performance of smartphone-based sound level meter apps, with and without the application of a 1/2" IEC-61094-4 working standard microphone, to IEC-61672 standard metering equipment in the detection of various problematic workplace noise environments**

*Robinson, David Paul (1); Tingay, James (1)*  
(1) Cirrus Research plc, UK

#### ABSTRACT

An increasing prevalence of sound level meter apps may appear to be a concern to manufacturers of metering equipment but such systems are readily disregarded by professionals due to unacceptable inaccuracy, incorrect measurement methods or parameters. On a technical basis, the [typically MEMS] microphone specifications are the primary limitation to the capabilities of such devices in meeting the requirements. This considered, the attachment of a high-quality condenser microphone and pre-amplifier, as used on professional equipment, may appear to be a solution for low-cost metering that meets IEC-61672, but it is shown that many other equipment factors affect the performance of the system, and conformance to the specifications. This study investigates the premise that, while it may be argued that approximate readings, provided by smartphone metering, can at least offer an indication that further investigation may be necessary, there exists the real chance that the shortfalls in equipment properly measuring the full range of required acoustical parameters will lead to non-detection of significant workplace or environmental noise problems.

- 652 **Protection of workers from risks caused by loud sound fields. Comparison between the European and the United States standards.**

*Sabato, Alessandro (1); Sabato, Adolfo (1); Reda, Alfredo (2)*  
(1) Laboratorio di Tecnica del Controllo Ambientale, Italy; (2) Self-employed engineer, Italy

#### ABSTRACT

Workers protection from risk arising from prolonged exposure to loud acoustic fields plays a key role in the safeguard of people physical and mental wellbeing. In workplaces, depending on level and time of exposition, annoyance or permanent damage may occur. Furthermore, other parameters such as impulsive events, spectral composition, and phenomenon variability can influence the hazard connected to the sound and can, eventually, reduce protection. Among the most evolved systems used to ensure workers protection from noise, there are the European and the United States Standards. In Europe, safeguard is ensured through Directive 2003/10/EC of the European Parliament and of the Council of February 6th, 2003. It supplies the minimum health requirements to assure health-care and protection from loud sounds to those workers who are exposed to noise as a result of their work. In the United States, the OSHA Standard number 1910, subpart G "Occupational Safety and Environmental Control" regulates the procedures. In this work, noise produced in different work activities is measured using dosimeters and real-time analyzers. The results are then analyzed using the two different Directives to show whether they supply different protection levels and to

highlight possible weaknesses in the individuation of protection from loud sounds.

- 366 **A practical comparison of occupational noise standards**

*Tingay, James (1); Robinson, David Paul (1)*  
(1) Cirrus Research plc, UK

#### ABSTRACT

The use of digital signal processing in noise measurement instruments has dramatically increased the measurement capabilities of even the simplest sound level meters and noise dosimeters. There are often a wide range of frequency and time weightings available as well as a selection of thresholds, exchange rates, criterion times and criterion levels. In many modern instruments, the results of a measurement are presented to the user automatically and this can often result in confusion as to the correct value or parameter to report, especially when the metrics appear to be very similar. In the case of occupational noise exposure, this can result in the under or over reporting of values when there is a need to provide data under a range of different or multiple standards. This paper describes a review and a comparison of a range of different occupational noise standards using real-world noise sources. The review demonstrates the differences in how the same physical noise exposure is reported under these different regulations, how often similar standards can produce significantly different outcomes and suggests ways in which users can be informed about the nature of the noise measurement data that they are presented with.

- 183 **New Zealand Code of Practice for retail fireworks - Revision of the noise testing provisions: Experiences and findings**

*Page, Wyatt H (1); McLaren, Stuart J (1)*  
(1) Massey University, New Zealand

#### ABSTRACT

Retail fireworks are sold in New Zealand (NZ) each year for a limited time after testing and approval by a qualified test certifier. In 2013, there were reports that some fireworks were excessively loud. Retail fireworks are regulated under the Hazardous Substances (Fireworks) Regulations 2001 which sets a level of 90 dB for fireworks with a percussive effect. However, as qualified test certifiers are generally not trained in noise measurement and may not understand many of the fundamental difficulties in making accurate noise measurements, they may be incorrectly measuring firework noise. This highlights the need to educate both test certifiers and importers about noise measurement. The NZ Environmental Protection Authority's Approved Code of Practice (COP) sets out requirements for the design, performance and testing of retail fireworks. This paper covers the process of revising the noise testing provisions of the COP, the public consultation process and the development of a new robust testing procedure. Using the new procedure, experimental findings unexpectedly demonstrated that wind effects and frequency-weighting selection have only a small effect on the measured noise levels of the percussive fireworks.

**Monday 15:40-17:20 Room 214**  
**H2b Outdoor sound propagation**  
**Chair: Rob Bullen, Ho-Chul Shin**

**453 Field noise measurement in the huge industrial plants for accurate prediction**

*Hida, Takahiro*  
 JGC Corporation, Japan

**ABSTRACT**

Proper noise controls of the industrial plants based on accurate noise prediction are important since noise from these plants will affect wide area both inside and outside of the plants. Also, occupational noise exposure is serious problem for workers of the plants. However, it is not easy to predict the noise propagation from the industrial plants such as refineries, petrochemical and gas treatment plants because of their huge amount of noise sources and complicated structures as obstacles and reflectors. At the inter-noise conferences in the last two years, we have presented our field data of noise propagation from industrial plants over the desert and sea with prediction results followed by ISO method. In this paper we focus on sound propagation in the near field of the industrial plants. From our new field measurements, the effect of the noise sources, obstacles, and various field circumstances is discussed. We also try to improve the usage of the ISO calculation methods for each plant condition at design phase based on our measurement experience.

**499 Determination of noise damping by forests**

*Trimpop, Mattias (1); Mann, Peter (2)*  
 (1) IfL GmbH, Germany; (2) BImA, Germany

**ABSTRACT**

To predict the attenuation value caused by a forest stand a model has been developed. The model depends on an attenuation coefficient for the forest and on the geometry of the forest and the positions for the source and the receiver. The attenuation coefficient has been measured by a specific test setup for several forest stands (three different pine forests and one oak forest stand) The stock of one pine stand was reduced in several steps and measured after each reduction. The results of the measurements lead not only to qualitative statements but also to quantitative attenuation values (and coefficients) for the different forest stands. The results also showed that the actual used model had to be extended because the sound path over the canopy can have a limiting effect on the maximum forest attenuation. This effect depends on the geometry of the forest and the sound and receiver positions as well as the specific forest attenuation coefficient. The extended model provides the possibility to predict the forest attenuation by forestal and geometric parameters.

**571 Ground effect due to periodic and resonant roughness structures**

*Shin, Ho-Chul (1); Taherzadeh, Shahram (1); Attenborough, Keith (1)*  
 (1) Open University, UK

**ABSTRACT**

The recent expansion of cities throughout the world means that traffic noise is an increasing problem. The area of land between the traffic source and the receivers can provide an appropriate space where a series of low-rise roughness structures can be placed as an alternative to conventional noise barriers and earth berms. Through laboratory measurements, we have investigated the effect of periodic roughness elements on the sound propagation above a smooth hard surface. First, the periodicity-induced diffraction created by an array of solid roughness structures was studied both numerically and experimentally in the laboratory. The effects of hollow resonant elements with slit openings have been investigated also to add an additional destructive interference below the first roughness-induced destructive interference and thereby mitigate the adverse effect of the low-frequency surface waves generated by the presence of roughness elements. Finally, we have constructed and tested a nested configuration of slotted hollow roughness elements and measured the effects of the associated multiple resonance phenomenon.

**775 Determining the transmission loss of apertures above the plane wave cutoff frequency**

*Li, Jiazhu (1); Chen, Jian (1); Li, Can (2)*  
 (1) Institute of Sound and Vibration Research, Hefei University of Technology, China; (2) China Automotive Technology & Research Center, China

**ABSTRACT**

In order for enclosures and barriers to be effective, the sound transmission through holes and openings must be minimized. In this paper, a modal and sound transmission coefficient superposition (MSTCS) method is used to predict the sound transmission loss (TL) of apertures. The approach is applicable both below and above the cutoff frequency and may be used for apertures of arbitrary cross-section. Rectangular cross-section openings are considered and results are compared with the transfer matrix method, Sgard et al., acoustic FEM, and published experimental data and demonstrate good agreement with each other.

**311 Acoustic Yagi-Uda Antenna Using Resonance Tubes**

*Tamura, Yuki (1); Yatabe, Kohei (1); Ouchi, Yasuhiro (1); Oikawa, Yasuhiro (1); Yamasaki, Yoshio (1)*  
 (1) Waseda University, Japan

**ABSTRACT**

A Yagi-Uda antenna gets high directivity by applying current phase shift between elements due to resonance phenomena. It has some directors and reflectors, which are elements without electric supply. The length of directors is shorter than half-wave and that of reflectors is longer than half-wave. We proposed an acoustic Yagi-Uda antenna which elements are resonance tubes and a loudspeaker. The aim of this research is to improve directivity in a specific frequency. This can be applied to Radio Acoustic Sounding System (RASS), which is a kind of radar



for weather observation, or to a parametric loudspeaker. The phase shift of sound waves was observed in the condition with a resonance tube and without the tube at the same position. That shift changes suddenly around the resonance frequency of the tube. Our acoustic antenna has resonance tubes that have different length as directors and reflectors to apply this phenomenon. Moreover, the distances between a loudspeaker and tubes were concerned by some experiments and by numerical analysis. The acoustic antenna showed directivity in an appropriate condition of the distances and the frequency of the sound source. It will be also added the consideration about the effective frequency band of this acoustic antenna.

**Monday 16:00-18:20 Room 213**  
**Q2d Numerical methods in vibro-acoustics**  
**Chair: James Forrest, Steffen Marburg**

**138 Vibration analysis of a steam turbine blade**

*Mohan, R S (1); Sarkar, A (1); Sekhar, A Seshadri (1)*  
 (1) IIT Madras, India

**ABSTRACT**

Blade failure is a common problem of a steam turbine and it's failure in-service results in safety risks, repair cost and non operational revenue losses. Thus, the reliability of these blades is very important for the successful operation of a steam turbine. Dynamic analysis of a steam turbine blade in computational environment is carried out in the present work. In order to gain physical insight into the flexural dynamics of such turbine blades with the inclusion of the rotor dynamic effect, the turbine blade was approximated as a twisted cantilever beam with an asymmetric aerofoil cross-section fixed on a rigid rotor disk. Methods to validate the computational procedures for cantilever beam were established. Similar computational procedures were leveraged for the turbine blade. Critical speeds were obtained for different excitations.

**356 Vibration transfer analysis based on characterization of vibration energy dissipation**

*Kitahara, Atsushi (1); Yoshimura, Takuya (1)*  
 (1) Tokyo Metropolitan University, Japan

**ABSTRACT**

Reducing vibration energy of mechanical structures by controlling energy dissipation is important for improving structure-borne noise, such as interior noise in a vehicle. In this study, vibration transfer characteristics are investigated using vibration energy evaluation, when no particular vibration mode is dominant. A beam structure modeled by Finite Element approach is used as an example. We examine the efficient method of determining effective position to add damping. The method using distribution of dissipation power and that using damping addition sensitivity analysis of the vibration energy are examined. In the resonance excitation case, the optimum damping layout for vibration suppression can be determined by both methods. On the other hand, in the non-resonance excitation case, no obvious correlation is found between the optimum damping layout and the distribution of dissipation power. However, the analysis of damping addition sensitivity leads the optimum damping layout even if the excitation frequency is non-resonance.

**221 Free vibrations of a box-type structure by plates with arbitrary boundary conditions**

*Zhang, Kaipeng (1); Zhang, Tao (1); Wu, Han (2); Shi, Dongyan (1)*  
 (1) Harbin Engineering University, China; (2) AVIC International Trade and Economic Development Ltd, Xi'an, China

**ABSTRACT**

In this paper, a modified Fourier solution is developed for the free vibrations of a box-type structure as four elastically coupled rectangular plates with arbitrary boundary conditions. The modified Fourier solution for the problem is obtained using improved Fourier series method, in which both three displacements of the rectangular plates are represented by a new form of trigonometric series functions with a drastically improved convergence as compared with the conventional Fourier series. It is shown that the general coupling and boundary conditions are accounted for using the artificial spring technique and can be easily obtained by assigning the springs with corresponding values. All the unknown series expansion coefficients are treated as the generalized coordinates and solved using the Rayleigh-Ritz technique. The efficiency, accuracy and reliability of the proposed approach are demonstrated by comparison with the Finite Element Method (FEM) results. In addition, the current approach offers an easy analysis operation for the entire model parameters and the change of any parameter from one case to another is as easy as changing structure parameters without need of making any change to the solution procedure, thus this will make a parametric study and further mechanism analysis easier compared to most existing procedures.

**445 Improvement of Experimental SEA model accuracy using Independent Component Analysis**

*Nakamura, Hiroki (1); Chida, Shohei (1); Yamazaki, Toru (1)*  
 (1) Kanagawa University, Japan

**ABSTRACT**

Statistical Energy Analysis (SEA) is a suitable tool to predict vibration stationary responses. It is roughly categorized into analytical, FEM based, and experimental SEA due to the process of model construction. SEA is expected to be used for designing machines with optimal vibration transfer paths. However experimental SEA model accuracy especially in low frequency is highly dependent on experimental condition and target structure. It is required to develop model construction process for more convenient use of SEA. In this paper, preprocessing algorithm using independent component analysis (ICA) is proposed for improvement of model construction of SEA. Here, ICA is a signal processing method which is originally developed for bio-signal analysis and it is used for separation of complex mixture of several vibration sources. Feasibility of the proposed method is examined through an experiment with a test structure, composed of three flat steel plates.

**448 Impulsive Response Analysis Using Transient Energy Distribution Analysis**

*Chida, Shohei (1); Nakamura, Hiroki (2); Yamazaki, Toru (2)*  
(1) Graduate School of Kanagawa University, Japan; (2) Department of Mechanical Engineering, Kanagawa University, Japan

**ABSTRACT**

Statistical Energy Analysis (SEA) and Energy Distribution Analysis (EDA) are suitable for predicting responses to stationary vibrations. These methods consider a structure of interest as an assembly of subsystems and analyze energy flows between the subsystems. In particular, EDA can analyze vibrations over the whole frequency range, while SEA is basically used only for high frequencies. However, these methods do not consider transient dynamic characteristics, so they are not applicable to the analysis of unsteady vibrations such as impulsive vibrations. This paper proposes transient EDA (TEDA) as an extension of EDA to impulsive responses. The proposed method is expected to be a suitable tool for impulsive analysis of huge structures like ships. The feasibility of the proposed method is examined through an experiment with a test structure composed of three flat steel plates. Also, the proposed method is compared with TSEA. We find that TEDA can predict the vibration energy of each subsystem more accurately than TSEA. Measurements of the energy response of a structure composed of three flat steel plates, including a coupling at right angles, showed specific energy transfer characteristics: the maximum energy of the end plate that is far from the input plate was larger than that of the second plate that is between the input and the end plates; and energy peak rise time of the end plate was faster than that of the second plate.

**163 The modeling and free vibration analysis of coupled plates of various types**

*Shi, Shuangxia (1); Jin, Guoyong (1); Chen, Mingfei (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

This paper is concerned with the modeling and free vibration analysis of coupled plates of various types, which includes T-shape plates, cross shape plates and a panel-linked double-panel structure. The in-plane vibration and bending vibration probe are considered in coupled structures. The vibration problems are solved using an improved Fourier series method in which the in-plane displacement and bending displacement are expressed as the superposition of a double Fourier cosine series and several supplementary functions to ensure (improve) the uniform convergence (rate) of the Fourier series expansion. The dynamic responses of the coupled structural-acoustic system are obtained using the Rayleigh-Ritz procedure based on the energy expressions for the coupled system. The accuracy and effectiveness of the proposed method are validated through numerical examples and comparison with results obtained by the finite element analysis.

**180 Numerical noise generation in modelled bearing vibration signals**

*Singh, Sarabjeet (1); Howard, Carl (1); Hansen, Colin (1); Kopke, Uwe (2)*  
(1) University of Adelaide, Australia; (2) Trackside Intelligence Pty Ltd, Australia

**ABSTRACT**

A two-dimensional (2-D) explicit dynamics finite element (FE) model of a rolling element bearing was solved using a commercial FE software package, LS-DYNA. It was found that the modelled bearing vibration signals contain a significant amount of numerical noise. This paper provides an explanation of the physical mechanism by which the numerical noise is generated. The noise frequencies were analytically estimated and filtered out to achieve comparatively clean vibration signals and rolling element-to-raceway contact forces.

**Monday 16:00-17:40 Room 212**

**B1 Fan and duct noise**

**Chair: Colin Tickell**

**17 Standard, quiet and super quiet – the modelling of flow and the reduction of turbulences**

*Bradwell, Simon*

**ABSTRACT**

The understanding of noise and efficiency characteristics of fan motor systems is important for all engineers developing air movement systems whether they are for stand-alone ventilation systems or for air movement solutions incorporated into broader systems. The volume of air flow and air velocity through static pressure resistances are the main and vital variables controlling system performance in air movement. However if these characteristics are not controlled, then turbulence causes losses and low system performance. The paper explores the noise characteristics of typical fan types. As the most common fan types, fluid flow characteristics of both axial fans and single inlet centrifugal backward curve fans without housing (plug fans) are detailed and design improvements discussed. Installation characteristics for improved noise are explored and recommendations for system design improvements are given including performance improvements in condensers and air handling units. Conclusions for mechanical engineers working on building systems are shown and recommendations and design principles given.

**496 Local improvement of flow and noise performances of axial-flow fans in a household refrigerator**

*Seong-hun, Kim (1); Seung, Heo (1); Cheolung, Cheong (1); Taehoon, Kim (2)*  
(1) Pusan University, South Korea; (2) LG, South Korea

**ABSTRACT**

In this paper, numerical and experimental investigations on an axial-flow fan with grooved/double-sectional blades are performed to improve its performance in terms of volume flow rate and noise at a local operating point. The target fan is used to cool a mechanical room of a household refrigerator.

However, it is found that the target system has more resistance than that for which the fan is originally designed and the fan's operating point is not optimal. First, the performance of the target fan unit is measured from the fan performance tester. Then, the P-Q curve is predicted using the virtual fan performance tester based on the CFD techniques to solve the incompressible RANS equations. The surface acoustic power of the fan unit is also predicted using the broadband noise sources modeled from the CFD results. The predicted P-Q curve is compared to the measured data, through which the validity of the numerical techniques is confirmed. On the basis of the prediction results, new fan units with modified fan's housing structures are devised. Further predictions using these new fan units show that these fan units generate higher volume flow rate while keeping surface acoustic power levels lower than the existing fan system on the local operating point

**745 Fan duct noise elimination by the use of helicoidal resonators**

*Lapka, Wojciech*  
Poznan University of Technology, Poland

**ABSTRACT**

This work focuses on describing the fan duct noise elimination by the use of helicoidal resonators. It is the newly patented passive acoustic filter in duct - especially cylindrical. The narrowband noise attenuation could be obtained by properly designed helicoidal shape inside cylindrical duct. The helicoidal resonator gives the possibility to reduce the discrete tonal sounds in different ways, a single or multiple application. The possible band filtering could be used to attenuate discrete noise generated in the range of rotational speeds of fan. Also, this work consists the theoretical considerations supported by practical examples of reduction of fan duct noise by the use of helicoidal resonators.

**1033 Withdrawn6**

*Withdrawn6,*

**ABSTRACT**

*Withdrawn6*

**742 Stall detection using near-field low frequency and pressure modulation in turbomachines**

*Corsini, Alessandro (1); Feudo, Sara (1); Tortora, Cecilia (1); Ullucci, Graziano (2)*  
(1) Sapienza University of Rome, Italy; (2) SED Soluzioni Srl, Italy

**ABSTRACT**

This work investigates on the use of unconventional sensors to measure the near field unsteady pressure on the casing of a fan in a view to detect rotating stall. Rotating stall is an aerodynamic issue with a frequency signature usually half the rotor frequency. In low speed turbomachines, such as industrial fan, this turns in very low frequencies, even lower than 10 Hz. The authors developed and set-up a measurement system able to acquire low frequency pressure signals using dynamic microphones. Traditional methods use piezoelectric sensors, e.g., pressure transducers or microphones, respectively in the near and far-field, to detect instability from the signal patterns with broad frequency ranges. Recently electret microphones

have been proposed, but with a cut-off frequency of 20 Hz as such not suitable for signal in infrasound region. The sensor used in this work, have a narrower frequency range than more advanced technologies. In this paper the authors developed a measurement chain based on dynamic microphone and pressure transducer in order to create a stall warning system. They tested the system on a low speed axial fan and they validated the work against state of the art acoustic control techniques. For this reason those devices represent candidate solutions for the detection of the patterns typical of rotating stall in turbomachines.

**Monday 15:40-16:20 Room 211**  
**N4b Classroom acoustics**  
**Chair: James Whitlock**

**691 Classrooms and voice recognition applications in a foreign language teaching**

*Ono, Yuichi (1); Ishihara, Manabu (2); Onishi, Akio (3); Yamashiro, Mitsuo (4)*  
(1) University of Tsukuba, Japan; (2) Oyama National College of Technology, Japan; (3) Version2, Japan; (4) Ashikaga Institute of Technology, Japan

**ABSTRACT**

The advantages of using Voice recognition software in a foreign language course to enhance speaking accuracy and fluency have been suggested in the literature (1,2). One of the difficulties faced with Voice recognition software is a "noise" around the speakers. In our campus, the normal class size is around 40 for one English course. This means is that the software has to recognize speaker's voice correctly among other speakers' "noise". In this study, we carried out several experiments in terms of the system and the devices of the classroom. We picked up two kinds of classroom. One is Computer-Assisted Language Learning (CALL) room, a specialized classroom for foreign language learning, where there are wired individual PC and headphone with microphone for each student. The other classroom is a normal classroom, where tablet computers or mobile devices were utilized. Our expectation is that the rate of recognition should be better in CALL classrooms than that of normal classroom with tablet computers, since students use headphones and microphones in a CALL classroom. The results of our study indicated that this hypothesis was true only with sight significance. This paper suggests that it is still difficult to integrate Voice recognition software into normal classroom with local application with tablet PC.

**29 Vocal problems for teachers and school acoustics - a field study**

*Durup, Nick (1); Shield, Bridget (2); Dance, Stephen (2); Sullivan, Rory (3)*  
(1) London South Bank University, UK, Sharps Redmore Acoustic Consultants, United Kingdom; (2) London South Bank University, UK; (3) Sharps Redmore Acoustic Consultants, UK, Sharps Redmore Acoustic Consultants, United Kingdom

**ABSTRACT**

School acoustic design in the UK is traditionally concerned with the needs of the listener, rather than the voice ergonomics of the speaker. However, a recent survey undertaken by London

South Bank University (LSBU) indicated that over 65% of the surveyed teachers had experienced voice problems during their career. This supports other studies suggesting that teachers have a significantly higher rate of voice problems than the general population. In an effort to better understand the influence of classroom acoustic design on the speech levels of teachers LSBU is currently undertaking measurements of teachers' voices in different classroom types. The measurements are being undertaken using an Ambulatory Phonation Monitor (APM) which measures voice parameters directly from the skin vibrations in the neck, thus eliminating the effects of other noise sources in the environment. The rooms involved are acoustically benchmarked separately to enable relationships between the voice data and acoustic parameters to be investigated. This paper presents results of the field measurements to date, with a brief summary of the data collected to date from the teachers' questionnaire survey, and discusses some of the initial findings. South Bank University (LSBU) indicated that over 65% of the surveyed teachers had experienced voice problems during their career. This supports other studies suggesting that teachers have a significantly higher rate of voice problems compared with the general population. In an effort to better understand the influence of classroom acoustic design on the speech levels of teachers LSBU is currently undertaking measurements of teachers' voices in different classroom types. The measurements are being undertaken using an Ambulatory Phonation Monitor (APM) which measures voice parameters directly from the skin vibrations in the neck, thus eliminating the effects of other noise sources in the environment. The rooms involved are acoustically benchmarked separately to enable to relationships between the voice data and acoustic parameters to be investigated. This paper will present results of the teachers' survey and the field measurements to date, and discuss some of the initial findings.

**Monday 16:40-17:40 Room 211**  
**N2 Healthcare facility acoustics**  
**Chair: Kenric Van Wyk**

**234 Review of design approaches to acoustics in Australian hospitals**

*Zoontjens, Luke (1); Cockings, Thomas (1)*  
 (1) SLR Consulting, Australia

**ABSTRACT**

Surveys of Australian hospital outpatients appear to overlook quietness, one of the lowest areas of satisfaction internationally and an issue which extends beyond individual dissatisfaction to impact actual health outcomes in both current (and soon to be commissioned) hospitals. However, in terms of acoustic design, few Australian hospitals are consistent in their tender requirements and construction provisions, with the exception of reference to several Australian Standards which are arguably due for an update. Consequently, recent research findings challenge the basis of existing guidelines and approaches currently recommended for the acoustical design of these and other healthcare facilities. This paper presents a short review of current guidelines in use and compares these guidelines against the literature state of the art. Recommendations are made as to suitable design positions to be used in the tendering and specification of future healthcare facilities.

**951 A summary of the 2014 FGI and sound & vibration guidelines for healthcare facilities**

*Van Wyk, Kenric (1); Horan, Daniel (2); Murphy, Kristen (1)*  
 (1) Acoustics By Design, USA; (2) Cavanaugh Tocci Associates, USA

**ABSTRACT**

The FGI Guidelines are the two-volume standard reference document for healthcare construction. Both volumes (hospitals; residential care) include comprehensive acoustical criteria written in code language that are used by authorities in the United States and 60 other countries, and serve as the sole reference for acoustics in USGBC-LEED for Health Care. The acoustical criteria set "minimum standards" and were developed by the FGI Acoustics Working Group, a ten-year-old standing committee including members of the Acoustical Society of America, INCE-USA, and other professional organizations. This group authors the sole acoustical reference for the Guidelines called Sound & Vibration Design Guidelines for Health Care Facilities (S&V-3.0-2014), publically available on the FGI website and to be published by Springer-Verlag during the first half of 2015. The Guidelines are edited and re-issued every four years by the Facility Guidelines Institute, and jointly published with the American Hospital Association. The Guidelines are revised following an open, formal, Continual Improvement Process that includes a peer- and public-review incorporating the latest research and changes in healthcare laws. This discussion by the national Secretary of the FGI Acoustics Working Group and the Chair of its Education Committee will: address the new code requirements related to acoustics; summarize the myriad changes from the 2010 edition; and describe the public and comment process for the next edition to be released in 2018.

**218 Acoustic design guidelines for dementia care facilities**

*Hayne, Michael James (1); Fleming, Richard (2)*  
 (1) Floth Sustainable Building Consultants, Australia; (2) University of Wollongong, Australia

**ABSTRACT**

People with dementia are particularly affected by the acoustic environment. While people with dementia might have normal hearing, they can lose the ability to interpret what they hear accurately. As such, the amount, type and variety of noise a person with dementia is exposed to needs to be carefully regulated, as over or under exposure to noise can cause confusion, illusions, frustration and agitation. This paper explores the role of noise on the ability of people with dementia to interpret and understand their surroundings. Examples are provided of acoustical design and management practices that contribute to increased levels of agitation and aggression among residents who have dementia. Guidelines are provided for the acoustic design of dementia care facilities with the ultimate aim of creating facilities that are calming and engaging for people with dementia in residential care.

**Monday 16:00-17:40 Room 210**  
**N7b Acoustic criteria in regulations and**  
**classification schemes for buildings**  
**Chair: Birgit Rasmussen, John LoVerde**

**650 Open plan offices - classification scheme based on ISO 3382-3 parameters**

*Nocke, Christian*  
 Akustikbüro Oldenburg, Germany

**ABSTRACT**

With the introduction of ISO 3382, part 3 for open plan offices in 2012 new room acoustic parameters have been introduced. For these parameters only little experience in real life projects is available. In contrast to the draft version of IOS 3382-3 in 2009 the final 2012 version of ISO 3382-3 does not suggest a classification scheme on open plan offices. With the revision of German guideline VDI 2569 on "Sound insulation and room acoustic design in offices" a classification scheme based on the ISO 3382-3 parameters is discussed. The result is a classification into three quality levels for single and multi-person offices. The definitions on propagation paths (in ISO 3382-3) as well as other aspects of ISO 3382-3 will be discussed and additional recommendations and clarifications will be presented.

**614 Psychoacoustical evaluation of heavyweight floor impact sounds in apartment buildings**

*Jeon, Jin Yong (1); Oh, Seong Min (1)*  
 (1) Hanyang University, South Korea

**ABSTRACT**

An auditory experiment was conducted to establish annoyance criteria for floor impact noise in apartment buildings. Heavyweight floor impact sounds were recorded using an impact ball; the impact sound pressure level (SPL) together with the temporal decay rate (DR), which is quantified by the dB drop per second, was analyzed. For the experiment, A-weighted exposure levels of the heavyweight floor impact sounds ranging 34–73 dB were evaluated at 3 dB intervals. Participants used a 7-point verbal scale to evaluate the level of annoyance from floor impact noise. The results show that the annoyance increases with increasing impact SPL and decreasing DR. Consequently, a classification and an acceptable level of floor impact sounds were proposed.

**887 A new metric to quantify and evaluate low frequency impact noise**

*LoVerde, John J (1); Dong, Wayland (1)*  
 (1) Veneklasen Associates, USA

**ABSTRACT**

Low frequency footfall noise ("thudding") is a common source of complaints in lightweight (timber) joist- framed multifamily projects. Previous work by the authors has indicated that the low frequency impact sound pressure levels (LFISPL) from a standard ISO tapping machine are highly correlated with occupant reaction. It remains to translate the raw LFISPL data into a useful single number metric that maintains the high correlation with subjective reaction, provides adequate dynamic range to distinguish the performance of different

assemblies, and is conveniently scaled. This paper introduces Low-frequency Impact Rating or LIR, a new metric to quantify and evaluate low frequency impact noise.

**202 Determination of vibration acceptability and annoyance design indicators for human response to wooden-floor vibrations**

*Negreira, Juan (1); Trollé, Arnaud (2); Jarnerö, Kirsí (3); Sjökvist, Lars-Göran (3); Bard, Delphine (1)*  
 (1) Lund University, Sweden; (2) Université de Lyon, France; (3) Technical Research Institute of Sweden, Sweden

**ABSTRACT**

The vibrational response of wooden floor systems is an issue that needs to be dealt with more adequately. Notably, studies addressing human response to vibrations are needed in order to better estimate what level of vibrations in dwellings can be seen as acceptable. In this investigation, measurements on five different floors were performed in a laboratory environment at two locations in Sweden. Acceleration measurements were carried out while a person either was walking on a particular floor or was seated in a chair placed there, as the test leader was walking on the floor. These participants filled out a questionnaire regarding their perception and experiencing of the vibrations. Independently of the subjective tests, acceleration measurements were also carried out, using a shaker as excitation source, with the aim of determining the dynamic characteristics of the floors. In addition, static load tests were performed using displacement gauges so as to measure the floor deflections. The ultimate aim was to develop indicators of human response to floor vibrations, specifically those regarding vibration acceptability and vibration annoyance, their being drawn based on relationships between the questionnaire responses obtained and the parameter values determined on the basis of the measurements carried out.

**906 Extensions of EN 12354 vibration reduction index expressions by means of FEM calculations**

*Crispin, Charlotte (1); De Geetere, Lieven (1); Ingelaere, Bart (1)*  
 (1) Belgian Building Research Institute, Belgium

**ABSTRACT**

In this paper, a comparison is made between the measured and calculated vibration reduction indices (Kij) and the engineering approximations in EN 12354-1. First, the existing expressions in EN 12354-1 for simple junctions of homogeneous elements are compared with a large data set of measured and calculated Kij spectra. For more complex junctions, not in EN 12354-1, like junctions with cavity walls (H-junctions) and junctions with different surface masses for in-line elements, a large number of FEM calculations have been made, from which new engineering approximations are derived.

**Monday 16:00-18:00 Room 209**  
**D2c Vehicle noise vibration and harshness**  
**(NVH)**  
**Chair: Zhichao Hou, Paul Kennings**

**932 Modelling of Fluid-Structure Interactions in the Hydraulic Circuit of Passive Interconnected Suspensions**

*Zhao, Jing (1); Zhang, Nong (1); Ji, Jin Chen (1)*  
 (1) University of Sydney, Australia

**ABSTRACT**

The pressure changes in the liquid-filled fluid circuits of Hydraulically Interconnected Suspensions (HIS) often lead to vibration of the whole pipeline and associated structures and hence become a source of structural noise, which degrades ride comfort.

This paper presents the numerical and experimental investigation into the vibration of this kind of hydraulic circuit. The one-dimensional wave theory is employed to formulate the equations of motions that govern the dynamics of the fluid-structural system. Axial and lateral vibrations as well as the effects of shear deformation on the lateral vibration of the pipe are considered. The dynamic interaction between fluid and pipe is modelled by considering Poisson and junction coupling.

The Transfer Matrix Method (TMM) is applied to determine the steady state response of the fluid-structural system, which consists of various pipe sections, hose sections, damper valves, accumulators, supports and joints. Laboratory experiments are performed on a liquid-filled hydraulic circuit with pulse trigger. The measured steady-state responses of the fluid circuit are compared with those obtained from the numerical simulations of the developed hydraulic circuit model. It is found that the developed model of the hydraulic systems including the coupling with boundaries has a reasonable accuracy in the frequency range of interest.

**305 The characteristic identification of disc brake squeal based on ensemble empirical mode decomposition**

*Yao, Liang (1); Hiroshi, Yamaura (1)*  
 (1) Tokyo Institute of Technology, Japan

**ABSTRACT**

Disc brake squeal, which is considered as a self-excited vibration induced by friction force, has received much attention over decades due to the high customer requirements of the NVH properties of vehicles. This paper presents a characteristic identifying method for the disc brake squeal by analysing the acoustic brake squeal signal obtained from experiment. The sound of brake squeal was recorded with a sound level meter to obtain the acoustic signal that later is examined by implementing several different signal processing methods. Firstly, the Fast Fourier Transform and the Short-Time Fourier Transform are performed to illustrate the frequency components of the signal and their evolution with time. Later, the acoustic signal is analyzed using ensemble empirical mode decomposition (EEMD) which is improved from empirical mode decomposition (EMD) by adding white noises of finite amplitude to the original acoustic signal to alleviate mode mixing problem occurred in EMD. After the implementation of EEMD, the original signal is decomposed into several intrinsic

mode functions (IMFs). Finally, the Hilbert Transform is conducted for revealing the detailed information about the frequency and amplitude features of each calculated IMF.

**74 Instability prediction of brake squeal by nonlinear stability analysis**

*Zhang, Zhi (1); Oberst, Sebastian (1); Lai, Joseph C S (1)*  
 (1) UNSW Canberra, Australia

**ABSTRACT**

Prediction of brake squeal as unwanted high frequency noise above 1 kHz remains a challenging problem despite substantial research efforts in the past two decades. Brake squeal, triggered by friction-induced self-excited vibration, can be caused by many different and interacting mechanisms with nonlinear origins in material properties and boundary conditions. Although brake squeal is essentially a nonlinear phenomenon, the standard industrial practice for prediction of brake squeal relies on the linear complex eigenvalue analysis which may under-predict or over-predict the number of unstable vibration modes. Brake squeal can be considered in nonlinear dynamics terms to be caused by a friction-induced self-excitation driven into instability and oscillating in a limit cycle through super-critical Andronov-Hopf bifurcations. In this paper, a nonlinear stability analysis that may be applied to a full brake system is examined using an unforced 4-DOF friction oscillator with cubic nonlinearity. The local bifurcation behaviour of this model is studied using the normal form theory and the nonlinear stability boundary is evaluated. Differences between results of linear and nonlinear analyses are discussed and the limitations of the linear analysis are highlighted. The energy provided by friction and consumed by damping is calculated by multiple scales method to provide a physical explanation for instability generation.

**176 Vehicle Chassis Decoupling Control Based on Neural Network Inverse Method**

*Yang, Jun (1); Zhao, Linfeng (1); Chen, Wuwei (1); Huang, He (1); Xia, Guang (1)*  
 (1) Hefei University of Technology, Hefei China

**ABSTRACT**

In order to eliminate the interference and coupling among automobile chassis electronic control subsystems, an integrated decoupling control approach based on neural network inverse method was proposed. The integration of active front steering (AFS), direct yaw moment control (DYC) and active suspension (ASS) was studied. According to Inter-actor algorithm, the reversibility of chassis system was analyzed and a BP neural network inverse system of the multivariable chassis system was obtained. Designing a close-loop controller and combining it with neural network inverse system, a compound controller was completed to improve dynamic performance. The simulation results showed that the proposed decoupling control approach could eliminate the interference and couple among automobile chassis electronic control subsystems, and improve the automobile handling and stability performance.

**70 Target setting and source contribution for sound quality of a motorcycle**

*Lu, Ming-Hung (1); Jen, Ming Une (1)*

(1) Industrial Technology Research Institute, Taiwan

**ABSTRACT**

Sound quality is an essential competitive attribute for motorcycles' marketing. In this study, the sound perception of a motorcycle, powered by a 400 cc single-cylinder engine, didn't achieve its "sporty" statement and the associated sound quality refinement engineering was initiated. The first phase of refinement included benchmark, noise source contribution and target setting. This paper focuses on the methods in setting sound target through source contribution and sound synthesization. Noise data were measured in a hemi-anechoic chamber with a rolling road facility. Loudness, sharpness and order spectra were used to provide objective quantification metrics. From the results of subjective and objective evaluation, it was concluded that the motorcycle studied should increase its sound pressure level, loudness and sharpness; it also should magnify the lower integer-order components of the perceived sound and suppress the single-cylinder engine characteristic half-order components. The noise source contribution results validated the exhaust and intake systems should be improved first to fulfill a favorable sound quality. Combining the objective, subjective and source contribution results, this study successfully synthesized a promising and feasible vehicle level sound target. It was then cascaded to get the synthesized intake and exhaust noise targets for next CAE design modification.

**782 Indoor pass-by noise engineering: a motorbike application case**

*Bianciardi, Fabio (1); Janssens, Karl (1); Choukri, Mostapha (1);*

*Van Der Auweraer, Herman (1)*

(1) LMS International, Belgium

**ABSTRACT**

Pass-by noise testing is nowadays a well-defined procedure in the development process of motorbikes. Manufacturers facing issues of non-compliance with regulations are looking for techniques to quantify the subsystem noise contributions, enabling the validation of designs for pass-by noise targets, early in the design process. Masking techniques are nowadays often used to separate the noise source contributions. However, since these techniques are time consuming and also have an influence on the operating conditions, motorbike companies are seeking for faster solutions. In this study, a time-domain TPA method was investigated and tested on a Piaggio Beverly 350 in an indoor pass-by noise test. The method consists in the application of time-domain filters, derived from FRF measurements, to microphone measurements close to the noise generating components. The results are time histories of the acoustic loads and partial contributions to the array of target microphones on the two sides of the testing room. The synthesized target response signals are mixed together into an overall pass-by noise level by taking into account the speed profile of the motorbike. The TPA method helps engineers to quantify the noise contributions to the overall pass-by noise level, with a remarkable time saved compared to the masking approach.

**Monday 15:40-18:00 Room 208**  
**D6 Tyre/road noise - tyre factors**  
**Chair: Piotr Mioduszewski, Ulf Sandberg**

**175 Characterisation of low-noise tyres for the roads of Hong Kong**

*Hung, Wing-tat (1); Leung, Randolph Chi-kin (2); Lam, Yat Ken (2)*

(1) CEE, HKPolyU, Hong Kong; (2) Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

This study on low noise tyres started with a survey on commonly used tyres on 941 light duty vehicles. Subsequently, most common brands of tyre with a carefully selected size and tread block patterns were selected for testing on one commonly laid road surface, namely wearing course (WC), and one low noise road surface, namely polymer modified friction course (PMFC). Over 30 new and old tyres with varying properties of rubber hardness, depth and sizes were tested; tyre/road noise, air and road surface temperature, tyre pressure and vibration data were recorded. In order to identify the tyre properties on tyre/road noise, over 500 runs on the roads were made. It was found that the bi-directional & asynchronous (Michelin) was the quietest and the symmetrical tyre pattern (SRTT) was the noisiest on WC. The asymmetric pattern (Yokohama C.drive) became noisiest on PMFC. The change of driving speed from 50 to 70 km/h changed the noise order of bi-directional tyre (Yokohama A.drive) and the directional tyre (Dunlop Direzza). Tyre/road noise increased as the tyre rubber hardness increased owing to aging. The effects of the tyre tread depth and the tyre size on the level of noise are uncertain and minor.

**770 An investigation of the relationship between texture and tyre/road noise for different types of road surfaces and passenger car tyres**

*Berge, Truls (1); Viggen, Erlend Magnus (1)*

(1) SINTEF ICT, Norway

**ABSTRACT**

The texture of the road surface has a major influence on the generation of tyre/road noise. For dense surfaces this may be the most important factor besides the tyre characteristics themselves. Throughout several projects, SINTEF has performed measurements of the tyre/road noise of a wide range of passenger car tyres on different types of road surfaces. These road surfaces are both normally used road surfaces in Norway and road surfaces on test areas. In this paper, some results from the analysis of the relationship between the texture levels and the tyre/road noise levels are presented. In previous investigations it has been found that there is a positive correlation between texture levels at longer wavelengths (like 20–200 mm) and the noise levels, while there is a negative correlation between texture levels at shorter wavelengths (below 8 mm) and the noise levels. In our analysis, the former is confirmed and the latter is found true for some data sets, but not for others. The analysis also shows that the noise from different tyres has a similar relationship with texture, even if the overall noise levels differ.

**979 Tyre tread pattern noise optimization by a coupled source-human perception model**

*Bekke, Dirk A (1); Wijnant, Ysbrand H (2); De Boer, Andre (2); Bezemer-Krijnen, Marieke (2)*  
(1) Apollo Tyres Global R&D, The Netherlands; (2) University of Twente, The Netherlands

**ABSTRACT**

The current tyre design process uses many experimental evaluations and it may take therefore more than 2 years to develop a tyre. The use of simulation tools improves and speeds up this process. Research has shown that the human perception of tyre tread pattern noise is mainly determined by the noise characteristics: level, tonalness and modulation (also called drumming). In this paper a new source model and human perception model is described. The source modelling approach predicts the correct trends of the three tyre tread pattern noise characteristics. From the noise characteristics dedicated Sound Quality Metrics are defined: for level the Standard Deviation (STD), for tonalness the Order Prominence (OP) and for modulation the Multi- Order Modulation (MOM). Using these Sound Quality Metrics the human perception model is obtained by regression analysis, predicting the human perception of tyre tread pattern noise correctly ( $R^2=0.94$ ). The coupled source - human perception model enables a very fast optimization of a complete tyre tread pattern design to human comfort.

**958 Temperature influence on tyre/road noise of selected tyres**

*Mioduszewski, Piotr (1); Taryma, Stanisław (1); Woźniak, Ryszard (1)*  
(1) Gdansk University of Technology, Poland

**ABSTRACT**

Air and road temperatures substantially affect road vehicle noise emission. The temperature influence on tyre/road noise depends mainly on tyre-road combination. It is different for dense and porous pavements, for bituminous and cement ones. It differs also depending on tyres. The correction procedures for temperature effect are still under consideration and preparation. Tyre/road noise measurements using CPX method were performed to establish correlation between noise emission and ambient temperature for a set of ten selected tyres (characterized by a wide range of noise levels and including the two ISO reference tyres) on a SMA8 dense pavement within the recommended air temperature range from 5°C to 30°C with a step of about 5°C. Both air and road temperatures were taken into consideration. The results of this experiment were presented and discussed in the paper. A good correlation between air and road surface temperature was outlined. A linear relationship between noise emission and temperature was observed for eight tested tyres. The derived temperature correction factor was varied from -0.067 dB/°C to -0.145 dB/°C with an average of -0.107 dB/°C (-0.09 dB/°C for the two ISO reference tyres). There was no correlation for the remaining two tested tyres.

**8 A study of the tyre cavity resonance and its mitigation using modal analysis method**

*Chanpong, Napasin (1); Mohamed, Zamri (1); Wei, Haiqiao (2); Watkins, Simon (1); Wang, Xu (1)*  
(1) RMIT University, Australia; (2) Tianjin University, China

**ABSTRACT**

This paper will focus on determining characteristics of tyre cavity resonance noise and its mitigation method. There are many factors that affect the noise transmitted to vehicle cabin, this includes coupling mode of structure and tyre air cavity which will be investigated in this paper. The results from experimental modal analysis will be compared with those from finite element modal analysis. These investigations would lead to understanding and reduction of tyre cavity resonance noise. Tyre samples were tested for their material properties using tensile tests and wheel assembly was tested for its dynamic properties through roving impact hammer tests. The frequency response data of roving impact hammer tests on a wheel tyre assembly was processed using MEScope software for identifying its mode shape. The results have shown the significant vibration response amplitude peak between 200-250 Hz is related to the tyre cavity resonance noise.

**155 Influence of Circumferential Tread Pattern Stiffness on Tire Road Noise Generation under Driving Torque**

*Stalter, Frank (1); Gauterin, Frank (1)*  
(1) Karlsruhe Institute of Technology KIT, Germany

**ABSTRACT**

Concerning the sound emission of electric vehicles there are two main challenges: On the one hand, the exterior noise is on a very low noise level and approaching electric vehicles might not be recognized in city traffic. On the other hand, compared to internal combustion engines, electric drives develop a considerably high torque from the standstill which might increase tire road noise of about 10 dB in the near-field. Since combustion engine noise gets eliminated, tire road noise will not be masked anymore during acceleration but instead occurs as a disturbing, dominant acoustic source. The paper describes first an inner drum test rig which allows the reproducible measurement of tire road noise on real road surfaces at driving and braking torque. Then, test results of special tires with different rubber compounds and pattern designs are presented. The influence of pattern stiffness and tire torque on tire road noise generation is analysed. Additional the inner drum test results were validated by pass-by measurements on different road surfaces. Finally, the effects and mechanisms of the noise phenomena are discussed and tire pattern design concepts for low noise emission under driving torque are derived.

**833 A Simulation Methodology for Tire/Road Vibration Noise analysis**

*Yintao, Wei (1); Feng, Xijing (1); Xiang, Dabing (1); Chen, Yalong (1)*  
(1) Tsinghua University, China

**ABSTRACT**

A new methodology for simulating tire/road vibration noise is presented in this paper, which is based on the Mixed Lagrange-Euler Method and Pseudo Excitation Method (PEM). A



non-rotational acceleration field is constructed by mapping the acceleration of the Lagrange mesh onto the Euler mesh. Using this acceleration field as the acoustic source, the rolling noise can be predicted numerically using the Boundary Element Method (BEM) and Finite Element Method (FEM). In addition, a Pseudo Excitation Method (PEM) is proposed to simulate effect of road surface profile on the tire noise, which transfers the road elevation power spectral density (PSD) to the sum of harmonic excitation. A frequency domain analysis can be conducted to obtain the dynamical response of the tire on the real road and a sound emission analysis can be performed to get the sound field excited by road profile. In this way the tire/road vibration noise can be modeled completely.

**Monday 16:00-18:00 Room 207**  
**R3b Underwater noise and its control**  
**Chair: Nicole Kessissoglou**

**595 Attenuation of low frequency underwater noise using arrays of air-filled resonators**

*Wochner, Mark S (1); Lee, Kevin M (2); McNeese, Andrew R (2); Wilson, Preston S (2)*

(1) AdBm Technologies, USA; (2) University of Texas at Austin, USA

**ABSTRACT**

This paper investigates the acoustic behavior of underwater air-filled resonators that could potentially be used in an underwater noise abatement system. The resonators are similar to Helmholtz resonators without a neck, consisting of underwater inverted air-filled cavities with combinations of rigid and elastic wall members, and they are intended to be fastened to a framework forming a stationary array surrounding a noise source, such as a pile driving operation, a natural resource production platform, or an air gun array. Previous work has demonstrated the potential of surrounding noise sources with arrays of large stationary encapsulated bubbles that can be designed to attenuate sound levels over any desired frequency band and with levels of reduction up to 50 dB [Lee and Wilson, Proceedings of Meeting on Acoustics 19, 075048 (2013)]. Open water measurements of underwater sound attenuation using resonators were obtained during a set of lake experiments, where a low-frequency electromechanical sound source was surrounded by different arrays of resonators. The results indicate that air-filled resonators are a potential alternative to using encapsulated bubbles for low frequency underwater noise mitigation.

**611 Underwater noise generated by merchants ships in coastal waters of the Gulf of Gdansk**

*Listewnik, Karol*  
 Polish Naval Academy, Poland

**ABSTRACT**

Currently, there has been a growing interest in monitoring underwater sound as pollution on the environment. The aim of the study was to gather experience in the measurement of commercial vessels and information about the changes in frequency and sound level for typical commercial vessels during normal operation at the selected point of shipping line. The paper presents description and chosen results of measurements campaign of underwater noise generated by

commercial vessels during normal operating conditions. Measurement campaign was carried out in several multi-day cycles in a designated place on the shipping line at a depth of 20 m. The underwater noise measurements were recorded with regard to the current parameters of the ship: draught at the bow and stern, speed and route transition (by AIS) and environmental conditions: sea bathymetry, wind, sea state, sound speed profiles with temperature, density and depth.

**671 Modelling underwater shipping noise in the Great Barrier Reef Marine Park using AIS vessel track data**

*MacGillivray, Alexander (1); McPherson, Craig (2); McPherson, Geoff (3); Izett, Jonathan (1); Gosselin, Jeremy (1); Li, Zizheng (1); Hannay, David (1)*

(1) JASCO Ltd., Canada; (2) JASCO Pty Ltd., Australia; (3) James Cook University, Australia

**ABSTRACT**

Shipping traffic is the largest contributor of anthropogenic noise in the ocean. Chronic exposure to shipping noise may be a significant habitat-level stressor to marine fauna. While sound measurements can characterise shipping noise at discrete locations and depths, acoustic models can predict anthropogenic sound levels over large regions of the ocean provided the types and locations of all important sound sources are known. We have developed one such model that uses Automated Identification System (AIS) ship tracking data and wind speed data to simulate the time-dependent noise field originating from many ships inside a large number of ships over a wide geographic area. We apply this model to simulate noise from ship traffic in a 25,000 km<sup>2</sup> region of the Great Barrier Reef Marine Park, off the coast of Townsville, Qld, using three months of AIS data. Acoustic source levels are assigned to the vessels present based on the respective ship-class information embedded in the AIS records. Frequency-dependent propagation loss functions in four dimensions (three spatial and time) are pre-computed for several zones within the study area, based on local bathymetry, geoacoustic, and water column properties. Modelled shipping noise predictions are compared with acoustic measurements collected at Wheeler Reef, off Townsville from April–July 2013.

**757 Is underwater thermal noise useful?**

*Readhead, Mark L*  
 DSTO, Australia

**ABSTRACT**

Traditionally thermal noise has been considered an inconvenient nuisance in underwater acoustic sound pressure measurements. Theory (e.g. Mellen, 1952) shows that the noise spectrum increases with frequency, and provides a lower limit for measurements above 50 kHz. However, Weaver and Lobkis (2001, 2003) showed that by using an ultrasonic detector to correlate thermal fluctuations in a metal block, they could extract details of the block's dimensions, in much the same way as if they had used the detector for active transmission and reception. This paper will examine the theory and previous measurements, and provide further measurements of thermal noise.

**459 Study on the effect of alignment style on shafting-shell coupled system radiated noise caused by propeller force**

*Cao, Yipeng (1); Zhang, Runze (1); Yang, Guodong (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

For the underwater structure, the propeller excitation force play an important role which can induce structure vibration and radiated noise in low frequency. Because of the arrangement of shafting, it is difficult to control the vibration of shafting-shell system. The effect of shafting alignment style on shafting-shell coupled system radiated noise is studied in this paper. The 2D Reynolds equation is calculated by finite difference method. The fluid film pressure distribution of each bearing is calculated. Load increment method is used to calculate the fluid film stiffness and finite element method is adopted to calculate the bearing support stiffness. On the basis of stiffness value, the propeller, shafting and shell coupled system is built by finite element method. The characteristic of shell underwater radiated noise caused by propeller force is studied. The alignment style of shafting is changed. The effect of alignment style on shafting-shell coupled system radiated pressure is calculated.

**1008 Real variability in ship systems' noise and vibration. Design and through-life management implications for underwater noise and habitability**

*McIntosh, David James*  
QinetiQ, UK

**ABSTRACT**

Customers require completed ships to achieve acoustic performance relating to military stealth, standards for crew and passenger habitability and legislation for environmental protection. Design activity derives equipment and system specifications for machines, distributed systems and isolation treatments, since the whole ship performance achievability and sustainability relates directly to component noises and vibrations. The paper examines databases, compiled over many years, during noise rangings and supporting vibration surveys, for several ship classes. The databases allow for objective study of the statistical variability evident in a sample of typical machinery source mechanisms that relate to specific measures of performance. The evidence provides important findings. Critically, very significant variability exists in real underwater noise performance and the related vibrations when compared to median measurements and fixed targets. Technical and cost implications of this observation should be considered by initial ship designs or update programmes, where multiple systems and related mechanisms co-exist. Authorities planning condition based maintenance for system availability and the through-life management of onboard habitability or underwater noise are also encouraged to study the predicted or evidential behaviours using such an approach. Stakeholders in different disciplines should expect mutual benefits. Surveying is recommended, typically using available populations of systems on ships in-service.

**Monday 15:40-16:20 Room 206**  
**S1b Soundscape and its diversity in history and culture**  
**Chair: Koji Nagahata**

**245 On the Study of Effects of Views to Water Space on Noise Annoyance Perceptions at Homes**

*Leung, T M (1); Chau, C K (1); Tang, Shiu Keung (1); Pun, L S C (1)*  
(1) Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

Noise annoyance poses various adverse effects on health and well-being of human beings. Earlier studies have shown that greenery views perceived from the apartments can reduce traffic-induced noise annoyances as a result of audio-visual effects. This study intended to explore whether similar noise annoyance moderation effects could be provided by perception of water spaces. Specifically, this study aimed to explore and quantify the effects of different types of water views on noise annoyance. The relationship between restorative capacity of water and noise annoyance was also revealed. Three residential estates in Hong Kong with views to rivers and seas respectively were selected for this study. One thousand four hundred and forty-six respondents were successfully administered via a series of questionnaire surveys, and the noise levels at homes were predicted using CRTN method. Results were analyzed to formulate multivariate ordered logit models linking noise annoyance, views to different types of water spaces and personal characteristics of the respondents. Findings from the study can facilitate urban planners and building designers in planning water spaces near residential estates so as to reduce noise annoyance. Other than the findings arising from this study, the methodology formulated in this study can be applied to study the effect of perception of other types of water spaces.

**1037 WithdrawnA**

*WithdrawnA,*

**ABSTRACT**

*WithdrawnA*

**Monday 16:40-17:40 Room 206**  
**S2 Soundscape and auditory cognition**  
**Chair: Dick Botteldooren**

**739 How the meaning a person gives to tranquility could affect the appraisal of the urban park soundscape**

*Botteldooren, Dick (1); Filipan, Karlo (1); Boes, Michiel (1); De Coensel, Bert (1)*  
(1) Ghent University, Belgium

**ABSTRACT**

It has previously been established that different people attach a different meaning to the concept of "tranquil public space". A majority of persons associate tranquility with social interaction, but others associate tranquility with hearing sounds from nature or even with pure silence. Having these different beliefs

and views in mind, hypotheses could be formulated on their effect on the perception and appraisal of soundscapes in urban parks. Firstly, persons associating tranquility with sounds from nature may focus more on hearing these sounds while visiting a park, and might notice them more often as a consequence. Secondly, the meaning given to tranquility also influences one's frame of reference and expectations. Thus, persons associating silence or sounds from nature to tranquility might state more easily that they hear less natural sounds and more mechanical sounds when visiting a park. These hypotheses were tested on survey and measurement data from 8 parks in Antwerp and on computational models of auditory perception. Results show that attention focusing is dominated by the change in frame of reference or expectation. In addition, a weak relationship was found between the park where persons were encountered and their view on the concept of tranquility.

**215 Studies of Combination Effects of Sound on Biology and Cognition- Interdisciplinarity in Action**

*Mossberg, Frans*  
Lund University, Sweden

**ABSTRACT**

The Sound Environment Center at Lund University has since 2005 hosted interdisciplinary research on sound environment issues promoting exchange of ideas between researchers through research projects, interdisciplinary symposiums and publications. The center aims at developing a holistic view to a field that is scientifically fragmented and scattered. Ranging from acoustics, noise abatement and soundscape understanding, to issues of epidemiological mapping of health, biological effects, hearing and voice disorders, music and cognition the center covers a multitude of facets of sound and noise.

The work of the center is connecting to both national and international research networks and partners. Going from research to practice and change, in joint collaborations between acoustics, logopedics and cognitive science the center is exploring how memory, cognition and reception are affected by sound and noise. Current major projects focuses on health and cardiovascular issues and noise, acoustics, voice production, speech intelligibility and understanding, as well as eye-tracking studies of cognitive aspects of noise and sound exposure.

The preliminary outcome of interdisciplinary design has been positive and fruitful leading to deepened network collaborations and continuously new research projects.

**901 Temporal features extraction for the binaural soundscape samples**

*Wang, Daiwei (1); Deng, Zhiyong (1); Li, Xinxin (1); Liu, Aili (2)*  
(1) College of Music, Capital Normal University, China; (2) College of Resource Environment and Tourism, Capital Normal University, China

**ABSTRACT**

Soundscape, earlier proposed by the Canadian composer and ecologist R. Murray Schafer in 1960s, contains a large amount of environmental information and event information for the expression of specific historic areas, the survival status of a particular nation or people, and especially, the native environment has important significance. 22 binaural recorded soundscape samples collected from Guangxi Zhuang

Autonomous Region of China and their temporal features, included IACF, IACC, temporal envelope, acoustical dynamic were introduced in this paper. The information of native location, sound event and the above temporal features are also highly corresponded to the keynote, sound signal and soundmark of the soundscape. The preliminary results in this paper can provide an important theoretical and practical significance for the further extraction and analysis for the acoustical parameters of soundscapes.

**Tuesday 08:20-09:20 Room Plenary**

**Keynote 3**

**Chair: Norman Broner**

**991 Noise and Low frequency noise from Wind Turbines**

*Søndergaard, Bo*  
Grøntmij, Denmark

**ABSTRACT**

Noise is a key issue when planning wind farms. The presentation will look into details in noise from wind turbines, noise measurements, noise assessment, including the Danish noise limits for low frequency wind turbine noise, and noise propagation. Development of noise and low frequency noise with the size of the turbines will be discussed. Questions like how far does low frequency noise propagate will be addressed.

**Tuesday 08:20-09:20 Room 213**

**Keynote 4**

**Chair: John Davy**

**144 The impact of building acoustics on speech comprehension and student achievement**

*Wang, Lily M*  
University of Nebraska - Lincoln, USA

**ABSTRACT**

The movement for improved classroom acoustics has primarily been grounded on studies that show how building acoustics (i.e. background noise levels and room reverberation) affect speech intelligibility, as determined by speech recognition tests. What about actual student learning, though? If students do not understand each spoken word in the classroom perfectly, can they still manage to achieve high scholastic success? This presentation will review two recent studies conducted at the University of Nebraska – Lincoln, linking classroom acoustic conditions to student learning outcomes and speech comprehension (rather than simply recognition). In the first, acoustic measurements in two public school districts in the Midwest were correlated to elementary student achievement scores. Results indicate that higher background noise levels, greater than 40 dBA, may lead to unacceptable scholastic performance in language and reading tests. The second study focuses on how room acoustic conditions impact English speech comprehension of native-English-speaking listeners in contrast to English-as-second-language (ESL) listeners, a group which includes 21% of children in the United States K-12 school system. Conclusions are that higher reverberation times and background noise levels do reduce speech comprehension in both groups of listeners, but adverse

noise conditions are particularly more detrimental on ESL listeners.

**Tuesday 09:20-11:00 Room 218**

**M1 Metamaterial**

**Chair: Stuart Bolton**

**56 A simple model of effective elastic properties of materials with inclusions**

*Skvortsov, Alex (1); MacGillivray, Ian (1)*  
(1) DSTO, Australia

**ABSTRACT**

The aim of this study is to develop a simple phenomenological model for the elastic moduli of a composite material formed by localized inclusions embedded in an elastic matrix. It is assumed that the material can be characterised by only two aggregated parameters, viz., volume fraction of inclusions and their resonance frequency within the elastic matrix. The values of these two parameters are assumed to be given (i.e. from experimental measurements) or deduced from other models (also presented in the paper). The shear wave velocity in the elastic matrix is assumed to be much smaller than the velocity of longitudinal waves. A simple analytical expression for the effective longitudinal wave velocity that is uniformly valid for the entire frequency domain is derived (including proximity to the resonance frequency of inclusions) and validated with some paradigmatic results of the mean-field theories.

**834 Noise shielding using active acoustic metamaterials with electronically tunable acoustic impedance**

*Mokry, Pavel (1); Steiger, Katerina (2); Vaclavik, Jan (1); Psota, Pavel (2); Dolecek, Roman (2); Marton, Pavel (1); Kodejska, Milos (1); Cernik, Martin (1)*  
(1) Technical University of Liberec, Czech Republic; (2) Regional Center for Special Optics and Optoelectronic Systems TOPTEC, Czech Republic

**ABSTRACT**

Noise pollution has become one of the most serious problems of our society. Considerable part of unpleasant noise is transmitted into the interior of buildings through large vibrating planar structures - windows with poor noise-isolation properties caused by their low flexural rigidity. In this Paper, we demonstrate and analyze a noise shielding using an active acoustic metamaterial (AAMM) with electronically tunable acoustic impedance. The AAMM consists of a curved glass plate with attached piezoelectric Macro-Fiber Composite (MFC) actuators shunted by negative capacitor (NC) circuits. Using this approach, it is possible to electronically control the effective elasticity of the MFC actuators and, therefore, the flexural rigidity of the composite structure of the AAMM. Key features that control the acoustic impedance of the AAMM have been analyzed on a simplified analytical model. Frequency dependence of the acoustic impedance and the acoustic transmission loss through the AAMM are measured and compared. Vibration modes of the AAMM are optically measured using Digital Holographic Interferometry (DHI).

**860 Random Incidence Transmission Loss of a Metamaterial Barrier System**

*Varanasi, Srinivas (1); Bolton, J. Stuart (1); Siegmund, Thomas (1)*  
(1) Purdue University, USA

**ABSTRACT**

It has been shown previously that a panel comprising a cellular array can yield a normal incidence transmission loss in a specified low frequency range that is significantly larger than that of a homogeneous panel having the same mass per unit area. The cellular metamaterial considered consists of a periodic arrangement of unit plates held in a grid-like frame. However, when the incident sound field is diffuse, the relative advantage of the metamaterial barrier is reduced or eliminated. Here it will be shown through a sequence of experimental measurements that the relative advantage of the metamaterial barrier can be restored by creating a hybrid system consisting of a layer applied to the front surface of the material that causes sound to approach the barrier at normal incidence, and a layer on the rear surface of the material that compensates for the transmission loss minimum that normally follows the peak in a metamaterial barrier transmission loss. In the implementation considered here, the front layer consists of a lattice structure, and the rear layer consists of high performance glass fiber. The role of each of these components will be illustrated using measurements of transmission loss of a 1.2 m square panel system.

**559 Acoustic metamaterial panel composed of funnel-shaped cell unit having multi-band negative material properties**

*Cho, Sungjin (1); Kim, Boseung (1); Min, Dongki (1); Kang, Jeonghoon (1); Park, Junhong (1)*  
(1) Hanyang University, South Korea

**ABSTRACT**

This paper presents two dimensional sound-proof acoustic metamaterials having tunable multi-band negative effective mass density. The acoustic metamaterial panel was composed of many periodic funnel-shaped cell units into square lattice. Each unit cell operates as multi-band resonators. By tuning unit cell the local reflected acoustic wave was almost out of phase with the incident wave. It leads to the negative effective density and created band gap for absorbing incident sound energy without transmission. Measurement of the transmission loss and negative effective mass density was performed using four microphone methods for characterization of barrier performance.

**37 Tailoring Acoustic Metamaterials to Aeroacoustic Applications**

*Iemma, Umberto (1); Carley, Michael (2); Pellegrini, Riccardo (1)*  
(1) Roma Tre University, Italy; (2) University of Bath, UK

**ABSTRACT**

The advent of metamaterials in acoustics is shaking-up the research community. The theoretical models and the realization technologies developed during the last decade have suddenly made possible applications that were barely conceivable before. Acoustic invisibility, perfect acoustic mirrors and lenses or ideal wave guides are now realizable with

devices exploiting the potential of acoustic metamaterials. The present paper aims to investigate the applicability of such technologies in the aeroacoustic domain. The final goal of the research is the disclosure of the tremendous potential of metamaterial technologies in the abatement of civil aviation noise. The acoustic metamaterial theory developed so far is based on the assumption that the compressible medium and the scattering obstacles are at rest. This is clearly a limitation not compatible with aeroacoustic applications, where aerodynamic convection plays a fundamental role in the propagation and scattering patterns. The paper presents an original approach to extend the existing theory to the analysis of moving media and obstacles. Attention is focused on the design of a cloaking device, i.e. a metamaterial cover able to cancel the scattering of the cloaked object. Two formulations are presented, both based on the extension of the classical coordinate transformation approach to consider the existence of the mean flow. Preliminary numerical results are presented to demonstrate the effectiveness of both the approaches.

**Tuesday 09:20-10:40 Room 217**  
**G1 Wind turbines -Evaluation at neighbours I**  
**Chair: Con Doolan, Mark Bastasch**

**51 Special Noise Character in Noise from Wind Farms**

*Lenchine, Valeri V (1); Song, Jonathan (1)*

(1) SA Environment Protection Authority, Australia

**ABSTRACT**

Noise produced by wind farms may exhibit a multitude of different noise characters, ranging from amplitude modulation, tonality and low frequency noise. The presence of the noise characters is able to increase the annoyance factor caused by a noise source significantly. A penalty to the noise levels is applied in accordance with some regulations when a noise character is detected. This paper discusses a noise character that can be described as "rumbling" that was detected during a long term monitoring program which was conducted in an area adjacent to a wind farm. The objective assessment of the data and subjective assessment of relevant audio records were performed to analyze the effect. The frequency spectra of the rumbling events indicate connection of the effect with low frequency noise and one of the low frequency components. The character was detected at low noise levels and might not be audible to a typical listener, however it is possible the character may cause an increased annoyance to people who have a higher sensitivity to the lower frequencies. Environmental conditions were also considered when discussing the occurrence of this noise character. The possible mechanism of the rumbling effect is suggested in the paper. The wind farm manufacturers may have to consider potential for low frequency impact of wind turbines and presence of prominent components at the design stage.

**683 Investigating the impacts of wind turbine noise on quality of life in the Australian context: A case study approach.**

*McBride, David Iain (1); Shepherd, Daniel (2); Thorne, Robert (3)*  
 (1) University of Otago, Dunedin, New Zealand; (2) Auckland University of Technology, New Zealand; (3) Massey University, Wellington, New Zealand

**ABSTRACT**

The WHO considers noise pollution to be of sufficient threat to public health to justify the publication of guidelines on noise effects and mitigation. 'Community noise' has largely been studied in the context of transportation and general neighbourhood noise, with exposure to wind turbine noise relatively understudied for historical, methodological, and political reasons. There also appears to be a general uncoupling of wind turbine noise from the other sources, which endows upon it an exclusivity that excuses it from the methods, guidelines, and critique used for other noise sources. This study aimed to advance understanding of wind turbine noise impacts by adopting a case study approach based on detailed information from 25 individuals, Australian adults residing rurally and within 1000-3500m of three or more wind turbines. Participants were selected on the basis of health concerns evidenced through statutory declarations or submissions to hearings. The 25 respondents completed a face-to-face survey measuring health-related quality of life (HRQOL) questionnaire as developed by the World Health Organisation (WHO), the 'WHOQOL-BREF'. The results were compared to normative population data and showed clinically significant reduction in HRQOL.

**685 Outcome of systematic research on wind turbine noise in Japan Part 1**

*Tachibana, Hideki*

University of Tokyo, Japan

**ABSTRACT**

In Japan, serious complaints about wind turbine noise have arisen from nearby residents since the commencement of large-scale construction of wind generation plants in about 2000. Regarding this new type of environmental noise problem, scientific knowledge is insufficient and no standard methods for measuring and assessing the noise have been established in Japan. To improve this situation, a research project entitled "Research on the evaluation of human impact of low frequency noise from wind turbine generators" has been conducted over the three years from fiscal year 2010, funded by a grant from the Ministry of the Environment, Japan. This project consisted of three main subjects: (1) physical research on wind turbine noise by field measurement, (2) a social survey on the response of nearby residents, and (3) auditory experiments on the human response to noises containing low frequency components. In this paper, the outcome of the research project is reviewed and standard methods for measuring and assessing the wind turbine noise are discussed.

**1026 Outcome of systematic research on wind turbine noise in Japan Part 2**

*Tachibana, Hideki*  
University of Tokyo, Japan

**ABSTRACT**

In Japan, serious complaints about wind turbine noise have arisen from nearby residents since the commencement of large-scale construction of wind generation plants in about 2000. Regarding this new type of environmental noise problem, scientific knowledge is insufficient and no standard methods for measuring and assessing the noise have been established in Japan. To improve this situation, a research project entitled "Research on the evaluation of human impact of low frequency noise from wind turbine generators" has been conducted over the three years from fiscal year 2010, funded by a grant from the Ministry of the Environment, Japan. This project consisted of three main subjects: (1) physical research on wind turbine noise by field measurement, (2) a social survey on the response of nearby residents, and (3) auditory experiments on the human response to noises containing low frequency components. In this paper, the outcome of the research project is reviewed and standard methods for measuring and assessing the wind turbine noise are discussed.

**Tuesday 09:20-10:40 Room 216**  
**C3a EU research projects on aircraft noise**  
**Chair: Dominique Collin, Samir Gerges**

**277 European aviation noise research network (X-NOISE)**

*Collin, Dominique*  
Snecma, France

**ABSTRACT**

The X-NOISE Coordination Action, through its network structure and comprehensive workplan involving experts groups, scientific workshops, international cooperation seminars and a common information system, addresses the noise challenges faced by Aviation. As such, the project scope significantly contributes to the objective of reducing Aircraft Noise by 10 dB per operation as set by the ACARE 2020 Vision, while addressing key factors associated with Airport Noise issues. A dedicated Aviation Noise Research Network has then been established, developing its activities along a 3-Pillar approach. (1) Definition, coordination and assessment of a European research strategy aimed at meeting the ACARE noise targets. (2) Dissemination and communication of the European research effort scientific and technological achievements as well as issues and priorities for the future. (3) Improved integration of European research community activities in the field of air transport related noise research.

**279 OPTimisation for low Environmental Noise impact AIRcraft - OPENAIR**

*Kors, Eugene (1); Collin, Dominique (1)*  
(1) Snecma, France

**ABSTRACT**

This template provides instructions to authors of papers to be included in the Proceedings of INTER-NOISE 2014, which will only be published on a USB memory stick. These instructions

are in the format to be used for ALL papers, which shall be submitted ONLY as a Portable Document Format (PDF) file. An abstract is required at the start of all papers and shall contain at least 100 words, but not more than 200 words. The abstract shall not include equations, images, numbered references, or footnotes. Abstracts will be printed in the Conference Abstract Book to help attendees plan their days at the Conference. Authors must upload the Abstract as well as the full paper manuscript for the complete paper via the Conference Website. A maximum of three keywords shall be added below the abstract to provide easy access to related papers in the Proceedings. At least one classification number from the I-INCE Classification of Subjects shall appear on the first page. OPENAIR is currently the main Level 2 European project working on aircraft noise reduction. As such, it is a key element of the European aircraft noise research roadmap as developed by the X-NOISE Coordination Action which aims to reduce Aircraft Noise by 10 dB per operation as set by the ACARE 2020 Vision. Over the years, a significant effort has been conducted in the field of source noise reduction technologies, marking a first step towards the achievement of the ACARE targets through the Silence(R) project. As part of the European 7th Framework Program, OPENAIR started on 1st April 2009 as a program on aircraft noise reduction with a total budget of 30 million Euros, 60% funded by the European Commission. OPENAIR aims to deliver a 2.5 dB noise reduction for both engine- and airframe noise sources, beyond the SILENCE(R) achievements. To do so, OPENAIR focuses on the validation of new technologies at TRL5, such as electronically assisted solutions, designs exploiting improved Computational Aero-Acoustics, new affordable absorbing materials and airframe noise solutions. In order to keep an unbiased view on results, OPENAIR uses the Aircraft Noise Technology Evaluation process ANTE. A summary of the OPENAIR research topics will be provided.

**87 AFLoNext – A European Contribution to Airframe Noise Control**

*Bauer, Michael (1); Büscher, Alexander (2); Pott-Pollenske, Michael (3)*  
(1) Airbus Group Innovations, Germany; (2) Airbus Operations GmbH, Germany; (3) DLR, Germany

**ABSTRACT**

AFLoNext is a project of four years duration, funded by the European Commission within the Seventh Framework Programme. The project's main objectives are proving and maturing highly promising flow control and noise reduction technologies for novel aircraft configurations, to achieve a big step forward towards improved aircraft's performance and thus reducing the environmental footprint. The project consortium is composed by 40 European partners from 15 countries. One of the six technology streams, which are forming the scientific concept of AFLoNext, is concerned about the mitigation of airframe noise during approach and landing, generated on flap and undercarriage and through mutual interaction. Following the success of previous achievements on European level, accomplished in projects such as TIMPAN, SILENCER and OPENAIR, low noise technologies for the reduction of landing gear/flap interaction and flap side edge noise are going to be further developed in wind tunnel testing with a common goal: The proof under real operational conditions in flight test at the end of the project. This paper is to give an overview on the intended approach in AFLoNext and the expected results

related to aircraft acoustics and impact on aerodynamic performance.

**151 Fundamental indirect noise generation by interactions between entropy, vorticity and acoustic waves in the context of aero engine applications**

*Ullrich, Wolfram Christoph (1); Schulze, Moritz (1); Sattelmayer, Thomas (1)*

(1) Technische Universität München, Germany

**ABSTRACT**

In aero engines indirect noise is released by the acceleration of entropy and vorticity waves in the turbine, which are in turn created mainly further upstream in the combustor by unsteady combustion. Recent studies show that these interactions contribute substantially to the total emitted core noise. Consequently a detailed knowledge of the sources of entropy and vorticity waves and their interactions with mean flow and acoustics is essential for the efficient development of technologies to reduce indirect noise. In this study, a generic convergent-divergent nozzle configuration is considered as a simplified model of the transonic turbine vane flow to study entropy noise as well as the acoustic scattering behavior. A two step numerical approach is applied consisting of RANS mean flow simulations and succeeding acoustic simulations in frequency domain based on linearized Navier-Stokes equations. Source terms for both waves are deduced from linearized entropy and vorticity equation and evaluated spatially. Important interactions between entropy, vorticity and acoustic waves and the mean flow are highlighted and confirmed by an energy analysis. This analysis can be applied to real aero engine combustors and turbines and enables to quickly identify the impact of the different source mechanisms on indirect noise.

**Tuesday 09:20-10:40 Room 215**

**A3a Noise policy**

**Chair: Maurice Yeung, Marion Burgess**

**278 The evolution of noise policy and noise management in England during the life of the UK's Institute of Acoustics**

*Grimwood, Colin (1); Turner, Stephen (2)*

(1) CJGEM, UK; (2) Defra, UK

**ABSTRACT**

The UK's Institute of Acoustics is 40 years old this year. One year before it was founded, the first UK Government guidance document on Planning and Noise was published. That year also saw the advent of the Land Compensation Act which allowed the Noise Insulation Regulations to be laid which provided a means for compensating those affected by noise from new roads. In the same year as the IOA was founded, the Control of Pollution Act was published consolidating the statutory noise nuisance regime and the following year saw the first version of BS 5228 – the code of practice on construction noise and the Noise Insulation Regulations revised. This paper will examine the evolution of noise policy and noise management in England during the lifetime of the IOA including the publication, during early 2014 of new Planning Practice Guidance on Noise.

**810 A Metric Matrix Establishment for Cases Studies on the Effectiveness of the Key Environmental Protection Policies for Transportation Pollution Control**

*Zhang, Jiping (1); Schomer, Paul D (2); Buret, Marc (3); Zhang, Lei (1); Wu, Dian (1); Boyle, James (2)*

(1) Zhejiang Research & Design Institute of Environmental Protection, China; (2) Schomer and Associates, Inc., USA; (3) VicRoads, Australia

**ABSTRACT**

In a study of the Effectiveness of the Key Environmental Protection Policies for Road Traffic Noise Control, the authors discussed 20 international case studies of road traffic and noise management. Although the key international environmental policies for road traffic noise control in developed countries are very technologically, economically, legally, and sociologically mature, these policies do not always result in compatible land use: roadways and highways are still built too close to existing residential areas, and vice versa. In China these issues are exacerbated due to its rapid urban growth and industrial expansion. In this paper, the authors expand their study to include non-noise policies (air pollution, public participation in the planning process, and other important factors) but the noise & vibration are the first impact metrics (e.g. airport, railway, shipping), and suggest a multi-dimensional matrix for such cases studies. At last, an airport case in China is employed to show the sharpened metric matrix emphasizing the compatible land use, because the noise metric dominates to the other ones in airport transportation construction demonstrating the matrix effectiveness. And the future work would be expanded to all transportation types cases.

**273 Challenges in Planning against Road Traffic Noise in Hong Kong**

*Wu, Marco (1); Ng, Isaac (1); Szeto, Wing Kwok (1); Yeung, Maurice (1)*

(1) Environmental Protection Department, Hong Kong

**ABSTRACT**

Hong Kong is one of the most densely populated metropolitan cities in the world in which road traffic noise is the major environmental noise problem. Given the scarcity of land and distinctive compact cityscape of Hong Kong with major roads running near high-rise residential buildings, traffic noise impact has become a huge challenge to overcome in the course of increasing housing supply to meet the demand of the society. With the space availability and other technical concerns, at-sources mitigation measures, e.g. roadside noise barrier, may not always be the most suitable ways to reduce noise. This paper will give an account on how the traffic noise problems to new residential development in Hong Kong are minimized with illustration of practical examples on effective noise mitigation measures provided at the housing development. Also from the planning procedures angle on how the noise mitigation measures are eventually implemented and materialized. The government's effort in putting forward innovative noise mitigation measures in resolving traffic noise problem in residential development, by ways of launching a web-based database for sharing successfully implemented noise mitigation designs and participating in studies of innovative building envelop designs, will also be discussed.

**948 Progress on environmental noise policies from 2008-2013 in Asia and the world**

*Schwela, Dietrich H (1); Finegold, Lawrence S (2); Gjestland, Truls (3)*  
(1) Stockholm Environment Institute, University of York, UK; (2) Finegold & So, Consultants, USA; (3) SINTEF, Norway

**ABSTRACT**

This paper provides a review of international progress on environmental noise mitigation policies and strategies, best practices and guidelines for environmental noise management. A considerable amount of relevant documents in many countries on these topics were published in the last five years. Much of this progress was made in the European Union and the World Health Organization, although other areas of the world demonstrated a continuing commitment to improvement on these issues, especially in the United States, Japan and Vietnam. These topics are particularly important because they embody the transfer into policies and legislation of expert work on the effects of noise exposure. In addition they address the vital area of the benefits of noise abatement. The latter focus area includes topics such as economic costs of environmental noise abatement and the benefits of adequate and affordable environmental noise mitigation policies in terms of avoided health and other costs, which is crucial for governments to implement strategies and policies for environmental noise management.

**Tuesday 09:20-11:00 Room 214**  
**H3 Noise mapping prediction tools**  
**Chair: Gilles Daigle**

**59 Fast traffic noise mapping of cities using the Graphics Processing Unit of a personal computer**

*Salomons, Erik M (1); Zhou, Han (1); Lohman, Walter J A (1)*  
(1) TNO, The Netherlands

**ABSTRACT**

Traffic noise mapping of cities requires large computer calculation times. This originates from the large number of point-to-point sound propagation calculations that must be performed. In this article it is demonstrated that noise mapping calculation times can be reduced considerably by the use of parallel computation on the Graphics Processing Unit (GPU) of a personal computer. Comparisons are presented between a GPU implementation and a conventional CPU implementation for various urban areas, from which a GPU speedup factor of 720 is obtained (compared with a single CPU). The complete traffic noise map of Amsterdam is calculated with the GPU implementation in 2 h. Local modifications of the noise map, for example to investigate the effect of a new building or a road, are calculated in a time of the order of a minute.

**561 Lessons from round 2 noise mapping in England**

*Hepworth, Peter (1); Shilton, Simon (2); Jones, Nigel (3); Burdett, Matthew (3)*  
(1) Hepworth Acoustics Ltd, England; (2) Acustica Ltd, England; (3) Extrium Ltd, England

**ABSTRACT**

The second round of noise mapping required under the EU Environmental Noise Directive has been completed. Lessons learnt during the initial round of noise mapping led to some differences in approach to the second round of mapping. Some of the changes have been contractual/organisational and have been made to facilitate greater efficiency in the production of noise maps. Other changes have been implemented to produce a higher level of comparability between different noise maps. This paper considers the differences in approach for Round 1 and Round 2 road and railway noise maps produced for the English government. The reasons for the changes are discussed and the outcomes that resulted from the changes are reported.

**563 Statistical Method for an Assessment of Actions against Noise and Air Pollution in Order to compare the total Improvement in an Investigation Area**

*Zacharias, Frank-Christian (1); Kunka, Rainer (1); Hoar, Christopher F J (2)*  
(1) Thüringer Landesanstalt für Umwelt und Geologie Jena, Germany; (2) NGIS China Ltd., Hong Kong

**ABSTRACT**

In accordance with the German regulation VBEB, LIMA provides intuitive methods for the evaluation of different planned actions. Noise and air pollution maps used alone are lacking in that they do not show any statistical evaluation of the quality of the actions. Actually, while the reduction of immissions is relevant, the reduction in numbers of exposed inhabitants after vs before any action is the most important evaluation criteria. In the following, we define the adapted statistical method for air pollution impact evaluation. All façades longer than 5m can be broken down into sub facades. For each part of the façade, a receiver point is calculated. LIMA determines the positions of the receiver points automatically. For noise mapping, we recommend 5 m or 10 m grid size, for air pollution mapping grid size can be fixed from 2 m up to 10 m. From the regular grid results, LIMA fetches by a sophisticated interpolation nicely fitted proper values to the necessary receiver points; this method is proved since years. The user is free to decide whether using the exact number of inhabitants for each building or using a statistical distribution of inhabitants proportional to volume of a building derived from the whole number of inhabitants in the investigation area.

**655 A low-budget road traffic noise model for individual building evaluation - a case study in Western Australia**

*Felder, Martin (1); Burgess, Marion (2); Arnold, Jörg (3)*  
(1) Gebäudeanalyse Martin Felder, Switzerland; (2) UNSW Canberra, Australia; (3) Bauhaus-University Weimar, Germany

**ABSTRACT**

The primary function of the project was developed to a nationwide traffic noise immission model, using as a case study a major city at the west coast of Australia (Perth WA). In this framework the relevant acoustic input parameters were



prepared and verified by measurements during the process on site. The concept originates from the consideration, that a wide range of technologies and necessary information about the model treatment becomes available nowadays by internet. Much of this information is provided free-of-charge. This project used geoinformation for the terrain and the internet for details of the buildings. Some noise measurements were taken on site, to compare the measured traffic noise to the software based traffic noise immission model. In addition, traffic counts were also done to verify the traffic volumes. The project describes the ability, to create a traffic noise model in a very simple way, by means of a concrete application, namely traffic noise impact for a city area of Perth Western Australia.

**676 A web-based approach for the evaluation of acoustic performance of development designs and assessment of performance of mitigation elements**

*Hoar, Christopher F J (1); Wong, Kin Man (1); Noor, Noor Azlan Mohammed (2)*  
(1) NGIS, Hong Kong; (2) Universal Quantum Forces Sdn Bhd, Malaysia

**ABSTRACT**

Maximising the community's investment in efficient transportation networks is the cornerstone of sensitive development, helping businesses and families thrive. However, meeting the legislative requirements around noise and air pollution issues has significantly increased the workload for national, state and local governments, authorities and industry. Web-based spatial and 3D visualization technology can be used to assist planners, engineers, architects and environmental practitioners to rapidly evaluate the acoustic performance of different development design options and noise mitigation strategies. The ODEN platform discussed in this paper provides an easy to use web-based interface through which a number of noise and air quality issues can be examined and addressed. These include assessment of the acoustic environmental baseline, performance of design options, comparison of mitigation strategies and quantification of impact on population. The system dramatically reduces the time and resources traditionally required to perform such analyses allowing planners, engineers and architects to more effectively deliver projects with an improved acoustic environment.

**Tuesday 09:40-10:40 Room 213**  
**Q2e Numerical methods in vibro-acoustics**  
**Chair: Abhijit Sarkar, Daniel Wilkes**

**460 Dispersion diagrams of a water-loaded cylindrical shell obtained from the structural and acoustic responses of the sensor array along the shell**

*Jung, B K (1); Ryue, J (2); Hong, C S (3); Jeong, Wei Bong (1); Shin, K K (4)*  
(1) Pusan National University, South Korea; (2) University of Ulsan, South Korea; (3) Ulsan College, South Korea; (4) Agency for Defence Development, South Korea

**ABSTRACT**

In order to analyze the vibration and the sound radiation from the waveguide structures, it is important to understand the dispersion relations of the waves sustained in the waveguides. By using the sensor arrays mounted on the surface of the

waveguides, these dispersion characteristics would be constructed from the structural and acoustic responses at the sensor locations. In this study, the waveguide finite and boundary element method is adopted to predict the dispersion curves for a water-loaded cylindrical shell. The structural responses and near-field acoustic responses of the shell are used to create the dispersion diagrams and the results are compared. Also the effect of the sensor spacing is examined for the two different spans. It was found from this study that the respective dispersion curves constructed from the structural and acoustic signals are considerably different. Also it was seen that the spatial aliasing takes place in the dispersion diagram as the sensor span grows.

**439 Acoustic and flexural wave energy conservation for a thin plate in a fluid**

*McMahon, Darryl*  
DSTO, Australia

**ABSTRACT**

Although the equations of flexural wave motion for a thin plate in a vacuum and a fluid are well known, it is not easy to find a discussion of energy conservation for plate flexural waves, particularly "leaky" waves where a plate and fluid can exchange energy. Nor are formulae easily found for acoustic and flexural wave kinetic energy density, potential energy density and energy density flux including the effect of leaky waves. This paper derives formulae for acoustic and flexural energy densities and energy density fluxes, and finds the energy conservation equation for the coupled thin plate – fluid system

**443 Acoustic forcing of flexural waves and acoustic fields for a thin plate in a fluid**

*McMahon, Darryl*  
DSTO, Australia

**ABSTRACT**

Consistency with conservation of energy for coupled acoustic fields and plate flexural waves, discussed in another paper for this conference, is used to derive the amplitude and phase of flexural and acoustic waves for an infinite thin plate – fluid system excited by an incident acoustic plane wave. The acoustic interaction of the plate – fluid system is defined by 1. specula reflection from the plate surface, 2. transmission through the plate material and 3. plate flexural waves taking into account fluid loading. This reproduces the well-known peak in plate flexural wave amplitudes above the coincidence frequency where the trace wavenumber of the incident acoustic plane wave along the plate equals the plate – vacuum flexural wavenumber. This is essentially a resonance with the resonant frequency that varies with the direction of the incident plane wave. The width of the resonance is governed by fluid loading which manifests as radiation damping of the flexural waves. It is found that flexural waves affect the acoustic reflectivity of the plate through coherent interference of the acoustic field from flexural waves with the specula reflected field, but only if there is a nonzero phase shift in specula reflection. Energy conservation considerations predict that a plate becomes acoustically soft close to the resonance condition. A simple formula for the approximate resonance width is also derived.

**Tuesday 09:20-11:00 Room 212**  
**Q6a Inverse approaches in vibro-acoustics**  
**Chair: Jeong-Guon Ih, Stephen Hambric**

**521 Research on eigenfrequency shifts due to cracks in cylindrical structures and the application in non-destructive testing**

*Stache, Martin (1); Guettler, Marcus (1); Marburg, Steffen (1)*  
 (1) Universität der Bundeswehr München, Germany

**ABSTRACT**

This paper presents numerical and experimental studies on modal behavior of cylindrical, beam-like lightly damped structures having circumferential cracks with variable position, width and depth. In the numerical investigation utilizing Finite-Elements a discretization strategy is worked out that enables a three-dimensional crack representation. The experimental setup uses a Laser Scanning Vibrometer in the frequency range between 0 – 40 kHz. The major challenges to achieve adequate precision of the experimental data exist in the realization of a broadband impulse excitation and support conditions for repeatable measurement conditions. Numerically as experimentally the first 15 mode shape pairs with the corresponding eigenfrequencies are identified. The model updating is performed for the elastic parameters and appropriate boundary conditions to minimize the deviation between measured and calculated eigenfrequencies. The acquired data serves for the implementation of a damage identification procedure in which the geometrical crack properties are identified. The deviation between real and determined crack positions is lower than 0.3 % for crack cross-section ratios less than 7 %.

**53 Vibration rendering on a thin plate by actuator array on the boundary**

*Woo, Jung-Han (1); Ih, Jeong-Guon (1)*  
 (1) KAIST, Korea

**ABSTRACT**

Generation of localized vibration on the display panel in the mobile electronic devices is needed for transferring the tactile sensation to the users. When the actuators cannot be positioned at the central part of the panel due to the interference with electronic components, the only choice for the actuator locations is the edge of the panel. To generate a rendered distribution and pattern of the vibration, eigenfunction expansion and superposition can be used as the basic principle. The target vibration field consists of the hot and cold zones. In the hot zone, high amplitude vibration should be felt by the user, and, in the cold zone, the vibration amplitude should be tranquil not to incur any tactile sensation. A general inverse method to determine the proper weighting for each actuator in the array is pursued. Experiments are conducted on a thin rectangular panel and employing small moving-coil actuators. Performance indices for evaluating the control results are suggested based on the threshold and difference limen of tactile feeling. Performances of vibration localization varying the location of hot zone and the number of involved modes are evaluated, and the measured and rendered vibration targets match very well.

**224 Separation of non-stationary sound fields using single layer pressure-velocity measurements**

*Bi, Chuan-Xing (1); Geng, Lin (1); Zhang, Xiao-Zheng (1)*  
 (1) Hefei University of Technology, China

**ABSTRACT**

This paper presents a sound field separation technique using single layer pressure-velocity measurements to extract the non-stationary signal generated by a target source in the presence of disturbing sources. In the technique, the time-independent pressure and particle velocity signals on one measurement plane are first measured; then the pressure signal generated by the target source alone can be extracted by a simple superposition of the measured pressure and the convolution between the measured particle velocity and the corresponding impulse response function. An experiment involving three speakers driven by a non-stationary signal was investigated, where a pressure-velocity probe was used repeatedly to measure the time-independent pressure and particle velocity signals on the measurement surface and a trigger was used to keep the measured signals the same at each measurement. The experimental results demonstrate that the proposed technique is effective in extracting the desired non-stationary sound field generated by the target source alone from the mixed one both in time and space domains.

**194 Approximate model of sound source in consideration of evanescent waves in far-field acoustical holography**

*Wang, Ziteng (1); Yang, Diange (1); Miao, Feng (1); Wang, Ruja (1); Wen, Junjie (1); Lian, Xiaomin (1)*  
 (1) Tsinghua University, Beijing, China

**ABSTRACT**

Far-field acoustical holography methods reconstruct the sound fields mainly based on the simple point source model because of the loss of abundant information compared with near-field acoustical holography (NAH). It brings problems that the reconstructed sound sources are different from the actual measured sound sources especially because of the evanescent waves which attenuate rapidly in the near field. In the recent study, we establish the approximation formulation of evanescent wave propagation which suggests that evanescent wave can be considered as the interference of dipole model and quadrupole model with different weighting factors distributed on the incident wave-front. Without the evanescent wave component, the constructed sound sources are actually the components that are effective in the far-field and we proposed the concept of "far-field effective sound source" to show its physical meanings. With simulations and actual experiments with known speakers, the approximation method of sound source model is validated and the far-field acoustical holography has been improved to achieve more accurate quantitative reconstruction results. The study explored the evanescent wave which is hard to capture and for engineering practice, this research can give more accurate reconstruction as well as the approximation.

**1023 Comparison of patch acoustic holography methods for confined space**

*Havránek, Zdeněk (1); Beneš, Petr (1); Klusáček, Stanislav (1)*  
(1) Brno University of Technology, Czech Republic

**ABSTRACT**

Localization and characterization of noise and vibration sources through measurement of sound fields radiated from vibrating structures plays an important role in vibration diagnostics. Sound pressure field measured in closed distance to the source with a microphone array is then inversely processed with the suitable near-field acoustic holography method to obtain the estimation of sound field very near the identified source surface. Several restrictions apply when measurement is performed in non-anechoic conditions and with the array smaller than the examined source. In these cases patch holography methods with sound field separation technique should be used. The Equivalent Source Method (ESM), Statistically Optimized Near-field Acoustical Holography (SONAH) and iteratively enhanced Fourier transformation based procedure are examples of such methods. In this paper an extensive comparison of these source identification methods has been carried out while other disturbing sources affect the acquired data. Experimental evaluation of the methods has been performed in ideal anechoic conditions and further in disturbing environment. Real measurement data has been obtained with double layer planar rectangular microphone array with MEMS transducers and the results of principal source identification accuracy for all methods have been presented. Some practical aspects of applicability of each method are also discussed.

**Tuesday 09:20-10:40 Room 211**  
**N6a Noise in lightweight structures**  
**Chair: Jean-Luc Kouyoumji, Heinz Ferk**

**34 A model based on loudness level to describe airborne sound insulation**

*Neubauer, Reinhard (1); Kang, Jian (1)*  
(1) University of Sheffield, UK

**ABSTRACT**

Sound transmission between units is one of the biggest complaints among apartment building residents today. Since living noise is an increasing problem particularly between dwellings there is a need for a method of assessing airborne sound insulation between rooms. In many practical cases, however, the objective measures of the airborne sound insulation using procedures in standards are not in agreement with the subjective assessment. This paper describes a calculation scheme based on loudness level linked with specific fluctuation strength, yielding a weighted normalized loudness level difference  $L_{nor,w}$ . By analysing the difference between standard airborne sound insulation values and the introduced weighted normalized loudness level difference, it is revealed that the sound pressure level that is transmitted through a partition contains important details concerning subjective assessments. It is shown, that a simple level difference does not exhibit the effect of a given signal to the frequency-dependent airborne sound insulation curve, while using  $L_{nor,w}$ , a significant effect can be observed, in terms of both computed and measured results.

**189 Influence of design and leakages of the window-wall connection on the sound insulation.**

*Ferk, Heinz (1); Buchegger, Blasius (1); Meissnitzer, Marlon (1)*  
(1) TU Graz, Austria

**ABSTRACT**

Sound insulation performance of enclosures like lightweight exterior wall systems depends on the one hand on the sound insulation of the exterior wall design, on the other hand on the sound insulation of windows and doors and finally on the design of the connections between. An investigation done under the laboratory conditions shows, that the influence of the connection design of the window element to the wall can reduce the resulting sound insulation remarkable, especially if there are higher requirements for the sound insulation against exterior noise. The effect of leakages on reducing sound insulation also depends as expected on the type of material that is used for thermal insulation and air tightness and possible leakages. Moreover also the position of leakages influences the result of the sound insulation – in some cases the wedges that are used to get the window in the right position are incorrectly processed and so sometimes have to be removed before finishing the connection and mounting of the window sills, with the consequence of a bad sound insulation performance. A handy tool was developed, based on a modified sound intensity method, that can help to find such leakages quickly. Finally the different methods in ISO EN 10140-1 for the estimating of the sound insulation of joints were discussed. Investigation shows, that it is necessary to be careful in designing such connections and also in choosing the right measurement or evaluation method to get reliable results for an estimation of the sound insulation performance of connections.

**767 Improvement of sound insulation performance at low frequencies by several fibrous absorbers in lightweight double leaf partition**

*Sugie, Satoshi (1); Yoshimura, Junichi (1); Iwase, Teruo (2)*  
(1) Kobayasi Institute of Physical Research, Japan; (2) Niigata University, Japan

**ABSTRACT**

Sound insulation performance is generally increased by installing a fibrous absorber such as glass wool into cavity of double leaf partition. It usually increases further as the thickness and density of fibrous absorber increase. However, installing the absorber decreases occasionally the sound insulation. In this study, we have measured the sound insulation performance by use of test facility in which the fibrous absorber in the cavity could be replaced without removing boards from studs. From the results, we have clarified the relationship between the parameters, such as thickness and density, of fibrous absorber and the sound insulation performance at low frequencies. The performance is reduced at frequency bands not greater than the mass-air-mass resonance frequency as installing glass wool into the cavity. It is also presented that the performance does not absolutely increase with increasing the bulk density in the frequency range from 125 Hz to 250 Hz. The proper value of the bulk density is about 24 kg/m<sup>3</sup> for improvement of the sound insulation.

**883 Parametric study of direct airborne insulation of wood stud walls in midrise construction**

*Zeitler, Berndt (1); Schoenwald, Stefan (2); King, Frances (1)*  
(1) National Research Council, Canada; (2) Empa Swiss Federal Laboratories for Materials Science and Technology, Switzerland

**ABSTRACT**

There has been a proposal in Canada to increase the maximum allowable height of wood framed construction in the National Building Code of Canada (NBCC) from 4 stories to 6 stories. Design of taller buildings will lead to a change in the details of the walls that have to withstand the higher axial and lateral loads. However, also requirements of other building physics disciplines, one of those being the sound insulation, still have to be met. In the study presented here various assemblies that meet the higher load requirements are compared for direct airborne sound insulation. Parameters that were modified include: sheathing membranes, stud arrangement, stud depth, and resilient channels. Some of the wall design variants that work well structurally have very poor sound insulation properties and most of them require the use of resilient channels to obtain somewhat acceptable sound insulation properties. These and more results will be presented here.

**Tuesday 09:20-10:40 Room 210**  
**N8c Room acoustics**  
**Chair: Nazli Bin Che Din , Reiji Tomiku**

**433 Absorption modeling with ensemble averaged impedance for wave-based room acoustics simulations**

*Otsuru, Toru (1); Tomiku, Reiji (1); Okuzono, Takeshi (2)*  
(1) Oita University, Japan; (2) Kobe University, Japan

**ABSTRACT**

With the rapid progress of computers, wave-based room acoustics simulations like finite element method have come to be applicable onto many practical problems on acoustics. Generally, such methods can calculate sound fields quite accurately provided their boundary modelings are given appropriately. Although the absorption on the boundary can be modeled efficiently by using surface impedance, the impedance database is not accumulated yet. It is due to the difficulty in the practical measurement of surface impedance of materials at field conditions. To overcome the difficulty, the authors proposed a way to measure surface impedance by using ensemble averaging technique. In this paper, the basic concept of the authors' measurement method of surface impedance is summarized first. Then, an application of the measurement technique onto a realistic sound field in a cafe-restaurant is shown, and comparisons with the other methods are given to prove the effectiveness of the technique.

**468 A technique based on the equivalent source method for measuring the surface impedance and reflection coefficient of a locally reacting material**

*Zhang, Yong-Bin (1); Lin, Wang-Lin (1); Bi, Chuan-Xing (1)*  
(1) Hefei University of Technology, China

**ABSTRACT**

A technique based on equivalent source method (ESM) is developed in this paper for measuring the surface impedance

and reflection coefficient of a test material. The technique requires the measurement of complex pressures on two parallel planes between the sound source and the test material. If the sound source has rotational symmetry, the measurement on two parallel lines is sufficient. The sound pressure and normal component of particle velocity on the surface of the test material can then be calculated by using the ESM. The technique is similar to that proposed by Tamura in which the spatial Fourier transform rather than the ESM is used. Numerical examples are given to compare the proposed technique with the Tamura method, and the results show that a smaller measurement aperture is required and the measurement noises are easier to be controlled when using the proposed technique.

**759 A coherent image source method for sound prediction in long spaces with a sound absorbent ceiling**

*Min, Hequn (1); Chen, Yan (2); Qiu, Xiaojun (2)*  
(1) Southeast University, Nanjing, China; (2) Nanjing University, China

**ABSTRACT**

Sound absorbing boundaries can attenuate noise propagation in a long space, but they may lead the sound field hard to be accurately predicted. This paper presents a coherent image source model for sound field in long spaces with a sound absorbing ceiling. In this model, the reflections on the absorbent boundary are separated from those on reflective ones during applying reflection coefficients. The model is compared with the classic wave theory, the existing coherent ray-based model and a scale-model experiment. The results show that the proposed model has considerable accuracy and distinct advantage over the existing model for sound prediction in long spaces with an absorbent ceiling.

**982 A trial on calculating the equivalent reflection coefficient by acoustic distance measurement method based on phase interference in the actual sound actual field**

*Nakasako, Noboru (1); Neki, Yuma (1); Nakayama, Masato (2); Shinohara, Toshihiro (1); Uebo, Tetsuji (3)*  
(1) Kinki University, Japan; (2) Ritsumeikan University, Japan; (3) WADECO Co., Japan

**ABSTRACT**

Since the distance to target is very important information, we have proposed an acoustic distance measurement (ADM) method using a standing wave, which is generated by interference between transmitted and reflected waves. The proposed method is very simple in that the distance between the microphone and the target is estimated as the peak position of the range spectrum (i.e., the absolute value of the Fourier transform with respect to the power spectrum of the observed wave). The ADM method can be used to measure distance under the assumption that the transmitted and reflected waves are plane waves, even if the target is placed in a very close range and the reflection coefficient of the target is unknown. The ratio of the magnitude of the reflected wave to that of the transmitted wave (which is referred to as the equivalent reflection coefficient) can be estimated for the special case of a single target. The equivalent reflection coefficient contains the reflection coefficient and the distance decay. The present paper describes a new method for

calculating the equivalent reflection coefficient using the ADM method based on phase interference in the actual sound field. We also examine the validity and effectiveness of the proposed method through a computer simulation and by applying the proposed method to an actual sound field.

**Tuesday 09:20-11:00 Room 209**  
**D2d Vehicle noise vibration and harshness**  
**(NVH)**  
**Chair: Joseph Lai, Zhichao Hou**

**238 Vehicle noise functional performance indicators using tire sound intensity**

*Donavan, Paul (1); Janello, Carrie (1)*  
 (1) Illingworth & Rodkin, Inc., USA

**ABSTRACT**

Tire noise plays an important role in the noise performance of light vehicles for both interior and exterior noise. Tire noise sound intensity can be considered as a functional performance indicator for both types of noise. Databases of vehicle interior noise and exterior pass-by noise combined with the corresponding on-board sound intensity (OBSI) results were assembled to examine the relationships between these types of data. Relationships or objective "filters" were developed for relating OBSI to interior noise quantified in terms of A-weighted sound pressure level, loudness in sones, speech interference level, and percent articulation. Relationships between OBSI and interior structure-borne road noise were also examined. For exterior noise, a filter shape relating controlled pass-by measurements to OBSI data were developed for assessing community noise due to different pavements. This filter can also be used to quantify the increased exterior noise produced by tires under acceleration with applied torque. The principles described can be used in the vehicle noise development process for interior noise and for diagnosing the contribution of tires to regulatory pass-by noise, such as defined in the ISO 365 test procedure.

**487 Parameter quantification for evaluation of vehicle's impulsive BSR noise**

*Lee, Sinyeob (1); Kwak, Yun-sang (1); Kim, Boseung (1); Lee, Jongho (1); Park, Junhong (1)*  
 (1) Hanyang University, South Korea

**ABSTRACT**

In vehicles, consumer complains against BSR (buzz, squeak, rattle) noises are increasing. The BSR noises includes continuous or impulsive sounds depending on the generation mechanism. The evaluation method for rating the annoyance of BSR noises is required after taking these irregularly and periodicity. For continuous sounds, conventional Fourier transfer provides sufficient information on the spectral characteristics. However, the spectral information for impact sounds is difficult to be identified from Fourier transforms. In this study, Prony's method is applied to evaluate the spectral components (frequencies and decay ratio) of impact noises. The sinusoidal and exponential models fits a sum of damped complex exponentials. Through the auditory test, the noise level and attenuation ratio were identified as important factors

influence annoyance. This attenuation term increased the annoyance of BSR sounds.

**518 Mechanism of Noise Generation on Outer Rotor Motor**

*Ikeda, Kazumasa (1); Semura, Junichi (1); Ohzawa, Tsukasa (1)*  
 (1) DENSO CORPORATION, Japan

**ABSTRACT**

A rotor and a stator of an outer rotor motor often resonate with electromagnetic force working between them. Sometimes resonating rotor and stator cause irritating magnetic noise. When they make noises with their resonance, noise from the stator shows its resonance frequency. However, noise from the rotor shows different frequency from its resonance frequency. To clarify the mechanism of the phenomenon, surface vibration of the rotor during rotation was measured by using cylindrical microphone array that covered the entire rotor and was calculated by using advanced non-stationary conformal mapping technology by Equivalent Source Method (ESM) approach. As a result, it was found that the rotor is resonating with rotation and the amplitude of air vibration is modulated on the surface of the rotor.

**318 Verification of contribution separation technique for vehicle interior noise using only response signals**

*Hirano, Tomohiro (1); Yoshida, Junji (1)*  
 (1) Osaka Institute of Technology, Japan

**ABSTRACT**

In this study, a contribution separation technique using only response signals were considered for an analysis of vehicle interior noise. Independent component analysis (ICA) was applied for the technique. To verify and consider the applicability of the method in contribution separation, vehicle engine, road, and wind noise sources were combined artificially to simulate vehicle interior noise and applied ICA to these signals for contribution separation. The result shows the contribution could not be obtained correctly by the permutation problem in which the correspondence relationship between calculated and actual contributions is not kept along frequency. A solution technique was then proposed to solve the problem using the characteristics of sound source. As a result, the technique with the method could calculate accurate sound source contributions using only response signals.

**295 Development of a prototype system to evaluate of contribution rate of each noise source in road traffic noise**

*Houzu, Hiroyuki (1); Sakamoto, Ichiro (1); Nishi, Takahiro (1); Ishihama, Masao (2); Sawatari, Katsumi (3)*  
 (1) National Traffic Safety and Environment Laboratory, Japan;  
 (2) Kanagawa Institute of Technology, Japan; (3) ONO SOKKI CO.,LTD., Japan

**ABSTRACT**

In Japan, the achievement of environmental standards for noise is evaluated by long-term average sound level. Therefore, it is quite difficult to identify the factors of exceeding the regulatory limit. This study aims to develop a system that enables to conduct a separate measurement of each noise source and an evaluation of each source. By the evaluation of contribution rate of each noise source in roadside noise, it is possible to

define priorities for countermeasures to deal with. As the first step of the system development, this paper introduces the development of prototype system, reporting on the configuration of the system and the results of verification tests.

**Tuesday 9:40-11:00 Room 208**  
**D8a Motor vehicle noise - policy and regulation**  
**Chair: Hans Bendtsen, James McIntosh**

**69 The Dutch Road Noise Mitigation Program**

*Faber, Nico*

AnteaGroup consultancy, The Netherlands

**ABSTRACT**

In July 2012 a new law on noise pollution along major roads entered into force in the Netherlands. This law contains three important elements of new noise legislation: a) the introduction of noise production limits; b) the stimulation of source related noise measures; c) the reduction of situations with high noise exposure. The first two elements deal with the prevention of new high noise levels occurring after introduction of the law. The third element concerns the reduction of noise for existing situations that already experience high levels of road noise from major roads in the Netherlands. To deal with the third element the Dutch National Road Authority developed the Dutch "Road Noise Mitigation Program" with a total budget of 275 million Euros. This program consists of three projects in which noise mitigation measures (noise reducing pavements, noise barriers, noise insulation of houses) will be taken along all major roads in The Netherlands. This paper deals with the first pilot project MJPG 1 of the program and discusses the first's results. In this project the Dutch cost benefit analysis method is used as a decision tool for designing noise measures.

**286 Value for Money in Road Traffic Noise Abatement**

*Milford, Ingunn (1); Aasebo, Sigve Jarl (2); Strommer, Kjell (3)*

(1) Multiconsult, Norway; (2) Visy, Norway; (3) Transport Administration, Sweden

**ABSTRACT**

Road traffic noise is a significant environmental problem. The purpose of this work by CEDR Project Group Road Noise 2, has been to provide support to National Road Authorities (NRAs) when developing strategies and plans for future noise abatement in order to reduce noise annoyance. To provide a recommendation on which strategy would be most beneficial to society in general, this project has focused on reduction in noise annoyance and the associated cost of implementing various noise abatement measures. There are almost 100 million inhabitants in Europe annoyed by road traffic noise. With an investment of EUR 6 billion over a 20 year cycle in a range of different possible noise mitigation measures, it is calculated that the cost of reducing noise annoyance varies from EUR 16 to EUR 4200 per person per year. The findings clearly show that noise reduction at source (quieter vehicles) is much more cost-effective than treating noise at the receiver.

**343 The Swiss way to silent roads**

*Walker, Urs*

Federal Office for the Environment, Switzerland

**ABSTRACT**

The objective of Switzerland's noise abatement policy is to protect the health of the population and create a high quality of life. In a society in which space for housing development is scarce and there is constant population and traffic growth, as well as increasing individualization, this is a major challenge. The latest calculations on noise pollution in Switzerland show that during daytime one in five persons, and at night one in six persons, are still exposed to harmful or disturbing road traffic noise. The associated decline of property values and health impacts generate massive costs. A study on long-term megatrends illustrates that the volume of traffic will continue to increase. Therefore forward-looking measures need to be taken today in order to prevent adverse health effects and preserve quietness as a significant location factor for housing, business and recreation. To achieve this goal, it will be essential to focus on measures that eliminate noise directly at source such as the use of low-noise tires and low-noise road surfaces, the lowering of speed limits and optimized driving behavior.

**506 The danish national road noise strategy**

*Pedersen, Frank (1); Kristensen, Brian (1)*

(1) EPA, Denmark

**ABSTRACT**

The Danish National Road Noise Strategy (2003) incorporates ten initiatives to reinforce the road authorities' efforts to reduce noise. The strategy address the annoyance and health impacts of traffic noise taking into account efficiency and costs of the noise mitigation measures. The socio-economic analysis of the initiatives shows that there are good opportunities to organize efforts providing economic surpluses. As nine out of ten dwellings affected by noise are situated adjacent to municipal roads, the strategy emphasizes helping the municipalities in their efforts to reduce noise. Nevertheless most of the initiatives to control noise problems before and after 2003 have been carried out along the national roads. As a follow-up to the strategy, a 'recipe book' for financial noise partnerships between municipalities and homeowners has been developed, so that this form of co-financing can become more widespread. In spite of the efforts of the government and the municipalities to reduce the road traffic noise, the latest evaluation of the strategy (2010) concludes that: The health effects are unchanged and the number of dwellings exposed to noise is not reduced. This emphasizes the importance of continued efforts to implement the strategy combined with the strategic EU noise mapping and action plans.



which can be calculated from an acoustic propagation model, the emitted signal for every grid location over search region can be estimated by using the least squares solution in the time domain. And then, the estimated signal is convolved with the ocean channel pulse for various trial source locations to generate the replica signal. Finally, matched field localization of using two-hydrophone for underwater acoustic pulse signals of unknown emitted signal can be estimated by comparing the difference between the cross correlation of the received signal and the cross correlation of the replica signal to construct the localization error function yielding the ambiguity surface of localization function. Theoretical analysis and numerical simulation demonstrate the effectiveness of the proposed matched field localization and the localization performance were analyzed under different signal to noise ratio (SNR) cases by simulation trial.

**Tuesday 09:40-11:00 Room 206**  
**T3a Effects of noise on humans**  
**Chair: Lily Wang, Andreas Liebl**

**217 Effects of room acoustics on comprehension of foreign-accented speech by native and non-native English-speaking listeners**

*Peng, Zhao (1); Hanna, Kristin E (1); Boyd, Brenna N (1); Wang, Lily M (1)*  
 (1) University of Nebraska-Lincoln, USA

**ABSTRACT**

In a previous study by the authors, reverberation time (RT) and background noise level (BNL) were both found to have negative effects on native and non-native English-speaking listeners in comprehending English speech produced by native American-English-speaking talkers. Comprehension scores were adjusted for listeners' baseline English proficiency levels. In the present study, instead of native English-speaking talkers, two native Mandarin Chinese talkers (one male, one female) with similar English spoken proficiency were recruited to produce the same speech materials used in the previous study. A similar methodology was adopted to conduct speech comprehension tests on three groups of listeners: 1) native American-English, 2) native Mandarin Chinese and 3) other non-native English. The listeners' performance on foreign-accented speech comprehension is investigated under 15 acoustic conditions, created from five levels of RT (0.4 to 1.2 seconds) and three levels of BNL (RC-30, 40 and 50). Does a talker having a foreign accent change the results amongst the different listener groups in comprehending English speech under adverse acoustic conditions? Comparisons are made with the previous study, which showed that the negative impacts of RT and BNL varied between native and non-native listener groups.

**535 Vibration properties of hand-arm system while holding a grip**

*Kuwada, Masashi (1); Yoshimura, Takuya (1); Tsurumi, Yasuaki (2); Yamada, Daisuke (2)*  
 (1) Tokyo Metropolitan University, Japan; (2) Toyota Central R&D Labs

**ABSTRACT**

Recently, many vibration tools such as concrete breakers are used in the construction site. Workers holding them may suffer

from vibration disorder such as white finger. They also feel uncomfortable from them. Many studies of vibration disorder have been carried out. However, there have been few studies for evaluating the comfort. Furthermore, dynamic properties of hand-arm vibration system by vibration exposure have not been reported. Thus, the purpose of this study is to investigate the vibration properties of hand-arm system when holding a grip. In this study, a motion capture system is used to measure the responses of the hand-arm; markers are attached to the subject's arm while holding a grip. The vibration is transmitted through the grip, and the transmissibilities of hand-arm system are measured. We investigate the vibration properties of hand-arm system by conducting curve fit to the measured FRFs. The subject's seated postures and the direction of the grip are changed to see the difference and common characteristics depending on these factors. In the result, we extract four natural modes of hand-arm system. The dependencies of vibration properties to the subject's conditions are also clarified.

**647 Assessment of noise-induced annoyance by tones in noise from building mechanical systems**

*Lee, Joonhee (1); Wang, Lily M (1)*  
 (1) University of Nebraska-Lincoln, USA

**ABSTRACT**

Prominent tones in noise generated by mechanical equipment in buildings can cause complaints from occupants in buildings. The ISO 1996-2 and ANSI S1.13 standards describe methodologies and metrics to quantify tonality perception, but the influence of tones in noise on human annoyance and performance is not fully understood yet. This paper investigates annoyance responses of humans while exposed to background noise with tonal components. Twenty participants completed digit span tasks while exposed to noise signals with differing levels of tones and overall loudness. Subjects were also asked to rate their annoyance after completing tasks under each noise signal. The subjective testing was carried out in the indoor acoustic testing chamber at the University of Nebraska. A dose-response model is investigated to predict the upper limits of acceptability for tonalness using assorted noise metrics.

**735 Combined effects of low frequency vertical vibration and noise on whole-body vibration sensation**

*Hiroshi, Matsuda (1); Nobuo, Machida (1)*  
 (1) Nihon University, Japan

**ABSTRACT**

The operators of vehicles and construction work machines experience a variety of vibration and noise stimulation from the surrounding environment. It has been reported that vibration and sound stimuli, such as vibration music therapy and background music, have the psychological and physiological effects of mitigating tiredness and tension. The purpose of this study is to determine the effect of musical sound and noise on whole-body vibration sensation such as changes in sensation strength or uncomfortable sensation of vibrations. We studied low frequency vertical vibration generated in vibration environments including vehicles. We hypothesized that uncomfortable sensation of vibration could be reduced by adding sound to the vibration environment and comforting musical sounds to the sound stimulation. The vibration



sensation when the subjects were simultaneously exposed to vibration and sound stimulation was measured by using a psychological method. From the experimental results, it was found that the vibration sensation strength has a maximum at a vibration frequency of 8 Hz. Also, the tendency of the vibration sensation to increase and decrease in response to the uncomfortable sensation of vibration was different with musical sound and noise.

**Tuesday 11:00-12:00 Room 220**  
**E3 Railway wheel and rail noise**  
**Chair: Barry Murray**

**1010 Curve Squeal: Causes, Treatments and Results**

*Hanson, David (1); Jiang, Jiandong (1); Dowdell, Bruce (1); Dwight, Richard (2)*  
 (1) Transport for New South Wales, Australia; (2) University of Wollongong, Australia

**ABSTRACT**

Curve squeal is a major impact from rail operations on tight curves through residential areas. TfNSW has embarked on an intensive study into curve squeal and this paper presents an overview of that study. We have taken a holistic approach by considering each of the key contributors to wheel squeal: rolling stock, the wheel/rail interface, and the trackform. This paper will report on the results of trials, measurements and research into each of these areas, including (1) measurement and analysis methods for identifying/classifying curve squeal. This includes how squeal is identified from wayside noise measurements, a means of determining which wheel is squealing and which wheel/rail contact area is involved. (2) Which rolling stock is causing squeal and why. This includes a discussion of wagon steering behaviour based on measurements from wayside systems, the difference in performance between wagon classes and designs, and what this means for squeal noise generation. (3) Management of the wheel/rail interface for mitigating curve squeal. This includes a discussion of the importance of rail profile and friction management and provides results from on-track testing.

**438 Acoustic rail grinding – measures of long term effectiveness: Epping to Chatswood Rail Link case study**

*Vegh, Serge (1); Kochanowski, Radek (2); Croft, Briony (3)*  
 (1) Transport for NSW, Australia; (2) Sydney Trains, Australia; (3) SLR Consulting, Australia

**ABSTRACT**

The Epping to Chatswood Rail Link (ECRL) commenced operation in February 2009 with approximately 11.1 million gross tonnes of electric multiple unit rolling stock using each of the two tunnels annually. However, during acceptance testing of the ECRL an in-car noise issue was identified which required a reduction of approximately 12 dB. An acoustic rail grinding strategy was then developed and implemented. Grinding on the Sydney rail network has typically been conducted at passby speeds of 10 km/h that leave a longitudinal signature on the rail head with a wavelength of approximately 40 mm, and this in turn leads to tonal noise at approximately 450 Hz. In comparison, the ECRL grinding strategy saw higher speed grinding passbys of 25-30 km/h, with finer stones. This shifted the wavelength of the grinding signature to approximately

100-150 mm and reduced the tonal peaks in the roughness spectrum. This strategy contributed 3 to 4 dB of the overall noise reduction in a cost and time effective manner allowing the ECRL to commence revenue operations. This paper assesses the sustainability and maintainability of this acoustic grinding strategy, and compares the roughness of the freshly ground track to the roughness after approximately five and a half years of operation (shortly before the next scheduled rail grind).

**400 Bearing defect size estimation for extended raceway defects**

*Petersen, Dick (1); Howard, Carl (1)*  
 (1) University of Adelaide, Australia

**ABSTRACT**

A method is presented for estimating the size of bearing raceway defects that are larger than the angular spacing between balls. Previous defect size estimation techniques cannot be used for such defects since they are limited to defects that are smaller than the ball angular spacing. The reason for this is that two defects that differ in size by the ball angular spacing produce the same time difference between the defect entrance and exit events in the vibration response, and it is this time difference that is used to estimate the defect size in previous techniques. Thus, to distinguish between such defects, a third feature of the vibration response is required. It is hypothesised and validated through simulations that the third distinguishing feature is the characteristic frequencies of the low frequency event. This event occurs when a ball gradually de- and restresses upon entering and exiting the defect and corresponds to a varying stiffness excitation of the rigid body modes of the bearing assembly. It is shown that two defects that differ in size by the ball angular spacing produce different rigid body modes because such defects generate different bearing stiffness variations. This results in low frequency events with different characteristic frequencies since these frequencies correspond to the natural frequencies of the rigid body modes that are excited as balls enter and exit the defect.

**Tuesday 12:00-12:40 Room 220**  
**E4 Rail acoustics policy**  
**Chair: Mark Batstone**

**136 Comparison of Kilde and NORD2000 rail noise prediction methodologies**

*De Lisle, Simon (1); Burgemeister, Kym (1)*  
 (1) Arup Acoustics, Australia

**ABSTRACT**

In Australia, predictions of rail noise are most commonly conducted using the Kilde Rep 130 methodology, which has been twice superseded. The most recent version of the Nordic methodology is NORD2000. This paper compares the practical results of the Kilde and NORD2000 methodologies in a range of simple scenarios which have been selected to isolate specific effects, such as source directivity, meteorological effects, shielding losses and reflections. A test case representing complex real-world conditions has also been studied. Significant differences have been observed in the results of the two methodologies, with NORD2000 generally predicting larger propagation losses. Determining which methodology provides

more accurate predictions would require comprehensive measurements in tightly controlled conditions. However, it appears that Kilde uses a more conservative approach, to provide 'margin for error' due to its simplistic calculations.

**66 A simplified approach for evaluating noise impact from high-speed lines**

*Zhang, Xuetao*

SP Technical Research Institute of Sweden, Sweden

**ABSTRACT**

Sweden is now considering new railway lines typically adapted to high speeds up to 320 km/h. Noise impact from high-speed lines and noise mitigation measures where required becomes urgent to be investigated. As the current calculation model for railway noise used in Sweden is not applicable for the purpose, the Swedish Transport Administration decides to prepare a new noise assessment method for high-speed lines. This new noise assessment method is not necessary to be comprehensive because noise evaluation along high-speed lines is mainly oriented. In this paper a simplified source module is described. The simplification has three folds of meanings: (1) only dominant noise sources, rolling noise and aerodynamic noise, are considered; (2) a classification of train types is made based on noise emission strength, not on the physical parameters; (3) the effect of noise measures (such as rail/wheel dampers, sleeper pads or mats, wheel skirts, etc.) is integrated into a single parameter, additional noise reduction (given either in total level or in spectrum). Moreover, the effect of noise barriers along a high-speed line is left to be handled by the sound propagation module.

**Tuesday 11:00-12:40 Room 219**  
**T7 Loudness and other psycho-acoustical parameters**  
**Chair: Klaus Genuit, Roland Sottek**

**479 Improvements in calculating the loudness of time varying sounds**

*Sottek, Roland*

HEAD acoustics GmbH, Germany

**ABSTRACT**

Recently, a new ISO standard for loudness of arbitrary sounds ISO 532-1 (1) was proposed for the revision of ISO 532:1975 section 2 (method B) (2). It is based on DIN 45631/A1:2010 (3), which includes the widely used standard DIN 45631:1991 (4) for stationary sounds as a special case. ISO 532-1 eliminates uncertainties of existing standards by strictly defining the complete procedure of loudness calculation starting with the waveform of the time signal and ending with specific and total loudness vs. time functions. The strict definition of the complete procedure is a step forward to comparability of calculated loudness results, and fully conforms to DIN 45631/A1:2010 for the sake of continuity. However, although the results of this algorithm are in accordance with the results of many listening tests, there are still phenomena that are not covered by this method. For example, the calculated loudness of sweep signals shows fluctuations, whereas the perceived loudness does not. This is due to the implemented filter bank based on fixed, contiguous

third-octave filters. As a possible solution a loudness calculation method is presented that is based on a hearing model (Sottek) using an aurally adequate filter bank of highly-overlapping asymmetric filters (5). In addition, the nonlinearity between specific loudness and sound pressure has been reconsidered in this model according to results of many listening tests (6).

**974 Loudness Using a Threshold Correction Factor**

*Novak, Colin (1); Ule, Helen (2); Gaspar, Robert (1)*

(1) University of Windsor, Canada; (2) Akoustik Engineering Limited, Canada

**ABSTRACT**

Experimental studies have shown that for short gaps (2 to 5 ms) loudness and threshold are higher than for uninterrupted noise. Other studies have also shown that the present integration models for loudness do not adequately account for short duration phenomena. Studies have instead shown that the multiple look approach is the applicable method for these short-term circumstances. However, present technologies (i.e. FFT) are not adequate to deal with short duration sounds across the entire frequency spectra. A compromised approach is taken here to account for the threshold phenomena in the presence of gaps while using an integration model. This approach is referred to as a threshold correction factor.

**477 Development of a new loudness model in consideration of audio-visual interaction**

*Aizawa, Kai (1); Kamogawa, Takashi (2); Arimitsu, Akihiko (2);*

*Toi, Takeshi (2)*

(1) Graduate school of Chuo University, Japan; (2) Chuo University, Japan

**ABSTRACT**

Recently, several researchers have been focusing on loudness perception of sound sources when the sounds are presented with the appearance of what radiates them. They concluded the visual information may increase/decrease the perceived loudness intensity. However, because these works concentrated mostly on subjective evaluation of actual sounds, there is a demand for an objective loudness model in consideration of the audio-visual interaction. Due to this reason, this paper focuses on its development. First of all, a new equal loudness curve considering the color effect is proposed for a limited frequency band based on experimental results of audio-visual stimuli consisting of sinusoidal sounds and color patches. Secondly, this function is applied to the loudness calculation to correct the effect of colors, whereas, the other computation processes are the same as a conventional loudness model of ISO532B. This is because it is considered that the mechanism of sound perception is not affected by colors but by our ear structures. Finally, several audio-visual stimuli are evaluated and the result is compared to result analyzed by the new loudness model using the corresponding conditions and the model accuracy is discussed.

**382 Noise evaluation based on loudness-perception characteristics of older adults**

*Kurakata, Kenji (1); Mizunami, Tazu (1)*  
(1) AIST, Japan

**ABSTRACT**

The frequency-weighting A used for noise measurement was determined based on hearing characteristics expressed as equal-loudness-level contours. The time-averaged, A-weighted sound level (LAeq) of a sound corresponds well with the perceived loudness. However, good correspondence between LAeq and the perceived loudness is confined to cases in which listeners are young people with normal hearing. This study used a psychoacoustic experiment to investigate loudness of various sounds perceived by older people aged over 60. Analyses of results revealed that sound levels weighted by listeners' hearing characteristics matched the judged loudness better than LAeq values did. This report describes the development of a noise evaluation method that can evaluate noises for senior citizens more accurately than the conventional method using A-weighting.

**725 Measurement of attention to auditory signal in noisy environment**

*Sato, Hiroshi*  
National Institute of Advanced Industrial Science and Technology, Japan

**ABSTRACT**

When people find or localize a target sound in noisy environment, he/she employ his/her attention to the sound. If we can measure degree of attentions to a sound in daily life situation, the results can be used to control and/or design sound environment as well as auditory sign. However, it is difficult to measure auditory attention especially in real life situation. The intention of this study is to develop a tool to be used in real public space for evaluating performance of acoustic guide signal to present target directions. The challenge of this study is to measure the degree of attention to a sound with gaze measurement and presenting the relation between S/N and gazing detection.

**Tuesday 11:20-12:20 Room 218**  
**M2 Nanomaterials in acoustics**  
**Chair: Anthony Zander**

**124 Acoustic absorption behaviour of carbon nanotube arrays**

*Ayub, Md (1); Zander, Anthony C (1); Howard, Carl (1); Cazzolato, Benjamin S (1); Shanov, Vesselin N (2); Alvarez, Noe T (2); Huang, David M (3)*  
(1) School of Mechanical Engineering, University of Adelaide, Australia; (2) Department of Biomedical, Chemical and Environmental Engineering, University of Cincinnati, Cincinnati, OH 45221, USA; (3) School of Chemistry and Physics, University of Adelaide, Australia

**ABSTRACT**

Advances in nanotechnology have provided acoustic researchers with a number of new materials with nano-fibres and nano-pores that can potentially be implemented as an

acoustic porous absorber. This paper investigates the acoustic absorption behaviour of carbon nanotube (CNT) arrays, in order to quantify the acoustic characteristics and absorption performance of nanoscopic fibres in comparison with conventional porous materials. Tests were conducted using an impedance tube to measure the normal incidence acoustic absorption coefficient of vertically aligned carbon nanotube (CNT) arrays. Results show that a forest of 3 mm CNT arrays can provide as much as 10% acoustic absorption capability within the frequency range 125 Hz - 4 kHz. It was found that CNT arrays, in some cases, may provide better acoustic absorption than conventional porous materials of equivalent thickness and mass. The outcomes of this investigation highlight the potential of nanoscopic fibres for use as light-weight acoustic absorbers.

**581 Thermophones using carbon nanotubes and alternative nanostructures for high power sound generation and noise cancellation**

*Aliev, Ali E*  
University of Texas at Dallas, USA

**ABSTRACT**

There is a large promise for thermophones in high power sonar arrays, flexible loudspeakers and noise cancellation devices. The freestanding aerogel-like carbon nanotube sheet as a thermoacoustic (TA) heat source demonstrates so far the best performance. However, the limited accessibility of large size free standing carbon nanotube sheets and other even more exotic materials published recently, hampers the field. I present here new alternative materials for TA heat source with high energy conversion efficiency, additional functionalities, environmentally friendly and cost effective production technologies. I discuss the TA performance of alternative nanoscale materials and compare their spectral and power dependencies of sound pressure in air. The study presented here focuses on engineering of thermal gradients in the vicinity of nanostructures and subsequent heat dissipation processes from the interior of encapsulated thermoacoustic projectors. Applications of TA projectors for high power SONAR arrays, sound cancellation, and optimal thermal design, regarding enhanced energy conversion efficiency, are discussed.

**264 Improving sound absorption bandwidth of micro-perforated panel by adding porous materials**

*Li, Dengke (1); Chang, Daoqing (1); Liu, Bilong (1); Tian, Jing (1)*  
(1) Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, 100190, Beijing, P.R.China

**ABSTRACT**

Micro-perforated panel (MPP) has been widely used in acoustic treatments due to its wideband sound absorption coefficient. When the MPP is applied to absorb low frequency noise, more space is required, while at the same time sound absorption bandwidth becomes narrow. In this paper, a combined absorption structure containing the MPP, airspace and porous materials is proposed to improve the sound absorption bandwidth of MPP. The absorption coefficients of combined absorption structures were calculated and as well were measured in the impedance tube. The measured and predicted results are well agreed in the frequency of interest. When the porous materials are put in front of the MPP and there is an air layer between them, the sound absorption is much better in

comparison with that of the porous materials are located behind the MPP.

**Tuesday 11:20-12:40 Room 217**  
**G2 Measurement of wind turbine noise**  
**Chair: Lars Sondergaard**

**844 An investigation of Different Secondary Noise Wind Screen Designs for Wind Turbine Noise Applications**

*Novak, Colin (1); Sjöström, Anders (2); Ule, Helen (3); Bard, Delphine (2); Sandberg, Göran (2)*

(1) University of Windsor, Canada; (2) Lund University, Sweden; (3) Akoustik Engineering Limited, Canada

**ABSTRACT**

The use of diaphragm type microphones with the typical foam windscreens for outdoor noise measurement applications are mostly restricted to wind speeds below 4 to 6 m/s. This is due to the extra noise induced into the microphone, particularly at low and infrasonic frequencies, as a result of the wind excitation on the diaphragm. For wind turbine noise measurement applications, it is often necessary to measure the turbine noise under the typical operating conditions with wind speeds up to 12 m/s. This introduces a problem in the measurement system, as the normal microphone setup and windscreen are not adequate at these elevated wind speeds. Secondary windscreens, such as for example that prescribed by IEC 64100-11, "Acoustic noise measurement techniques" imparts their own problems including ridged body motion of the windscreen structure due to turbulence. Also, ground plane secondary windscreen measures the noise at ground level, instead of at ear level. This study investigates the use of several secondary windscreens with microphones capable of measuring at infrasonic frequencies for measuring wind turbine noise at elevated wind speeds. The result was that no windscreen provided a full solution to the problem. Specific recommendations for additional windscreen design and investigation are included.

**472 Wind turbine sound - metric and guidelines**

*Larsson, Conny (1); Öhlund, Olof (1)*

(1) Uppsala University, Sweden

**ABSTRACT**

The meteorological conditions vary over the globe but also change over the day and the year and vary a lot depending on the terrain for a certain location. The meteorological parameters govern both the wind turbine emission sound levels and the sound propagation conditions and therefore gives rise to different sound immission levels. Long-time measurements of meteorological effects on sound propagation from wind turbines over forest areas have been performed at two sites in Sweden for more than two years. One site is located in the southern part with flat terrain and the other site is located in the northern part of Sweden with more hilly terrain. The aim of the project is to improve the knowledge of sound propagation from wind turbines and especially over varying terrain and weather conditions. Control measurements of wind turbine immission sound levels will be needed to see that they fulfill the noise regulations. It is therefore of most importance to be able to make representative measurements. Discussions about under what meteorological conditions the immission

measurements have to be carried out, the sound metric and the impact of the guidelines are presented in this paper.

**287 Wind turbine noise measurements - How are results influenced by different methods of deriving wind speed?**

*Broneske, Sylvia*

Hayes McKenzie Partnership, UK

**ABSTRACT**

With the increasing number of operational wind farms/turbines, the requirement for noise measurements required to demonstrate compliance with planning conditions is increasing as well. The British ETSU-R-97 noise limits are often set relative to measured or standardised 10 m height wind speeds and therefore the assessment of noise from wind turbines requires simultaneous noise and wind speed/direction measurements. For financial reasons, smaller and single turbine sites are often not equipped with a meteorological mast. If no independent hub height wind measurements are available, wind speed is either taken from nacelle anemometers or derived from power measurements combined with the power curve for the respective wind turbine type. Noise measurements referenced to nacelle anemometer data will be compared with the same measurements but correlated with derived power curve wind speed, and measured wind data from separate met mast or other remote sensing devices. The influence of incorrect filtering of wind data for shadow effects (mast and/or nearby wind turbines) on the noise assessment may be presented, depending on how much time is available. The advantages and disadvantages of the various methods will be discussed.

**171 Correlation of amplitude modulation to inflow characteristics**

*Madsen, Helge Aagaard (1); Bertagnolio, Franck (1); Fischer, Andreas (1); Bak, Christian (1)*

(1) Technical University of Denmark, Denmark

**ABSTRACT**

Amplitude modulation (AM) of noise from wind turbines and its more extreme version named "other amplitude modulation" OAM have been investigated intensively during the last few years due to the additional annoyance impact this type of noise has compared to broad band noise. In a recent published research by RenewableUK the hypothesis has been that one of the causes of OAM is transient stall on the blade due to non uniform inflow such as shear. Part of the RenewableUK research work was a contribution by DTU on analysis of data from the DANAERO MW experiment from 2009. In the DANAERO experiment a new 38.8m test blade for a 2MW NM80 turbine was manufactured and equipped with a massive instrumentation comprising flush mounted surface microphones, pressure taps and five hole pitot tubes. The correlation of the spectra from the surface microphones and the measured inflow angle (IA) confirmed the strong increase in the noise source for high IA. As only few 10min data sets were measured in the DANAERO project a data set with measured inflow angle from 2003 on the same turbine has been used to explore the statistical properties of AM and OAM based on assumed correlation to IA.

**Tuesday 11:00-12:20 Room 216**  
**C3b EU research projects on aircraft noise**  
**Chair: Dominique Collin, Samir Gerges**

**505 IDEALVENT: Characterization of installation effects in aircraft Environmental Control Systems**

*Schram, Christophe (1); Kucukcoskun, Korcan (1); Christophe, Julien (1); Van De Wyer, Nicolas (1)*  
 (1) von Karman Institute for Fluid Dynamics, Belgium

**ABSTRACT**

Environmental Control System (ECS) are used in order to provide equipment cooling and good thermal comfort for passengers in commercial aircrafts. They are also responsible for significant acoustic annoyance affecting both passengers in the cabin and personnel servicing the aircraft on the ramp. The IDEALVENT project is tackling these issues by proposing a combination of detailed experimental work and advanced simulation techniques to better model, predict and mitigate ECS noise. A specific focus is placed on installation effects, which are addressed through a modular experimental rig permitting various combinations between a blower unit, downstream obstacles and upstream inflow distortions. The preliminary results of the project have permitted highlighting the importance and nature of the aerodynamic and acoustic installation effects that occur in such configurations. This paper is focused on acoustic measurements that have been performed using in-duct microphone arrays. These arrays have been designed to decompose the active and passive components of the blower scattering matrix into a modal basis including up to the first radial mode of the duct.

**40 COSMA – A European Approach on Aircraft Noise Annoyance Research**

*Bauer, Michael (1); Collin, Dominique (2); Iemma, Umberto (3); Janssens, Karl (4); Márki, Ferenc (5); Müller, Uwe (6)*  
 (1) Airbus Group Innovations, Germany; (2) SNECMA SA, France; (3) Università Degli Studi ROMA TRE, Italy; (4) LMS International N.V., Belgium; (5) Budapesti Muszaki és Gazdaságtudományi Egyetem, Hungary; (6) Institute for Aerospace Medicine, Germany

**ABSTRACT**

COSMA - Community Orientated Solutions to Minimize Aircraft Noise Annoyance - was a European approach within the 7th Framework Programme of the European Commission. Aircraft noise engineering is focused more or less on the reduction of the noise emission for single aircraft components, and separately treating the noise abatement procedures during take-off and landing. COSMA's aim was to combine both under the aspect of noise annoyance: To develop basic engineering criteria for an annoyance friendly aircraft design and managing flight operation routines in order to reduce the noise related annoyance within airport communities. The project had to create the link between the aircraft/sound engineering domain, and the noise effects domain. To achieve this goal, extensive field studies around European airports, combined with psychometric studies in laboratories have built the basis for describing the optimal aircraft sound characteristics which anticipates a lower annoyance. Specific sound synthesis methods, combined with the optimization of procedures for flight operations were used to create low noise annoyance

practices, including future aircraft concepts. The authors give an overview about the final status of the project's achievements in the major project areas: Annoyance related examinations, sound engineering, and optimization.

**58 Multi-objective optimization of takeoff and landing procedures: level abatement vs quality improvement of aircraft noise**

*Iemma, Umberto (1); Burghignoli, Lorenzo (1); Centracchio, Francesco (1); Galluzzi, Valerio (1)*  
 (1) Roma Tre University, Italy

**ABSTRACT**

The present paper deals with an original multi-objective optimization approach to the mitigation of the acoustic impact of commercial aircraft. The method is based on the coupling of the classical noise level reduction approach and an innovative sound-quality assessment method, developed during the EC-funded projects SEFA (Sound Engineering For Aircraft, FP6, 2004–2007) and COSMA (Community Noise Solutions to Minimise aircraft noise Annoyance, FP7, 2009–2012). Indeed, the increase of air traffic and the rapid expansion of urban areas around airports are making the aviation community noise a key aspect of the sustainable development of the transportation system. As a consequence, the scientific and industrial research community is focusing the attention on the development of innovative aircraft configurations, aimed at a substantial reduction of the acoustic impact of aircraft. Unfortunately, such a new concepts will be ready for operation only in the long-term, thus making extremely urgent the identification of alternative strategies to mitigate the impact on the residential community. The present work addresses the problem by integrating into the multi-objective, multi-disciplinary optimization framework developed and validated in COSMA, the sound-matching criterion developed within SEFA, with a noise-level based indicator minimization. Specifically, the two merit factors to be minimized are the norm of the difference between the noise produced by the configuration under analysis and a target sound, and the EPNL (effective perceived noise level) at a certification point. The target sounds are obtained by synthesis, using sound engineering techniques aimed at the sound quality improvement, on the basis of the results of the psychometric tests campaigns performed in SEFA and COSMA. The simultaneous reduction of the two objective functions is achieved through a multi-objective optimization problem adopting global evolution methods, as implemented within the MDO environment FRIDA (FRamework for Innovative Design in Aeronautics). Results will be presented for procedure optimization in terms of Pareto fronts, for two types of aircraft in both take off and landing conditions.

**523 NINHA: Noise Impact of aircraft with Novel engine configurations in mid- to High Altitude operations**

*Van Oosten, Nico (1); Collin, Dominique (2)*  
 (1) Anotec Engineering, Spain; (2) Snecma, France

**ABSTRACT**

The potential introduction of aircraft fitted with advanced counter-rotating open rotor (CROR) engine power plants should contribute significantly to the reduction of fuel burn and gaseous emissions. In the 1980s, prototypes of the first generation of open rotor engines were developed and tested.

One of the findings was that the noise generated by these engines, even in the en-route flight phase, could be considered significant, thus hazarding public acceptance. Since then significant effort has been dedicated to improving the CROR aero-acoustic design; the new generation of CROR engines currently envisaged will be much quieter than its predecessors.

**Tuesday 11:00-12:40 Room 215**  
**A3b Noise policy**  
**Chair: Maurice Yeung, Marion Burgess**

**132 Control of noise from public entertainment activities in Hong Kong**

*Kwok, Kwun Ting (1); Cheng, Kin Wui (1)*

(1) Environmental Protection Department, Hong Kong

**ABSTRACT**

Hong Kong is a vibrant and hyper-dense metropolitan city with over 7 million people being housed in a total area of around 1,100 square kilometers. In such a dynamic city, there is a huge demand of entertainment venues from the community for various kinds of entertainment. Due to the land sparsity, availability of appropriate venues is limited. Outdoor places for other uses, such as stadiums, parks, promenades and streets etc., are frequently used for holding public entertainment events, in particular, during various festivals. However, these open-air places are usually located in close proximity to residential premises. Noise from frequent public entertainment activities had aroused great concern from local residents. This paper describes the current framework and noise control criteria adopted in Hong Kong for controlling noise from open-air public entertainment activities with a view to striking a balance between the quest for quieter environment and the community's aspiration for enjoyment of public entertainment activities.

**911 Residential acoustic amenity in 'vibrant' mixed use areas**

*Wheatley, Glenn Robert*

Renzo Tonin & Associates, Australia

**ABSTRACT**

The 'compact city' is a focus of many sustainable urban development models around the world. With higher density mixed-use development a central element, developments that were previously separated to reduce potential conflict (such as from noise) are now being brought closer together. This research investigated noise impacts between commercial and residential uses, in the context of New South Wales (NSW) planning policy, where fine-grain and vibrant mixed-use development is promoted. A single site case study, which included resident and business operator surveys, was used to gather information on expectations and experiences with regard to noise impact. The case study was supplemented by a policy and academic literature review. The results of the research suggest that NSW planning policy does not adequately address the expectations of residents and business operators in mixed-use areas regarding noise impact, or the objectives of their strategic planning policies concerning the creation of vibrant mixed-use sites. It is concluded that strategic planning objectives for the promotion of vibrant/active mixed-use areas, particularly those with late night trading premises, should only

be set if suitable design responses are available, as the development of incompatible uses may ultimately restrict development or reduce the quality of life for inhabitants in urban areas.

**792 Live music and the 'agent of change' principle**

*McArdle, Sean (1); Lee, Gillian (2); Hui, Elizabeth (2)*

(1) Rigby Cooke Lawyers, Australia; (2) Marshall Day Acoustics, Australia

**ABSTRACT**

The gentrification of Melbourne's inner suburbs since the late 90s has resulted in increasing tension between inner city residential development and well-established music venues. Fuelled by strong community support for live music, the Victorian government recently announced a suite of reforms to implement the 'agent of change' principle to protect live music venues from residential encroachment. In advance of pending law reform activities, this paper examines the key issues relevant to development of noise policy to complement the agent of change principle. The paper describes the current regulatory framework in Victoria for music noise, identifies risks associated with potential policy approaches and provides high level discussion concerning stakeholder viewpoints as relevant to the issue.

**537 New techniques to determine specific noise for increasing the effectiveness of continuous unattended noise monitoring systems**

*Manvell, Douglas (1); Stollery, Phil (2)*

(1) Brüel & Kjaer Sound & Vibration A/S, Denmark; (2) Brüel & Kjaer Sound & Vibration A/S, UK

**ABSTRACT**

Continuous, unattended noise monitoring systems can immediately alert you should noise levels exceed defined criteria. Once alerted to an exceedance, operators can act to return levels to compliance. This approach has two significant limitations. Firstly the operator can only take action after the breach has occurred and therefore systems are only able to inform owners about problems that have occurred in the past, rather than allowing them to maintain compliance. Secondly the noise limit exceedances might not be due to specific noise from the operator but from unrelated, residual noise in the often complex noise climates around the site. Compliance breaches are frequently triggered by aircraft overflights, road traffic or community sources. Modern monitoring systems enable users to view noise characteristics and listen to the noise breach to determine the source and take action if it is relevant. However, this approach can create significant false positives each taking up operator time to address. This paper describes how airport noise management systems have addressed this problem by combining data from other systems. It also shows how different techniques are required in urban & industrial noise management, giving examples of techniques that allow operators to take action before a compliance breach occurs.

**413 Continuous noise monitoring network design: an end user perspective**

*Sparke, Clayton James*  
Advitech Pty Ltd., Australia

**ABSTRACT**

Continuous Noise Monitoring (CNM) systems are commonly utilised to assist in the remote assessment of noise impacts associated with industrial complexes. In Australia, these systems have benefited significantly from rapid innovation in technology and wireless communication networks in the last 20 years, and now collect vast quantities of data that may be used in near real time or stored for later processing. In some sectors, the speed of this innovation and rapid uptake of new technology has outpaced the development of training and education tools that adequately equip end users with the ability to transform this data into useful information. A survey of Environmental and Community managers was undertaken to explore how CNM Systems are used to assist in the management of environmental noise impacts in the NSW mining sector. The survey sought to understand the various objectives of continuous noise monitoring, identify constraints and opportunities, and provide for self-assessment of end user competencies. The outcomes of this study contribute to narrowing of the knowledge gap between users and suppliers of environmental management technology, and furnish stakeholders with information to improve the utility of CNM Networks.

**Tuesday 11:00-12:20 Room 213**  
**Q2f Numerical methods in vibro-acoustics**  
**Chair: Stephen Conlon, Weikang Jiang**

**532 Sound transmission between rooms coupled through partition with elastically restrained edges**

*Zhang, Yufei (1); Du, Jingtao (1); Liu, Yang (1); Yang, Tiejun (1); Liu, Zhigang (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

Sound transmission between rooms is often encountered for the acoustic design and noise control engineers. A clear understanding on the acoustical behavior of rectangular cavities connected by flexible panel structure can be of the fundamental significance. In this paper, sound transmission between rooms through the flexible partition with its edges elastically restrained is investigated. Both the translational and rotational springs are assumed along each panel edge to simulate the structural boundary conditions. The energy variational formulations in conjunction with Rayleigh-Ritz procedure are employed for this structural-acoustic coupling system modeling with the improved Fourier series constructed as the admissible functions, in which the supplementary terms are introduced to overcome potential discontinuities associated with the spatial derivatives of the conventional Fourier series on the panel-cavity interface as well as the panel elastic edge supports. Numerical examples are then presented to demonstrate the reliability and effectiveness of the current model through the comparison with the predicted data obtained by Finite Element Analysis using NASTRAN. Effect of the position and boundary restraining condition of flexible partition on the sound transmission characteristics of coupled

rooms is analyzed in detail. Finally, some useful and interesting findings from this work are given in the conclusion section.

**618 Transfer-matrix-based approach for an eigenvalue problem of a coupled rectangular cavity**

*Iwamoto, Hiroyuki (1); Tanaka, Nobuo (2)*  
(1) Seikei University, Japan; (2) Tokyo Metropolitan University, Japan

**ABSTRACT**

This study concerns an eigenvalue problem of a vibro-acoustic coupling system. In the conventional method, the dynamics of a vibro-acoustic coupling system is calculated with modal coupling methodology which uses eigenfunctions of a rigid-walled cavity. Therefore, particle velocity on the surface of a panel is always calculated as zero, while it should be coincident with the velocity of the panel. To overcome the problem, this paper presents a new methodology for deriving accurate eigen-pairs of a vibro-acoustic coupling system. First, a transfer matrix is introduced which can describe the characteristics of the sound field. This is followed by the derivation of the sound pressure on the coupled rectangular panel. Then, the vibrational velocity of the panel is derived with the sound pressure being used as the input. Furthermore, the eigenvalue problem is formulated based on the equations of vibration and sound field. Finally, the numerical simulation is carried out, demonstrating the validity of the proposed method.

**936 Study on aero-acoustic structural interactions in fan-ducted system**

*Chiang, Yan Kei (1); Choy, Yat Sze (1); Cheng, Li (1); Tang, Shiu Keung (1)*  
(1) Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

Mitigation of sound radiation from subsonic axial fan in the fan-ducted system at low frequencies remains a technical challenge. Traditional dissipative approach such as absorption material often requires sufficiently long attenuation path for desirable noise reduction performance. More advanced passive control technology such as membrane housing which relies on vibro-acoustic coupling mechanism works effectively on the attenuation of the first and second blade passage frequency in case of steady flow. However, the performance of such device which is composed of thin membrane may be affected by unsteady flow field. This study examined the interaction between vortex unsteady motion, a tensioned membrane housing of finite length and axial fan with dipole nature using the matched asymptotic expansion technique and potential theory. A two-dimensional numerical model is established to explore the sound radiation of each components and the performance of the membrane housing for controlling sound radiation from axial fan in the present of vortex inside uniform mean flow. The results show that there is higher chance of sound amplification when a vortex stream is closer to the light membrane under weak mean flow speed. Under the condition of weak mean flow speed, the sound radiation from the membrane is also amplified when the cavity height is shallower. The result is beneficial for the design of the device of membrane housing.

**774 Modal contributions to the acoustic responses of fluid-loaded shells**

*Qu, Yegao (1); Hua, Hongxing (1); Peters, Herwig (2); Kessissoglou, Nicole (2)*  
(1) Shanghai Jiao Tong University, China; (2) UNSW Australia, Australia

**ABSTRACT**

This work compares results from analytical and numerical techniques to predict the modal contributions to the radiated sound power and far-field sound pressure for structures submerged in a heavy fluid medium. A fluid-loaded cylindrical shell with hemispherical end caps is examined. The cylinder is excited by either axial or transverse forces acting at one end, to predominantly excite the lowest order cylinder circumferential modes. A modified variational method combined with a spectral boundary element method is used to develop an analytical model of the coupled hemispherical and cylindrical shells under heavy fluid loading conditions. The displacement components and the sound pressure are expanded in the form of a double mixed series using Fourier series and Chebyshev orthogonal polynomials. A fully coupled finite element/boundary element model of the same coupled hemispherical-cylindrical shell is also developed. A numerical technique for modal decomposition of the acoustic responses of the structure using the fluid-loaded structural modes is implemented. The individual contributions of the cylinder circumferential modes to the sound power and directivity of the radiated sound pressure are observed. The techniques presented here provide greater physical insight into structure-borne radiated noise from fluid-loaded shells.

**Tuesday 11:20-12:40 Room 212**  
**Q6b Inverse approaches in vibro-acoustics**  
**Chair: Jeong-Guon Ih, Nourredine Atalla**

**842 A shape classification for the acoustic radiator using its sound field**

*Kim, Koo-Hwan (1); Kim, Yang-Hann (1)*  
(1) KAIST, South Korea

**ABSTRACT**

A method for classifying the shapes of sound radiator is presented. It assumes that sound field can be measured by a linear array. A sound field, due to the radiator vibrating with uniform velocity, can be determined by its shape, size, and orientations. Measured data also can be varying from the array's position. To classify the shape of radiators from these measured data, sound field data has to be converted into a measurement positions invariant feature. We show that the directivity factor has these invariability and it can categorize the unknown shape of radiator according to several pre-defined candidate shape. In this paper, suggested method is applied to classify the several regular polygons.

**608 A moving sound source localization method based on TDOA**

*Miao, Feng (1); Yang, Diange (1); Wang, Rujia (1); Wen, Junjie (1); Wang, Ziteng (1); Lian, Xiaomin (1)*  
(1) Tsinghua University, China

**ABSTRACT**

The Time Difference of Arrival (TDOA) method has been widely used for sound source localization. However, because of the Doppler-effect, the TDOA method cannot be directly used for locating moving sound sources. This paper develops a moving sound source localization method based on TDOA, combining with Doppler-effect elimination and source plane scanning. This method is suitable for locating sound sources moving in a plane, with a measurable velocity. In this method, the sound source plane is meshed into grids. Choose one grid point as the assumed sound source location, eliminate the Doppler-effect from the measured sound pressure signals, and then locate the sound source using TDOA method. The deviation between the localization result and the chosen grid point is recorded. Do this progress by scanning all the grids on the plane. The grid point which minimizes the deviation through the plane is taken as the sound source location estimation. Simulations show that this method can accurately locate high speed sound sources even with background noise, using short sections of signals received by a four-microphone array.

**458 High-resolution nearfield acoustic holography based on iterative weighted equivalent source method**

*Xu, Liang (1); Bi, Chuan-Xing (1); Zhang, Xiao-Zheng (1); Zheng, Chang-jun (1)*  
(1) Hefei University of Technology, China

**ABSTRACT**

Because of the ill-posed nature of equivalent source method (ESM)-based nearfield acoustic holography (NAH), regularization methods based on the minimum L2-norm criterion such as the Tikhonov regularization are usually employed to stabilize its reconstruction procedure. However, the minimum L2-norm constraint sometimes makes the reconstruction result too smooth and thus degrades the spatial resolution of NAH, because this kind of constraint tends to disperse the acoustic field energy on the hologram surface to all the equivalent sources. To deal with this problem, an iterative weighted ESM (IWESM) is proposed, in which an iterative weighted regularization procedure is developed to solve the strengths of equivalent sources. The IWESM can reduce the dispersion of acoustic field energy on the hologram surface to those equivalent sources that contribute little to the acoustic field, and get more reasonable solution of source strengths. The validity of the IWESM is proven by a numerical simulation, and the result shows that comparing with ESM-based NAH, the proposed method can significantly improve the spatial resolution of reconstruction results.

**1035 Withdrawn8**

*Withdrawn8,*

**ABSTRACT**

*Withdrawn8*



**Tuesday 11:00-12:40 Room 211**  
**N6b Noise in lightweight structures**  
**Chair: Jeffrey Mahn, Rikard Öqvist**

**780 Challenges for acoustic calculation models in "Silent Timber Build", Part 2**

*Kouyoumji, Jean-Luc (1); Bard, Delphine Gérard (2); Borello, Gérard (3); Guigou, Catherine (4)*  
 (1) FCBA, France; (2) Lund university, Sweden; (3) InterAC, France; (4) CSTB, France

**ABSTRACT**

The project "Silent Timber Build" will develop new prediction tools for timber structures. There are several challenges that have to be overcome to provide a full prediction tool. The differences in weight, stiffness and density for wooden structures compared to traditional, heavy and more homogeneous structural material have repercussions on how the sound propagates throughout the structures, affecting the sound and vibration insulation performance and also theories to be used in prediction models. The project will use Finite element simulations (FEM) and Statistical Energy Analysis (SEA) approaches to predict acoustical behavior of light weight timber constructions. This article, following another article Part 1, will focus on medium and high frequency range calculations. Statistical methods will be used in the medium and high frequency, where the acoustic performance of wooden building components (walls and floors) is generally limited by the presence of structural links and couplings. Statistical Energy Analysis (SEA) has proven to be an efficient approach, providing robust vibroacoustic models in this frequency region. The extension of statistical methods towards the low frequencies has to be evaluated, especially regarding time responses of impact noise on floor systems. For full-scale building, Virtual SEA method will be used as well as analytic SEA approach in frequencies low enough in order to optimize the overlap to FEM.

**694 Laboratory data examining impact and airborne sound attenuation in heavy timber loft style construction.**

*Byrick, Wilson Robert*  
 Pliteq Inc., Canada

**ABSTRACT**

An increasingly popular trend in urban neighborhoods is to convert old factory or industrial spaces into "loft" style condominiums. The structure in these old factory spaces tends to be comprised of heavy timber floor-ceiling systems. A floor-ceiling system, representative of what is found in the field, was constructed in the laboratory to complete impact insulation and airborne sound testing in accordance with ASTM E492 and ASTM E90 respectively. The baseline assembly was constructed of 300mm x 300mm (12"x12") wood beams spaced 100 mm (48" OC), 57mm x 133 mm (nom 3"x6") wood planks, and 19 mm x 149 mm (nom 1"x6") wood planks laid perpendicular to the layer below. No ceiling was used, as part of the commercial desire for this type of space is the exposed wood ceiling. The baseline assembly tested to IIC 24 and STC 29. Various floor toppings were tested and the resulting IIC and STC data is presented in the paper.

**375 Effects of sample construction, sample size and niche depth on measured sound transmission loss**

*Wareing, Robin R (1); Davy, John Laurence (2); Pearse, John R (1)*  
 (1) University of Canterbury, UK; (2) RMIT University, Australia

**ABSTRACT**

Sound transmission loss measurements, performed using a small test facility (1.5 m<sup>2</sup> sample size) are compared with results from full wall sample (11.6 m<sup>2</sup>). The effects of sample construction, sample size and niche depth are investigated. Significant changes in the measured sound transmission losses were observed between the samples measured. The variation between the two sample sizes was found to be heavily influenced by the construction of the sample. The variation between the sizes was further confounded by the niches present in both sample arrangements. Individually the contributing factors could be explained using existing theories but the interaction of the different factors was more difficult to predict. The behaviours observed were investigated, including the variations in the pressure at the surface of each panel and the pressure variations throughout the room. The pressure variations within the room were not a major contributor to the variations in transmission loss, whereas the variations across the surface had a small effect on the transmission loss. Finally the appropriateness of using the small transmission loss rig for comparative testing of samples was evaluated. The small test rig was found to be useful for tests in which the construction of the test sample was consistent.

**880 The uncertainty in sound insulation of an industrially prefabricated lightweight timber construction**

*Öqvist, Rikard*  
 Tyréns AB, Sweden

**ABSTRACT**

The variations in sound insulation are often large for lightweight constructions. A large number of measurements is therefore necessary to reliably evaluate the acoustical properties of a lightweight construction. The Swedish company Lindbäcks Bygg has since the '90s developed a timber system based on industrially prefabricated volumes. This paper presents a statistical evaluation of all measurements of impact and airborne sound insulation made on the system between 2011 and 2014. The objective was to quantify the variations in impact and airborne sound insulation in both weighted terms and 1/3 octave bands, and investigate the relationship between workmanship and acoustical properties. The study consists of a large number of vertical measurements between nominally identical room pairs. The measurements were grouped according to date, room size, floor level and assembly team. The variations were larger for impact than for airborne sound insulation. The impact sound level was higher in large rooms, which may have been caused by the method of joining several volumes. The sound insulation was somewhat better on higher floors. No significant differences could be identified between the different assembly teams. To improve the system, the impact sound insulation should be in focus.

**852 Laboratory facilities for sound transmission measurements – validation by measurement and simulation methods**

*Meissnitzer, Marlon (1); Buchegger, Blasius (1); Ferk, Heinz (1)*  
(1) TU Graz, Austria

**ABSTRACT**

Test facilities for sound transmission measurements have to be designed according specific international standards. The experience, e.g. of past round robin tests showed, that in spite of the specifications within these standards some differences in the sound transmission measurement occur within different facilities. Some of these differences are related to possible varieties of the room configuration, others may be caused by different mounting conditions of the test specimens, but there are also some effects that are not fully investigated and described within these standards. This paper deals with the validation of such test facilities by measurement and simulation. The combination of these techniques can be helpful to find the right measures for a good diffusivity, avoid unwanted resonances and find the right places for diffusors, microphone and loudspeaker positions in a virtual way before realization. Thus, a step by step validation, combining simulation and measurement can help to get the necessary knowledge for a qualified room and equipment design, as it is shown by an example.

**Tuesday 11:00-12:40 Room 210**  
**N8d Room acoustics**  
**Chair: Toru Otsuru, Delphine Bard**

**726 The prediction of the complex characteristic acoustic impedance of porous materials**

*Larner, David James (1); Davy, John Laurence (1)*  
(1) RMIT University, Australia

**ABSTRACT**

Modeling the complex characteristic acoustic impedance and complex wavenumber of porous materials allows the prediction of the complex specific acoustic impedance of a system consisting of porous absorbers and air cavities in front of a rigid surface. By using the transfer matrix method, the complex characteristic acoustic impedance and complex wavenumber of a porous material can be predicted by using the measured complex specific acoustic impedance of two different systems of the porous material and an air cavity, performed in a two-microphone impedance tube. Depending on the method, the material can be measured with either a rigidly terminated back plate at the back of the material, or a rigidly terminated air cavity at the back. This paper looks at why predictions using the single and double thickness method break down for thinner, less dense materials.

**145 A BEM study of the influence of musicians on onstage sound field measures in auditoria**

*Panton, Lilyan (1); Holloway, Damien (1)*  
(1) University of Tasmania, Australia

**ABSTRACT**

Many recent studies have sought to assess the acoustical experience of musicians playing in ensembles through

development of acoustic measures undertaken on stage in auditoria. It is generally proposed that such measures be undertaken in the presence of stage furniture to better replicate the real conditions onstage with an ensemble present. However, conditions are arguably not necessarily realistic because furniture is customarily removed within 2m radii of the source and receiver to avoid disturbing reflections, and because it is seldom practical to make the measurements with the musicians present. Furthermore, consistency of conditions is also potentially an issue. This paper uses BEM (boundary element method), validated against published full and model scale data, to investigate the differences between sound fields on a stage with an orchestra present and on a bare stage. Sensitivity to perturbations of the stage configuration is also investigated. The results of this study show that for a chamber orchestra, set up on stage, for 250 Hz and above the sound field on an occupied stage differs significantly from an empty stage.

**292 An explicit time-domain finite-element method for room acoustics simulation**

*Okuzono, Takeshi (1); Otsuru, Toru (2); Sakagami, Kimihiro (1)*  
(1) Kobe University, Japan; (2) Oita University, Japan

**ABSTRACT**

The time-domain finite-element method (TD-FEM) is a reliable numerical method for room acoustics simulation. With the recent progress in computer technology, the use of FEM at high frequencies has become a realistic option. However, efficient simulation at high frequencies is still cited as a challenging task. One of the key to realize such simulation is to reduce the discretization error called dispersion error. In this paper, the applicability of an explicit TD-FEM with a dispersion reduction technique called modified integration rule on room acoustics simulation at high frequencies is tested. First, an explicit scheme with frequency-independent impedance boundary condition is derived for addressing boundaries with finite impedance. Then, the accuracy and efficiency of the explicit TD-FEM is demonstrated in comparison with an implicit TD-FEM for sound field analysis inside a cubic cavity with rigid boundaries at the frequencies up to 8 kHz. Finally, the accuracy of the explicit TD-FEM is examined for sound field analyses with finite impedance boundaries. Results showed that the explicit method offered the same accurate results as the implicit method with less computational time, whereas the implicit method was more efficient in term of memory requirement.

**474 Digital sound system modelling and design**

*Davis, Lauren (1); Mackenzie, Neil (1)*  
(1) Aurecon, Australia

**ABSTRACT**

As part of a staged redevelopment of the Adelaide Convention Centre, a new Plenary Hall is to be constructed with a capacity of 3150 seats. The Hall can be subdivided and includes an operable theatre in the round within each sub-division. This paper outlines the acoustic performance criteria for the complex operation modes of the Plenary Hall. It provides a review of the sound system design philosophy and electro-acoustic modelling technique used to predict the acoustic performance of the sound system. It also provides an outline of evolving networking technologies used to provide a

flexible digital audio network using a standard data network infrastructure.

**20 Evaluation of the acoustic performance of a theatrical space set up in a restored Latomia in Ragusa Iblea**

*Patania, Francesco (1); Gagliano, Antonio (1); Nocera, Francesco (1); Cicero, Andrea (1)*  
(1) University of Catania, Italy

**ABSTRACT**

Sicily has many artistic and architectural treasures, wonderful historical buildings, monasteries, abbeys and convents that are often restored and used as government buildings, university buildings, theatre and collective spaces for exhibitions. They often have elliptic or irregular shapes and characteristic values of absorption and diffusivity coefficient of wall surfaces that cause serious acoustical problems such as standing waves, flutter echo, sound focusing and intensive late reflections (greater than 100 ms). Moreover, long and flat parallel walls cause undesirable flutter echo which decreases speech intelligibility seriously and diminishes the effectiveness of early arriving sound energy. The paper presents the results of an acoustic study on outstanding Latomia of Gonfalone located in Ragusa Iblea that was restored and is used as marvelous theatrical space. Firstly, the Authors carried out an acoustic measurement campaign to evaluate the main acoustic indices and parameters and set the current acoustic quality. After that, they applied acoustic computer simulations on the Latomia in order to compare the measured data coming from the survey measurements and the data coming from the code. In this way, it has been possible to test the reliability and accuracy of the code and to evaluate on the spatial distribution patterns of speech intelligibility and other acoustic indices defined in ISO 3382. Finally, they have determined the suitable interventions of acoustic correction to improve the acoustic quality of the theatrical space.

**Tuesday 11:40-12:40 Room 209**  
**S4a Soundscape and methods of evaluation**  
**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**758 Measuring a Soundscape of the captive Southern White Rhinoceros (*Ceratotherium simum simum*)**

*Wiseman, Susan (1); Wilson, Preston S (2); Sepulveda, Frank (3)*  
(1) Texas State University-San Marcos, USA; (2) University of Texas at Austin, USA; (3) Baylor University, USA

**ABSTRACT**

Many creatures, including the myopic rhinoceros, depend upon hearing and smell to determine their environment. Nature is dominated by biophonic and geophonic sounds quickly absorbed by soil and vegetation. Anthrophonic urban soundscapes exhibit vastly different physical and semantic characteristics: reflections from hard geometric surfaces, multi-path propagation and reverberation, and often increased sound pressure levels compared to nature, in addition to much anthropogenic noise not found in nature. Noise damages humans physiologically, including reproductively, and likely damages other mammals. Rhinos vocalize sonically and infrasonically but audiograms are unavailable. They generally

breed poorly in urban zoos, where infrasonic noise tends to be chronic. Biological and social factors have been studied but little attention if any has been paid to soundscape. To comprehensively describe the rhinos' acoustic environment at Fossil Rim Wildlife Center, one of the few U.S. facilities to successfully breed white rhinos in recent years, its broadband sound metrics were studied throughout a week of normal park activities. Further analysis will seek particular parameters known to be injurious to humans, plus those already known to invoke response in animals. Later, a variety of other facilities could be recorded to seek correlations between their soundscapes and the health and well-being of the creatures within their care.

**396 Towards a quantitative tool to assess the soundscape**

*Welch, David (1); Shepherd, Daniel (2); Dirks, Kim N (1); Tan, Mei Yen (1)*  
(1) University of Auckland, New Zealand; (2) Auckland University of Technology, New Zealand

**ABSTRACT**

The aim was to develop a quantitative questionnaire that could easily be administered to assess people's perceptions of the current Soundscape. In a preliminary phase, a group of people identifying themselves as good writers were recruited and played recordings of natural, traffic, and human Soundscapes. As these were playing, participants were asked to write their impressions and responses to each for approximately twenty minutes. Qualitative analysis was used to extract themes from the writing. These themes were identified by key words and scalar (6-point) items were developed to form a short, 19-item questionnaire. This was then administered to 228 people in Auckland city centre, New Zealand. Respondents were able to use the questionnaire, and analyses showed that the items were not independent of each other. Factor analysis revealed patterns of responding, and comparisons between people reporting different levels of Noise Sensitivity and Noise Annoyance revealed that these were associated with the perception of the Soundscape as measured by our questionnaire. The questionnaire appears to be a useful tool, and further research will improve upon it.

**975 Soundscape Transects: Case Studies from New York City and O'ahu**

*Carter, J Parkman*  
Rensselaer Polytechnic Institute, USA

**ABSTRACT**

A new method of linking both the aural and visual conditions of a soundscape is used to create transect maps across complex sonic environments. Two case study transects from New York City will be demonstrated: one comparing highway noise penetration in two adjacent but very different northern Manhattan parks, and the other spanning the width of the island of Manhattan at 75th Street encompassing the Hudson Riverfront park, the Upper West Side neighborhood, Central Park, the Upper East Side neighborhood, and the East River walkway. Another series of soundscape transect case studies from Hawaii's island of O'ahu demonstrates the impact of traffic noise at elevations ranging from sea level to over 800 meters (2,700 feet) high, captured along a variety of ridges across the island. In all of these case studies, having the directional audio information embedded in the extensive

photographic field provides salient representations of the specific characteristics of the soundscapes under study.

Results from this review can apply to EIA for road projects and their optimization.

**Tuesday 11:20-12:00 Room 208**  
**D8b Motor vehicle noise - policy and regulation**  
**Chair: Hans Bendtsen, James McIntosh**

**673 Outcome based optimisation of road traffic noise mitigation**

*Kean, Simon*

NSW Roads and Maritime Services, Australia

**ABSTRACT**

New South Wales, Australia has shifted to an outcomes based approach to delivering traffic noise solutions with mandatory principles that must be met. Supporting procedures give guidance to achieving the principles most of the time. Key tasks in meeting desired outcomes are to identify appropriate noise criteria and to design an equitable mix of 'at-source' and 'at-receiver' road traffic noise mitigation. Particular attention has been given to noise barrier optimisation. This paper presents how legacy approaches have been revised to address recent criteria changes and a shift to outcomes based policy. In New South Wales road traffic noise criteria are set by the State Environmental Protection Authority based on how the road functions in a network. These criteria are guidelines rather than mandatory legislation. Road construction proponents such as the State's Roads and Maritime Services are required to meet these criteria where reasonable and feasible. This is in recognition that it may not always be reasonable to mitigate barely perceivable changes in noise level.

**812 Buffer distances for surface roads and elevated highways correlated with pre-existing ambient noise**

*Zhang, Jiping (1); Buret, Marc (2); Wu, Shuoxian (3); Zhao, Yuezhe (3); Shen, Saiyan (1); Zhang, Xin (1)*

(1) Zhejiang Research & Design Institute of Environmental Protection, China; (2) VicRoads, Australia; (3) South China University of Technology, China

**ABSTRACT**

The guidelines for environmental impact assessment (EIA) in China prescribe a buffer zone - consisting in reserved land or compatible uses - on both sides of noisy roads. However, many EIA reports typically only include predictions and assessment of the traffic noise levels due to the concerned road only. The pre-existing ambient environmental noise levels are then overlooked which may result in under-estimating the resulting noise levels and in buffer distances that are too short. Moreover, in the specific case of viaducts or elevated roads, consideration should be given to extend the concept in the vertical direction as well as the horizontal direction. Based on 3D mathematical modeling by means of proprietary software and typical input traffic data, several road situations are assessed and discussed here. These include surface urban road (e.g. arterial and access roads) and elevated highways passing through different land uses with specific pre-existing noise environments. These examples are used to determine and review the distribution of buffer zones and their boundaries.

**Tuesday 11:20-12:40 Room 207**  
**R5 Bubble acoustics**  
**Chair: Joe Cuschieri**

**126 Application of lattice Boltzmann method to research bubble interacting with spherical particle**

*Shi, Dongyan (1); Wang, Zhikai (1); Zhang, Aman (1)*

(1) Harbin Engineering University, China

**ABSTRACT**

During the process of bubbles interacting with particles, the bubble movement velocity, jetting phenomenon, topological deformation, and even properties of flow field may demonstrate novel variation. To investigate these characteristics, the lattice Boltzmann method (LBM) which is based on kinetic theory is adopted to build up the three dimensional coupled model. The gas-liquid interface with large density ratio is described with free-energy based lattice Boltzmann multiphase model, and the fluid-structure boundary is implemented in the form combining LBM and finite difference method (FDM). Except the obvious and traditional phenomenon such as large interface deformation and velocity variation, it has been found that the gravity-driven spherical bubble finally become a bubble ring after the coupling process. Combining the intrinsically microscopic property of LBM, the complex coupling process is researched with deeper study on relative size and fluid properties. The results may not only advance the LBM application in multiphase coupling field, but make a significant insight into the micro-transient phenomena of bubbles interacting with particles.

**127 Interaction of a pair of horizontally aligned bubbles in gravity field**

*Jiao, Han (1); Shi, Dongyan (1); Wang, Zhikai (1); Li, Hongqun (1)*

(1) Harbin Engineering University, China

**ABSTRACT**

Both large deformation and strong discontinuity problems exist in the process of bubble-bubble interaction. The lattice Boltzmann method which is based on the microscopic level has naturally comparative advantage to describe tiny changes in multiphase flow system. A three-dimensional lattice Boltzmann (LB) model of two horizontally aligned bubbles is presented to explore the bubble movement, topological transformation and bubbles interaction characteristics. In this model, the viscous effect is easily considered, and surface tension effect is realized by introducing a discrete LB body force term. To provide a reference, the isolated bubble dynamics driven by gravity is simulated firstly, and the surface tension effect is studied. Then the effect of gap distance and interface width on the coalescence of two stable bubbles is discussed. Finally, the interaction of two horizontal bubbles with different size ratio in gravity field is explored carefully. The results not only show the detailed coupling and coalescence process of two rising bubbles, but expose that the relative size ratio plays an important role in the interaction. The opposite phenomenon can be seen. When bubbles are of different size, the

coalescence phenomenon will happen, but when they are in the same size, the rejection phenomenon will replace it.

**377 Planar laser induced fluorescence imaging of bubble formation**

*Fedrizzi, Marcus (1); Soria, Julio (2)*  
(1) Monash University, Australia; (2) Monash University, Australia; King Abdulaziz University, Saudi Arabia

**ABSTRACT**

A slowly forming underwater gas bubble will grow, form a neck and detach when the neck collapses, emitting a pulse of sound. During the late stage of the neck collapse the acoustic pulse displays a rarefaction and the acoustic compression begins shortly after detachment. This compression appears to coincide with the formation of an internal jet inside the bubble and an understanding of the behaviour of the bubble internal jet is sought in order to understand the origin of the acoustic emission. In this study time resolved high speed imaging of the bubble detachment process has been undertaken using planar laser induced fluorescence (PLIF) illumination. From these images the internal jet development and evolution are investigated as well as the effect of the jet on the instantaneous bubble volume. The link between the internal jet and the surface waves on the bubble is also investigated for insight on their contribution to bubble sound emission.

**544 Acoustic imaging of surface ship wakes**

*Kouzoubov, Alexei (1); Wood, Shane (1); Ellem, Richard (1)*  
(1) DSTO, Australia

**ABSTRACT**

Techniques for three-dimensional visualization of a surface ship bubbly wake using a high-frequency narrow beam profiling sonar are reported. Instrumentation, experimental set-up, and data processing are described. An Imagenex profiling sonar is mounted on the side of a boat at about 1 m below the water surface. The narrow pencil beam scans the water through the sectors whose plane is perpendicular to the direction of the boat motion. Two scanning techniques were used. In the first, the wake is scanned from the side with about 50° sectors, with the profiling boat moving slowly along the wake in the direction opposite to that of wake laying ship. In the second technique the boat moves inside the wake and scans it with a 180° sector. Both techniques have their advantages and disadvantages which are discussed in the paper. The GPS coordinates of the profiling boat and angular position of the sonar head are recorded. These data allow building a three-dimensional image of the bubbly wake during post-processing.

**Tuesday 11:20-12:20 Room 206  
T3b Effects of noise on humans  
Chair: Lily Wang, Andreas Liebl**

**845 Transferability of the results from laboratory basic research on cognitive impairment by background sound to real life offices**

*Liebl, Andreas (1); Kittel, Maria (1)*  
(1) Fraunhofer Institute for Building Physics, Germany

**ABSTRACT**

The Irrelevant Sound Effect (ISE) is considered to be of great practical importance to real-life work tasks, like in open-plan offices. The knowledge about the physical parameters determining the ISE has also been implemented in national and international standards determining the physical set values for the acoustic design of open-plan offices. However, it may be questioned whether this phenomenon, which stems from basic research in cognitive psychology, can easily be generalized to office environments. Simplifications and means of control applied to laboratory experiments guarantee for reliability and internal validity of the experimental results. However, external validity may be questioned. Details of the real life environment must be properly considered. This paper focusses on the relevance of specific sound conditions. Results are reported which address the relevance of the number, gender and location of speakers for the ISE to arise.

**868 Road traffic noise, air pollution and cardio-respiratory health in European cohorts: a harmonised approach in the BioSHaRE project**

*Blangiardo, Marta (1); Cai, Samuel (1); De Hoogh, Kees (1); Gulliver, John (1); Morley, David (1); Doiron, Dany (2); Elliott, Paul (1); Hansell, Anna (1); Hodgson, Susan (1)*  
(1) Imperial College London, UK; (2) McGill University and Genome Quebec Innovation Centre, Canada

**ABSTRACT**

Background and aims: Few studies have investigated joint effects of road traffic noise and air pollution on cardiovascular outcomes. This project aims to quantify the joint and separate effects of both exposures on prevalent and incident cardiovascular disease and asthma as part of the EU-funded BioSHaRE project involving five European cohorts (EPIC-Oxford, EPIC-Turin, HUNT, Lifelines, UK Biobank). Methods: Health outcomes have been ascertained by self-report (prevalence) and medical record (incidence) and retrospectively harmonised across the five cohorts. Residential road traffic noise exposures for each participant are being estimated using a European noise model based on Common Noise Assessment Methods in Europe (CNOSSOS-EU). Cross-sectional epidemiological analyses are in progress, virtually pooled using DataSHIELD methods. Results: In total, 716,945 men and women are included, mostly >40 years. Initial analysis of EPIC-Oxford and Lifelines showed prevalence of self-reported hypertension to be 26%, high blood lipids 15% and asthma 11% and mean annual 24-hour noise estimates of 56.4 dB(A) (EPIC-Oxford) and 65.8 dB(A) (Lifelines). Correlations between noise estimates and NO<sub>2</sub> are generally low ( $r \sim 0.1$  to  $0.4$ ). Conclusions: Pooling of individual level harmonised data from established cohorts offers the large sample sizes needed to

investigate effects of road traffic noise and ambient air pollution on cardio-respiratory diseases.

**672 Prediction of virtual sound source elevation improved by including input source spectral shape in the prediction equation**

*Manor, Ella (1); Martens, William Leigh (1)*  
(1) University of Sydney, Australia

**ABSTRACT**

Presented with familiar broadband sound sources, human listeners are expected to base reports of source elevation primarily upon spectral variation due to directional dependence of the head-related transfer function (HRTF). Using four recorded speech sounds as sources, this study tested whether reported elevation of virtual sound sources might be systematically influenced by the spectral shape variation that naturally occurs in human speech. A set of 36 virtual sound stimuli were created by processing those four sound sources with nine binaural HRTFs collected at angles spaced at 10-degree intervals on the frontal plane, ranging from 40 degrees below the horizontal plane to 40 degrees above. Perceived source elevation was reported via a graphical user interface by each of five listeners who showed substantial individual differences in response distribution. Overall the collected reports were not highly correlated with the angles at which HRTFs had been measured; however, after the perceptual data were adjusted by subtracting from each source elevation report the overall mean elevation reported by each listener, these centred elevation angles were well predicted by a regression equation that included two terms. The first term was the elevation angle at which the binaural HRTFs were measured, while the second term captured source spectral bandwidth variations between the four sound sources processed using the nine HRTFs.

**Tuesday 13:40-15:20 Room 220**  
**E2 Ground-borne vibration and noise from railways**  
**Chair: Barry Murray, Mark Batstone**

**785 Force Density Measurements at Sound Transit**

*Nelson, James (1); Watry, Derek (1); Faner, Patrick (1); Lamb, Isabelle (2); Reed, Tracy (3); Wright, Armin (4)*  
(1) Wilson, Ihrig & Associates, USA; (2) Jacobs Associates, USA; (3) Sound Transit, USA; (4) USA

**ABSTRACT**

The environmental assessment of ground vibration caused by rail transportation systems is becoming more detailed as new transit and commuter rail systems approach or encroach on sensitive manufacturing and laboratory research activities. Methods for measuring low frequency vehicle/track forces were developed to improve predictions of vibration in Seattle and identify appropriate vibration control strategies. These methods expand on the methodology of ground vibration prediction used by the U.S. Federal Transit Administration, based on the concept of force density level and line source response. Vehicle/track force density measurements were conducted in tunnels using sinusoidal excitation and statistical tests of significance to improved estimates. The methods were

used to overcome the low vibration response of the tunnel structure at low frequencies in over-consolidated soils. The vibration data indicate the effect of track curvature, axle spacing, and profile grinding.

**752 Use of a "Hybrid" Empirical/Finite Element Approach for Predicting Groundborne Vibration from Rail Systems**

*Saurenman, Hugh (1); Roulo, Eric (2)*  
(1) ATS Consulting, USA; (2) Roulo Consulting, Inc., USA

**ABSTRACT**

The finite element method (FEM) is widely used in various engineering fields to model complex structures. Applying FEM to predict groundborne vibration from rail systems has been tested, but always has been limited by difficulty in characterizing soil properties. The empirical method developed in the 1980s (often referred to as the "FTA method") remains the standard approach used in North America to perform detailed predictions of groundborne vibration and to determine the need for vibration mitigation measures. The FTA method is based on in-situ vibration propagation tests and is almost always found to provide more accurate predictions than even the most complex computer models. This paper describes a "hybrid" approach that uses data from vibration propagation testing to refine input parameters for an FEM model. The basic steps are (1) perform a standard vibration propagation test, (2) develop an FEM model of the test configuration using estimated soil properties, (3) "tune" the properties of the FEM model to optimize the correlation with the test results, and (4) modify the FEM model to be a tunnel in place of a borehole. The accuracy of this hybrid approach and other approaches for using FEM models to improve predictions of groundborne vibration will be discussed.

**320 A parametric study on the influence of track irregularities upon train induced ground vibration**

*Yokoyama, Hidefumi (1); Yashiro, Kazuyuki (2); Kato, Shinjiro (2); Ohta, Takehiro (1)*  
(1) Railway Technical Research Institute, Japan; (2) JR-Central Consultants, Japan

**ABSTRACT**

Track irregularity is an important factor of train induced ground vibration, and sometimes causes strong ground vibration. For example, track irregularity due to corrugated rail increased 16 to 31.5 Hz components of ground vibration more than ten decibels on a shallow freight train line tunnel. To estimate the influence of track irregularity, we performed a parametric study using a program for solving coupled vibration of moving-vehicle and structure. We at first confirmed the accuracy of the program by comparing measured and calculated vibration of an in-situ measurement site. In the parametric study, we calculated the acceleration of roadbed caused by sine wave form track irregularity with various wavelength and amplitude. As a result, track irregularity amplitude was found to have certain threshold value. If track irregularity amplitude is larger than the threshold, roadbed acceleration increases as the track irregularity amplitude increases. However, if track irregularity amplitude is smaller than the threshold, roadbed acceleration is almost independent to the amplitude of track irregularity. The threshold amplitude corresponds to the balance point of static axle load and inertial force excited by the track irregularity.

**659 Study on elevated light rail induced vibration attenuation along the surrounding ground**

*Liu, Changqing (1); Zhou, Yude (1); Tu, Ying (1); Xu, Weimin (1)*  
(1) Shanghai Academy of Environmental Sciences, China

**ABSTRACT**

In this paper, the elevated light rail induced vibration attenuation along its surrounding ground is studied. A finite element vibration analysis model is established to compute the vibration response of the surrounding ground with different soil conditions, and the effects of soil parameters on the ground surface on vibration attenuation is analyzed. Vibration measurements were conducted at the surrounding ground of elevated light rail with different soil conditions, which verified the feasibility of FEA (finite element analysis). By the combination of FEA and vibration measurement results, a fast prediction method of the ground vibration is put forward. It is concluded that soil parameters have great effect on the attenuation of ground vibration and environmental vibration caused by the elevated rail could be predicted through finite element method. The conclusion is meaningful to the control and prediction of environmental vibration around the elevated light rail.

**1019 Experimental modal analysis of high-speed railway carriage**

*Ouyang, Shan (1); Sui, Fusheng (1)*  
(1) Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, China

**ABSTRACT**

Experimental modal analysis of high-speed railway carriage Body in White (BIW) with 7 meters long is presented in this paper. The validity of modal testing is verified by comparing mode shapes of the entire carriage with that of beam structures assembled at the bottom floor. Results show that, the demarcation frequency between low frequency vibration and high frequency vibration is 100 Hz. As below 100 Hz, all 6 global modes are included; while above 100 Hz, the mode count within a 1/3 octave frequency bandwidth is higher than 5, which means it could be regarded as high frequency range in statistic energy analysis. Results of modal testing can be provided to modify the finite element model of the carriage structure.

**Tuesday 13:40-15:20 Room 219**  
**V2a Sound visualization and manipulation**  
**Chair: Yang-Hann Kim, William Martens**

**589 Exploring the limitations and expectations of sound source localization and visualization techniques.**

*Heilmann, Gunnar (1); Doeblner, Dirk (2); Boeck, Magdalena (1)*  
(1) gfa tech, Germany; (2) GFAI e.e.v. Germany

**ABSTRACT**

In the late 80's and early 90's institutions like NASA (USA), DLR (Germany), NLR (Netherlands) as well as companies like Boeing (USA) and Airbus (Europe) were leading the academic and technical development of sound source localizations techniques. As companies in today's globalized world operate under pressure of competition and governmental legislation,

the visualization of sound sources was and is essential for understanding a product's acoustic behavior and therefore an integral part of product development. To make the world a quieter place, all try to improve it by understanding, reducing and controlling noise. Even 15 years after the initial market introduction of commercial Beamforming systems not everyone trusts and understands their capabilities and limitations. The aim of this paper is to present a variety of applications and results to show their possibilities and increase the understanding of the limits for different technologies for sound source localization and visualization methods. To do so, a vast selection of colorful and practical examples will provide a better understanding of what is feasible. The given examples range from small motors for digital cameras to household appliances, from cars to mining trucks, from small rooms to theatres and stadiums or from bats to elephants.

**686 Developing beam-forming devices to detect squeak and rattle sources by using FPGA**

*Kim, Youngkey (1); Kang, Jungoo (1); Lee, Myunghan (2)*  
(1) SM Instruments, Korea; (2) Hyundai Motors, Korea

**ABSTRACT**

Industry's high interest on squeak and rattle leads the development of a beam-forming device. Detecting squeak and rattle (SR) noise has been one of the best applications of the beam-forming devices. Localizing the SR noise sources is the most important step of the whole SR noise reduction efforts. In addition, the SR noise mainly consists of high frequency components and the beam-forming has better performance in high frequency range. Successful beam-forming devices for SR noises need to have fast data processing ability in order to detect transient behavior of the SR noise. The paper introduces how digital technologies are used to develop high speed beam-forming device. Since beam-forming process mainly consists of basic mathematical operation, such as addition, delay and multiplication, the process can be implemented in a Field Programmable Gate Array (FPGA) Chip. Because the FPGA has real-time MHz fixed loop rate, the processing loop rate is not the problem anymore. In this paper, two types of beam-forming devices developed by using FPGA are introduced. Application examples show the performance of the devices.

**811 Detection and direction estimation of a sudden loud sound for the hearing assistive eyeglasses**

*Kim, Ki-Won (1); Choi, Jung-Woo (1); Kim, Yang-Hann (1)*  
(1) Korea Advanced Institute of Science and Technology, South Korea

**ABSTRACT**

An assistive device for the hearing-impaired is proposed to detect and visually display the direction of incidence when a sudden loud sound occurs out of sight. The result is intuitively presented in four angular regions, such as the front, back, left, right regions, through the three procedures; decision of the sound occurrence, reduction of reflections, and direction estimation. Basic concepts of the direction estimation is to use the four directional microphones steering toward corresponding angular regions, and each directional microphone is realized by the array signal processing based on the modified LCMV beamformer. The result is obtained by comparing the beamformer output levels, and leads our

attention to corresponding region using LEDs only when a sudden loud sound is detected. The detection is performed using the change of the overall sound pressure level with respect to time as a feature, and its performance and latency are affected by the length of temporal integration. To keep the performance with short latency, an amplitude follower is applied.

#### 111 Non-stationary Holography on Arbitrary Source Shapes

*Gomes, Jesper (1); Ishii, Yutaka (2); Ginn, Bernard (1)*  
(1) Brüel & Kjaer SVM, Denmark; (2) Brüel & Kjaer SVM, Japan

##### ABSTRACT

Laser scanning and accelerometer measurements are often used for analysing vibrations of for instance motors under operation. However, the methods have certain disadvantages: Laser techniques typically scan one point at a time, which limits the methods to be applied only for stationary conditions. Accelerometers can be used for non-stationary conditions, but their physical mounting will to some extent influence the vibration of the source surface and due to cabling they are not practical for rotating objects. Near-field Acoustical Holography (NAH) is a non-contact experimental technique for mapping sound and vibration, and since the sound field is measured at multiple points around the source simultaneously, it can also be applied for non-stationary conditions. In particular, the Equivalent Source Method (ESM) is an attractive holography method, because it does not require neither the source nor the array geometry to be given in separable coordinates (planar, spherical, cylindrical etc.). This paper describes a non-stationary ESM approach for reconstruction of quantities like surface velocity and displacement. A set of measurements has been made with a 60 channel microphone array on a small electrical motor. Vibrations were also measured with a laser vibrometer in order to validate the accuracy of the array calculations.

#### 850 Reconstruction of sound fields with a spherical microphone array

*Fernandez-Grande, Efren (1); Tim, Walton (1)*  
(1) DTU, Technical University of Denmark

##### ABSTRACT

Spherical microphone arrays are very well suited for sound field measurements in enclosures or interior spaces, and generally in acoustic environments where sound waves impinge on the array from multiple directions. Because of their directional properties, they make it possible to resolve sound waves traveling in any direction. In particular, rigid sphere microphone arrays are robust, and have the favorable property that the scattering introduced by the array can be compensated for - making the array virtually transparent. This study examines a recently proposed sound field reconstruction method based on a point source expansion, i.e. equivalent source method, using a rigid spherical array. The study examines the capability of the method to distinguish between sound waves arriving from different directions (i.e., as a sound field separation method). This is representative of the potential of the method to perform sound field identification and visualization in non-anechoic spaces, and ultimately for general in-situ measurements.

### Tuesday 13:40-15:40 Room 218 L3a Applications and systems for active control Chair: Xiaojun Qiu, Woon Seng Gan

#### 73 Applying Active Noise Control Technique for Augmented Reality Headphones

*Ranjan, Rishabh (1); Woon Seng, Gan (1); Yong-Kim, Chong (1)*  
(1) NTU, Singapore

##### ABSTRACT

With the increased popularity of wearable devices, we are seeing head gears (such as Google glass) that provide augmented visual information. We can also extend augmented information to audible signals to guide users in finding their way, alert user to prominent danger in noisy environment, or simply creating virtual-and-augmented reality gaming platform. In this paper, we outline new approaches in combining real sonic environment and augmented virtual sound source through an open-ear headphones. Microphones are positioned in the headphones to capture the sonic information as well as the signal playback to the headphones. Active noise control (ANC) techniques have conventionally been used for noise cancelling headphones, and this paper shows how we can apply ANC techniques in augmented reality headphones to compensate for the sonic difference between augmented and real sound objects and provide a seamless combination of the two. Some interesting new applications using the augmented reality headphones can be realized with this augmented reality headphones, and open up new possibilities for other interactive applications.

#### 167 Active Snore Control System Integrated with Apnea Detector

*Kuo, Sen M (1); Chang, Cheng-Yuan (1); Pottim, Karunakar (2); Liu, Lichuang (2)*  
(1) Chung Yuan Christian University, Taiwan; (2) Northern Illinois University, USA

##### ABSTRACT

This paper presents a snore active noise control (ANC) system to effectively reduce the loud snore for the snorer's bed partner. Real-time experiments are conducted to evaluate the noise reduction performance based on the headboard and pillow setups. This snore ANC system is integrated with a non-obtrusive technique to detect obstructive sleep apnea (OSA) of the snorer. The OSA detection is based on the bispectral analysis of the snore signals picked up by the reference microphone of ANC system.



**174 A decoupled hybrid structure for active noise control with uncorrelated narrowband disturbances**

*Wu, Lifu (1); Qiu, Xiaojun (2); Burnett, Ian S (2); Eva, Cheng (2); Guo, Yecai (3)*

(1) Royal Melbourne Institute of Technology, Australia; Nanjing University of Information Science and Technology, China, Royal Melbourne Institute of Technology, Australia; (2) Royal Melbourne Institute of Technology, Australia; (3) Nanjing University of Information Science and Technology, China

**ABSTRACT**

In real active noise control (ANC) applications, the following situations frequently occur, one is that disturbances only present at the error sensor and have low correlation with reference signal, the other is that there is no enough space or ideal position for locating the reference sensor to satisfy causality condition. Thus the residual noise after feedforward control can be seen as uncorrelated narrowband disturbances in these situations and a hybrid adaptive feedforward and feedback structure is often utilized to cope with this problem. Many efforts have been paid to improve the performance of the hybrid ANC system, nevertheless, few interests are concerned about the combination method between the feedforward and feedback structure. After investigating the conventional combination method of hybrid feedforward and feedback system, this paper introduces an alternate combination method for hybrid ANC system which features that it avoids the coupling between the feedforward and feedback structures and both structures are concatenated to attenuate the ambient noise. Simulations are carried out to validate the effectiveness of the introduced method for ANC with uncorrelated narrowband disturbances.

**177 Development of a voice shutter (Phase 1: A closed type with feed forward control)**

*Nishimura, Masaharu (1); Tanaka, Toshihiro (1); Shiratori, Koji (1); Sakurama, Kazunori (1); Nishida, Shinichiro (1)*  
(1) Tottori University, Japan

**ABSTRACT**

Telephone voice is annoying in public spaces like trains and cafés. The speaking voice was tried to be attenuated by using an active noise control technique. It is called 'Voice Shutter'. Two types of voice shutter, which are open type and closed type, were supposed to be possible. In this paper, a closed type voice shutter with a small vent hole controlled by a feed forward active noise control method was manufactured and tested. In order to develop a small handy type of voice shutter, the distance between the reference microphone and the control speaker should be as short as about 20 mm. The causality law was satisfied by using very high sampling frequency (100kHz) and a high speed signal processor with FPGA. In order to follow the rapid change of voice, partitions with a hole was successfully installed in the voice shutter for the primary path and the secondary path not to be affected by the configuration of a mouth. As the results, the handy scale voice shutter was proved to be feasible.

**661 Active flow control of the exhaust noise from internal combustion piston engine**

*Leclercq, Damien J J (1); Howard, Carl (1)*  
(1) University of Adelaide, Australia

**ABSTRACT**

The concept of reducing piston engine exhaust noise by controlling the flow through the exhaust line has been investigated theoretically and demonstrated experimentally in previous work. While this work demonstrated a successful application to a medium size diesel engine in fixed operational conditions, the issue of back pressure was not addressed. Back pressure can be mitigated by the interposition of a buffer volume, the size of which is a determining factor in system performance, particularly when it is designed to operate over a broad range of engine speed and loading. This paper presents a simplified model of an active flow control exhaust system, which is then applied using a 16 litres, 8 cylinder diesel engine, in order to estimate back pressure, control valve loading and dimension its key components in such a way that back-pressure is maintained below a specified threshold over a broad range of speed and loading.

**Tuesday 13:40-15:00 Room 217**  
**G3 Wind turbines - Evaluation at neighbours II**  
**Chair: Renzo Tonin**

**432 Using Wind Farm Noise Auralisations for Effective Community Consultation**

*Butera, Frank (1); Burgemeister, Kym (1); Fisher, Kai (2); Mounter, David (3)*  
(1) Arup Pty Ltd, Melbourne, Australia; (2) Arup Pty Ltd, Melbourne,; (3) Hydro Tasmania, Hobart, Australia

**ABSTRACT**

Two of the most common questions that wind farm developers face during community consultation are 'what will the wind farm look like' and 'what noise will it make?' A lot of work has been undertaken recently to develop 'visualisations' or 'photomontages' to answer the first question. However, there has not been an equivalent tool available to enable local communities to understand what a wind farm actually sounds like. Arup and Hydro Tasmania have jointly developed a tool that will accurately and effectively communicate what a wind farm sounds like under different wind conditions and from a range of distances and orientations. This auralisation tool provides a practical and affordable means for the industry to effectively communicate what a wind farm will sound like to the community. This paper looks at how auralisation techniques used in other sectors (such as transport and aviation) have been adapted for the renewable wind energy sector and serve as a valuable tool for increasing transparency, minimising risk and building trust within local communities early in the wind farm development process. It shows how a comprehensive field measurement program at Studland Bay Wind Farm, Tasmania has enabled a wind turbine sound library to be developed for future use in wind farm acoustic models and how calibrated auralisations can be presented at community settings.

**1002 The noise characteristics of 'compliant' wind farms that adversely affect its neighbours**

*Large, Sarah (1); Stigwood, Mike (1)*  
(1) MAS Environmental, UK

**ABSTRACT**

In the UK many wind farms cause complaints of noise despite complying with control limits. Problems relate to reliance on the LA90 index, failure to consider or apply ratings on the context of the sound characteristics and actual human responses due to complex characteristics. In general in the UK low frequency and very low frequency sound effects are either ignored or denied. The complex interrelationship of features within this noise and difficulties in quantifying and qualifying noise impact and inappropriate comparison with other sources of noise renders the effects difficult to investigate or quantify with contradictory outcomes possible using the same data sets. Claim and counterclaim of health and adverse effects complicate the analysis. This paper explores some of the interrelating characteristics of wind farm noise measured and observed in the field that appear to influence complaints made by communities. Cumulative effects occurring in environments normally dominated by natural sounds and both audible and inaudible elements remain alien sounds which are not habituated to. It appears that sensitisation arises. The physical reason for the failure to appropriately identify modulating noise effects and in particular low frequency modulating noise problems are explored.

**597 The Relevance of the Precautionary Principle to wind farm noise planning**

*Thorne, Bob*  
Noise Measurement Services Pty Ltd, Brisbane, Australia

**ABSTRACT**

Wind farms consist of clusters of industrial wind turbines which, when placed in rural areas, are associated with intrusive and unwanted sound. Wind turbine noise has characteristics sufficiently different from other, more extensively studied, noise sources to suggest that standard industrial noise standards are not appropriate for measurement and assessment purposes. A seven year study is reported and, although limited in population size, it is clear that there are definite adverse health effects related to wind farm noise. Time-aggregated noise metrics have limited utility in assessing individual human health and well-being, and a cluster of metrics are needed to describe and estimate potential effects on individuals and communities. Sleep deprivation is a widely reported occurrence by people in the vicinity of a wind farm. At this time, however, the quantity and quality of research are insufficient to effectively describe the relationship between wind turbine noise and health, and until such time that a definitive relationship is obtained, legislation should apply the precautionary principle and conservative criteria when assessing proposed wind farm developments.

**1001 Initial findings of the UK Cotton Farm Wind Farm long term community noise monitoring project**

*Stigwood, Mike (1); Stigwood, Duncan (1); Large, Sarah (1)*  
(1) MAS Environmental, UK

**ABSTRACT**

This paper provides early results of a long term study of community impact from wind farm noise and uses of the data obtained. A continuously recorded database of noise collected under different meteorological conditions has allowed detailed analysis of particular characteristics such as amplitude modulation and also the reliability of assessment methodologies for predicting and quantifying impact. Surprising outcomes are explored including upwind impact. In 2013 MAS Environmental established a permanent monitoring station to record and publish data online located 600m from the nearest turbine to correlate the impact upon the community and provide an extensive database. This paper maps the evolution of the project. Online data enables a wider study of the effect of meteorological change on noise immission in a flat eastern area of the UK. Anyone can independently observe and listen to the audible elements of the noise that people complain about. This tool aids understanding as well as predicting times of likely adverse impact. The database has enabled testing of proposed controls, particularly in relation to audible amplitude modulation and demonstrated the recent Renewables UK proposed control mechanism fails. Data obtained challenges blade stall research claims as the primary cause of far field AM and wind farm noise prediction methodologies.

**Tuesday 13:40-15:20 Room 216**  
**C4a New experimental techniques**  
**Chair: Vincent Valeau, Carsten Spehr**

**143 Beamforming array optimisation and phase averaged sound source mapping on a model wind turbine**

*Prime, Zebb (1); Doolan, Con J (1); Zajamsek, Branko (1)*  
(1) University of Adelaide, Australia

**ABSTRACT**

Beamforming is an array processing technique often used to localise sound sources. This paper details the design and testing of a new planar microphone array in the School of Mechanical Engineering at the University of Adelaide which will be used for localising the noise generation from a model wind turbine. The array microphone locations were found using a constrained bi-objective optimisation to find a good compromise between the array resolution, also known as beamwidth, and the maximum value of spurious lobes, known as the maximum side-lobe level. Aggregate and phase averaged beamforming results of a rotor rig experiment are presented.

**558 Development of the Microphone-Array Measurement Technique for use in Cryogenic and Pressurized Wind Tunnels**

*Ahelfeldt, Thomas (1); Spehr, Carsten (1)*  
(1) DLR, Germany

**ABSTRACT**

In the development process of aircrafts and rail vehicles, the use of microphone phased arrays to acquire acoustic data on

scaled models in conventional wind tunnels has become feasible. Since conventional wind tunnels cannot generally achieve full-scale Reynolds numbers, aerodynamic measurements are performed in cryogenic and/or pressurized wind tunnels which are capable of full-scale/higher Reynolds number flows. The microphone array measurement technique has been further developed for the use in cryogenic (down to 100 K) and pressurized (up to 450 kPa) wind tunnels. The comparison of aeroacoustic results obtained from wind tunnel tests with results from real flight tests shows differences. The differences can be attributed to lack of model-fidelity, installation effects, the Reynolds number and the assumptions made in phased array processing. This work focuses on the effect of the Reynolds number. This paper gives an overview of the efforts at to make microphone array measurement technique available to use in pressurized and cryogenic condition. The aim of this development is to enable acoustic measurements on scaled aircraft models in start and landing configuration at real-flight Reynolds numbers.

**587 Beamforming of aeroacoustic sources in the time domain**

*Fischer, Jeoffrey (1); Valeau, Vincent (1); Brizzi, Laurent-Emmanuel (1)*  
(1) Institut P', University of Poitiers, France

**ABSTRACT**

A classical array processing technique used for the analysis of aeroacoustic sources is the frequency-domain beamforming technique. The use of this technique requires an assumption on the stationarity of the sources as it works with a time-averaged estimate of the cross-spectral matrix. As a consequence this technique provides an estimation of the average position (in space and time) of an aeroacoustic source. However, some studies, focusing in particular on jet noise, have shown the intermittent nature of some aeroacoustic sources. The aim of this paper is then to show that the time-domain beamforming technique allows assessing the intermittent nature of aeroacoustic sources, and makes possible a space-time tracking of short duration acoustic events occurring in the flow. The method is applied to experimental wind-tunnel measurements. The noise produced by the flow over a forward-facing step is analyzed by using both frequency-domain and time-domain beamforming, and the intermittent structure of such an aeroacoustic source is investigated.

**776 Correlation of parallel car interior and exterior beamforming measurements in a wind tunnel**

*Neugebauer, Stefan (1); Rösel, Reinhard (1); Döbler, Dirk (1)*  
(1) GFal e.V., Germany

**ABSTRACT**

In aeroacoustics, beamforming measurements have become a standard tool for sound source localization. Additionally, correlation methods are applied to determine the contributions of local wind noise to the measurement. We present a series of synchronized measurements of a car in a wind tunnel, all of them using two beamforming arrays at the same time. One is placed outside the wind stream near the shear layer while the other array is located inside the car's cabin. This setup enables us to localize wind noise transmission into the car's cabin. In the next step, leaks will be ranked by their exterior origins, e.g. side mirror, wheel house etc. by correlating interior and

exterior acoustic images. In contrast to this method, we additionally used measurement microphones as reference channels, which is the classic approach up to now. The paper will compare those two methods.

**327 Three-dimensional beamforming of aeroacoustic sources.**

*Porteous, Ric (1); Prime, Zebb (1); Valeau, Vincent (2); Doolan, Con J (1); Moreau, Danielle (1)*  
(1) University of Adelaide, Australia; (2) CNRS - Université de Poitiers-ENSMA, France

**ABSTRACT**

This paper outlines the development and implementation of an alternative beamforming processing technique known as 'multiplicative beamforming'. The technique is well suited to non-planar microphone arrays scanning a three-dimensional (3D) grid. Numerical simulations show that the technique improves 3D spatial localisation by reducing side lobe levels and removing the directional bias of the main lobe of the beamforming output. It can also be used to accurately localise dipole sound sources, which are commonly found in aeroacoustics. The technique has also been applied to experimentally obtained data measured using a non-planar array inside an open-jet anechoic wind tunnel at the University of Adelaide. The experimentally obtained results show good agreement to that of the numerically simulated results.

**Tuesday 13:40-15:20 Room 215**  
**A3c Noise policy**  
**Chair: Maurice Yeung, Marion Burgess**

**522 Challenge on Environmental Mitigation Measures on Site Formation Work to Achieve Win-Win-Win Situation for Project Proponent,**

*Lee, Lawrence (1); Cheung, M K (1); Liu, Alfa (1)*  
(1) MTR Corporation Limited, Hong Kong

**ABSTRACT**

The construction of South Island Line (East) is a designated project under the Environmental Impact Assessment Ordinance (EIAO) in Hong Kong. An Environmental Impact Assessment (EIA) tool has been developed for the project and was approved in 2010 during the design stage. An amendment of noise mitigation was further enhanced to suit and optimize their methodology in order to achieve a win-win-win situation for the Project Proponent, the Contractors and the Stakeholders. The EIA defined two main activities for the South Horizons Plant Building works, namely "Slope Stabilization and Rock Slope Excavation". The excavation work was presumed to last for over 2 years by mechanical means involving intensive breaking and drilling with hydraulic breakers and drilling rigs respectively which could potentially generate excessive noise impacts to the nearby high density of residents with nearest 30m away from the work site. This paper gives an overview of challenges on the amendment of EIA which included the technical aspects of blasting operation and noise impact from the proposed alternative construction methodology by using opencast blasting in comparison to the mechanical method presumed, where pros and cons are also examined.

**677 Effective noise objectives for industrial and resource developments – setting, compliance assessment monitoring and audit**

*Tickell, Colin*  
Hatch Pty Ltd, Australia

**ABSTRACT**

As a part of government approval of industrial and resource development projects, limits for noise emissions received in surrounding communities is a required activity. Governments have policies and regulations to set limits which are usually based on either achieving acceptable sound levels for amenity or health, often based on WHO guidelines. Limit conditions based on ambient sound levels become difficult for resource or industrially intensive areas, such as the Hunter Valley in NSW, for both governments and communities if policies are not followed. Monitoring is typically required to demonstrate compliance and specific methods may also be required for this. Demonstrating compliance with limits can be difficult despite extensive permanent monitoring systems. Auditing of the monitoring system and reported results may be rare. This paper reviews typical approaches to setting approval limits in some Australian and Canadian states/provinces and how they are typically monitored to assess for compliance. Limit conditions should be like effective specifications – have a sound level objective, location and conditions for assessment, and method, tolerance and reporting requirements. Some difficulties observed in recent projects are discussed improvements to make both limit conditions and monitoring more effective are suggested.

**322 Noise sentinel – a proactive approach to noise management in mining operations at BHP Billiton Worsley Alumina Pty Ltd**

*Kenny, Silver (1); Manvell, Douglas (2)*  
(1) BHP Billiton Worsley Alumina Pty Ltd , Australia; (2) Brüel & Kjær Sound & Vibration Measurements A/S, Denmark

**ABSTRACT**

BHP Billiton Worsley Alumina Pty Ltd (BWAPL) consists of mining operations located near the town of Boddington, a 51km conveyor linking to an alumina refinery located in Worsley and a port load out facility located in Bunbury. BWAPL mining operations expanded in 2012, resulting in mining operations taking place much closer to a number of residential properties in the community and closer to the township of Boddington. Given the proximity of the mining operation to these sensitive receptors, noise was identified early on as a high risk to the operations that needed to be proactively managed to ensure that BWAPL's environmental and social licences to operate were maintained. BWAPL adapted Brüel & Kjær's Noise Sentinel monitoring system to monitor noise generated by mining operations and ensure that the impact on near neighbours was minimised. This was achieved by incorporating alert systems that allowed for proactive management. This paper will cover the compliance parameters required to be measured; the adaptations applied to the software and the key project challenges that were overcome. On the basis of the experiences gained and the positive outcomes achieved through implementing the Noise Sentinel system, BWAPL received a Highly Commended award at the 2013 BHP Billiton Health, Safety, Environment and Community Awards in the Environment category.

**285 Quiet Construction: State-of-the-Art Methods and Mitigation Measures**

*Cheng, Kin Wui (1); Law, Chi-wing (1); Wong, Cheung-lam (1)*  
(1) Environmental Protection Department, Hong Kong

**ABSTRACT**

Alongside with the economic growth, construction activities to cope with the intense demand for infrastructural developments and housing in Hong Kong are at high time in recent years. However, noise from these activities is often a concern to the local communities and it is necessary to strike a balance between the need for meeting tight construction timeframes and the quest for quieter living environment. Typical ways to control noise from construction activities include applying standards for controlling noise at source; site boundaries; and at the receiver such as a residence. No matter which approach is adopted, the use of quieter construction methods, equipment, and effective noise mitigation measures is essential to, both comply with the control requirements and, to certain extent, meet the rising public expectation. This paper will describe the findings from a review on the available state-of-the-art quieter construction methods, equipment and innovative noise mitigation measures. Assessment and analysis of their applicability to Hong Kong situation will be discussed. This paper will also address the issue on promoting wider adoption of these quieter means and enhancing noise awareness through partnership programmes established with the construction trade.

**463 Quality Powered Mechanical Equipment System to Reduce Construction Noise in Hong Kong**

*Law, Chi-wing (1); Wong, Cheung-lam (1)*  
(1) Environmental Protection Department, Hong Kong

**ABSTRACT**

Quality Powered Mechanical Equipment (QPME) System is an administrative system in Hong Kong for promoting the use of environmentally friendly construction equipment. It recognizes construction equipment which is newly manufactured, notably quieter, more environmentally friendly and more efficient. The recognition is realized by granting QPME labels for twelve types of equipment that meet the latest European or Japanese requirements. This System is well received and at present, other initiatives such as the "Pay for Safety and Environment" scheme and profit tax concession have been developed concurrently with the QPME system. This paper will describe how the QPME System is operated and evolved since 2005, its benefits to the environment of Hong Kong, and in particular its effectiveness in reducing construction noise in a dynamic city like Hong Kong.

**Tuesday 13:40-15:40 Room 214**  
**H4a Airport noise modelling and measurement**  
**Chair: Ichiro Yamada, Chris Middleton**

**607 Challenges in Producing an Australian Noise Exposure Forecast**

*McLeod, Ian (1); Latimore, Mark (1)*  
 (1) Airservices, Australia

**ABSTRACT**

Commonwealth owned airports are required to produce an Australian Noise Exposure Forecast (ANEF) every 5 years under the Airports ACT 1996. An ANEF is developed using Australian Standard AS2021. In 1999 the Minister for Transport and Regional Services directed Airservices to endorse ANEFs for technical accuracy. This ministerial direction is still current. The interpretation of technical accuracy has changed over the years since 1999. In the past basing a new ANEF on the previous one was an acceptable practice however this is no longer valid. New technology is changing the way aircraft fly. The improved accuracy resulting from modern navigation instruments has allowed (suitably equipped) aircraft to fly with reduced clearances. New flight paths are today being designed to take advantage of these emerging technologies. Though the majority of the current aircraft may not use them, these new flight paths are within the scope of today's ANEFs. In many cases an ANEF will need to predict how ATC will manage operations at close to the airport's physical capacity. A further complication is the tendency of airports to use long range and ultimate capacity ANEFs that try to predict well beyond the normal 20 year ANEF horizon. This paper examines the common issues past and present that Airservices has had to deal with in carrying out its obligations for technical endorsement of ANEFs and ANELs.

**19 Land-use planning at airports in Germany**

*Weinandy, Rene (1); Myck, Thomas (1); Thierbach, Roman (1)*  
 (1) Federal Environment Agency, Germany

**ABSTRACT**

In 2001 the International Civil Aviation Organization (ICAO) initiated the Balanced Approach to Aircraft Noise Management. It consists of four essential elements to reduce aircraft noise. One is land-use planning and management. In Germany, this already starts with planning of an airport in order to find a suitable site. This planning process deals with aircraft operational aspects as well as economical and environmental ones. After the airport has been built, noise protection areas are to be established according to the German Act for Protection against Aircraft Noise. The noise protection area is subdivided into two daytime and one nighttime protection zone. The act obliges the airport operator to pay for constructional soundproofing measures in existing residential buildings located in daytime protection zone 1 and in the nighttime protection zone. Moreover, expenses for installation of ventilation systems in rooms predominantly used for sleeping are to be reimbursed by the airport operator for buildings in the nighttime protection zone. Furthermore, several local regulations which comprise building restrictions in the vicinity of the airport exist which primarily have the aim to prevent or reduce noise conflicts. The land-use planning at

German airports will be described and evaluated.  
 Keywords: Airport, Noise, Insulation

**594 Reliability of aircraft noise evaluation by measurement for comparison with prediction**

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 (1) Narita International Airport Promotion Foundation, Japan;  
 (2) Aviation Environment Research Center, Japan

**ABSTRACT**

This paper discusses the reliability of measured airport noise evaluation compared with prediction. In Japan, airport noise mitigation measures are performed based on yearly-average airport noise predictions. It is necessary to realize a high reliability in predictions, which are determined by comparing them with noise measurements in order to confirm their validity. However, various factors including microphone height, SN ratio and SEL calculation procedure and incomplete observations affect the reliability of measured noise evaluation. When evaluating yearly-average aircraft noise using short-term measurements, the reliability changes dependent on the measurement period in addition to the afore mentioned factors. Thus, it is necessary to estimate the long-term average using short-term noise measurements and result of continuous noise monitoring or average aircraft operation number. The sound of airport ground activities such as APU or taxiing can be heard in the surroundings of the airport, but the sound propagation significantly changes dependent on meteorological conditions. In other words, airport ground noise becomes louder and audible only in cases of favorable conditions for sound propagation. But, evaluation of yearly-average sound exposure due to aircraft noise requires average-day sound exposure of the year. So, it is necessary to consider what conditions we should suppose for noise measurement.

**395 Measurement of noise exposure planar distribution in aircraft approach path vicinity**

*Ishii, Hirokazu (1); Yokota, Takatoshi (2); Makino, Koichi (2); Shinohara, Naoaki (3); Sugawara, Masayuki (4)*  
 (1) Japan Aerospace Exploration Agency, Japan; (2) Kobayasi Institute of Physical Research, Japan; (3) Narita International Airport Promotion Foundation, Japan; (4) Airport Environment Improvement Foundation, Japan

**ABSTRACT**

Japan Aerospace Exploration Agency is conducting a research project called DREAMS which aims to develop key technologies for future air traffic management systems which will enhance safety, efficiency, user convenience and environmental compatibility of flight operations. One of the research subjects in DREAMS is noise abatement flight technology. Its key element is an aircraft noise prediction model taking into account the effect of meteorological conditions on noise propagation. In order to verify the developed noise prediction model, noise measurement was conducted to obtain the planar distribution of noise exposure below the approach paths. The measurement area was about 4- by 4.4-kilometers and was divided into 110 (11×10) 400- by 400-meter grids. A GPS-synchronized multipoint noise measurement system was placed in every grid. The obtained results proved that the predicted instantaneous noise level and the noise exposure level were in good agreement with the measurement. The average and standard deviation of the noise exposure level

prediction error calculated from 2543 data for Boeing 777-300ER were 0.41 dB and 1.50 dB, respectively.

**260 Noise assessment in the neighbourhood of Italian military airports**

*Filomena, Vincenzo (1); De Vivo, Luciano (1); Notarnicola, Lorenzo (1); Aversano, Renato (2); Tusciano, Manolo (2)*  
(1) CIRA, Italy; (2) Italian Air Force, Italy

**ABSTRACT**

This paper reports the most recent application of the MILNOISE PROCEDURE for the assessment of noise pollution due to training flight operations at Italian military airports. The experimental acoustic characterization of different military aircraft, like C27J, NH500, MB339, AM-X, F-16, EFA, HARRIER, TORNADO, operating in various military airfields, was carried out in the last 10 years. The results of airport acoustic impact on the surrounding environment, with reference to the actual traffic, have been reported in terms of LVA contour plots on 1:25000 scaled maps. In order to minimize the noise impact on inhabited areas surrounding the airfield, both dedicated noise impact evaluation for each aircraft (and for every single noise event such as: take-off, approach, touch & go and flyover) and a specific airport noise assessment with different air traffic scenarios have been carried out. Moreover, a numerical study aimed at evaluating the noise impact of the new F35 military aircraft and at comparing its noise characteristic with present and future military airfield scenarios have been undertaken. All the reported activities have been made in cooperation between CIRA and the Italian Air Force.

**621 Angular and distance dependence of the standard deviation of maximum sound level for aircraft noise**

*Wall, Martin (1); Liljergren, Mikael (1); Heed, Christer (1); Tari, Alborz (1)*  
(1) Swedavia, Sweden

**ABSTRACT**

The current method to calculate number above threshold (NAT) in Sweden does not take into account the natural variation of sound level arising from variations in the sound emission and sound propagation. This leads to unrealistic discontinuities in the calculated noise contours as all movements of a specific aircraft type with a specific procedure are assumed to generate the same maximum sound level. Using long term measurements, the standard deviations of maximum sound levels are analyzed after dividing the airspace around the microphones into sections depending on the elevation angle and distance from aircraft to microphone. The standard deviation in each section is determined by calculating the standard deviation of each aircraft type that passes through that section and combining the aircraft type specific results into one figure. The standard deviation varies from about 1 dB to 3 dB with generally higher values the greater the slant distance and the smaller the elevation angle. The found standard deviations are presented in polar diagrams and are implemented in NAT calculations. The resulting noise contours are not only smoother and without discontinuities, but they are also a better representation of what NAT stands for.

**Tuesday 13:40-15:20 Room 213**  
**Q3a Vibro-acoustic methods for noise control treatments**  
**Chair: Nourredine Atalla, Stephen Hambric**

**873 Numerical modelling of the vibro-acoustic behavior of a closed vehicle with frequency dependent polymer materials**

*Bouayed, Kaiss (1); Mordillat, Philippe (2); Mebarek, Lassen (1); Hamdi, Mohamed Ali (3)*  
(1) ESI Group, France; (2) Renault, France; (3) University of Technology of Compiègne, France

**ABSTRACT**

In this paper, the vibro-acoustic response of a closed vehicle (Renault B95) is computed using a prototype tool based on the VPS software developed by ESI Group. This prototype tool takes into account the frequency dependence of the modulus of viscoelastic materials represented by the PVB of the windscreen and joints between the vehicle's body and glass surfaces. In a first step, the accelerations at different points of the windscreen and pressures inside the cabin are computed and compared to those obtained by NASTRAN software. In a second step, these results are compared with experiments obtained by Renault using accelerometers and those obtained by the University of Technology of Compiègne using a 3D laser vibrometer. Comparisons show an acceptable agreement between different numerical and experimental results.

**3 Research on vibration and sound radiation characteristics of ship stiffened composite plate structure**

*Pang, Fu-zhen (1); Song, Hong-bao (1); Miao, Xu-hong (2)*  
(1) Harbin Engineering University, China; (2) Naval Academy of Armament, China

**ABSTRACT**

Based on Statistical Energy Analysis method, the vibro-acoustic characteristics of stiffened composite plates are investigated in this paper. First, the vibration theoretical model of the stiffened composite plate is developed by using the Hoff sandwich plate theory. The method to calculate the modal loss factor of stiffened composite plate structure is proposed. Then the influence of damping layer thickness, elastic modulus and constraint layer elastic modulus on the vibro-acoustic characteristics of the stiffened composite plate has been studied. The results show that the above three parameters have a great impact on the structural vibro-acoustic characteristics. On this base, the vibro-acoustic characteristics of the cabin segment in composite are investigated. The influence of different constraint damping structure parameters and laying positions on the ship vibration radiation are analyzed. Results show that the laying location of constrained layer damping (CLD) has a great impact on the acoustic radiation reduction. The constrained layer damping laid in the excitation source place can achieve better acoustic radiation reduction.

**35 Optimal design of unconstrained damping material on a thin panel by using topology optimization**

*Yamamoto, Takashi (1); Yamada, Takayuki (2); Izui, Kazuhiro (2); Nishiwaki, Shinji (2)*  
(1) Kogakuin University, Japan; (2) Kyoto University, Japan

**ABSTRACT**

Damping material is usually applied on the steel panel of a vehicle to reduce vibration level. On the other hand, the weight reduction is also required to improve fuel consumption. Therefore, modal loss factors induced by damping material on the steel panel of a vehicle body structure need to be maximized with a given volume. In this paper we propose a practical design method to maximize modal loss factors by optimizing the material distribution of damping material under a prescribed volume constraint. The modal loss factor of an eigensmode can be written as the ratio of the strain energy stored in the damping material over the total strain energy in the system under consideration. In the proposed method, we assume the eigenvectors are almost the same as the eigenvectors when damping material is removed. The modal loss factor can then be expressed by using a corresponding eigenvalue where the mass density of the damping material is ignored whereas the stiffness is taken into account. Several numerical examples are provided to show the optimal distributions of the damping material by using a flat panel. Damping material is distributed in the domain where the strain energy is stored, which agrees well with our experiences. Moreover, by applying a sensitivity filter that utilizes a weighted average of design sensitivities over local area, damping material can be distributed collectively in a single domain to meet practical requirements for manufacturing,

**72 Optimal Configurations of ACLD/Plate for Bending Vibration Control using INSGA-II**

*Zhang, Dongdong (1); Zheng, Ling (1); Li, Yinong (1)*  
(1) Chongqing University, China

**ABSTRACT**

Active constrained layer damping (ACLD) has been demonstrated as an effective means of vibration and noise control for flexible structure. The overall performance of ACLD system is governed by the performance of the passive and the active controls on which the configurations of ACLD treatments have significant effect. In this paper, a multi-objective optimization model for ACLD treatments is established based on the finite element model of the plate partially covered with ACLD treatments. The improved non-dominated sorting genetic algorithm (INSGA-II) is developed to obtain the optimal configurations of ACLD treatments for vibration control of bending modes of the plate. In the optimization procedure, an integrated multi-objective optimization strategy is proposed, in which the passive and the active controls performance are considered simultaneously. The modal loss factors and the frequency response excited by the unit control voltage are selected as the passive and active control objectives, respectively. The location-numbering of the ACLD patches and the thickness of the viscoelastic materials (VEM) and piezoelectric material (PEM) are served as design variables. The vibration control results show that the better results of vibration control can be achieved in passive and active control when the optimal ACLD treatments are employed.

**801 Stochastic porous model of a bone-implant healing process using polynomial chaos expansion**

*Yang, Ji (1); Faverjon, Béatrice (2); Dureisseix, David (3); Swider, Pascal (4); Kessissoglou, Nicole (1)*  
(1) UNSW Australia, Australia; (2) UNSW Australia & Université de Lyon, France; (3) Université de Lyon, France; (4) IMFT UMR 5502 CNRS-INPT-Toulouse 3, France

**ABSTRACT**

Porous material is used in engineering and biomedical structures, where the solid phase is the frame of the material and dissipation effects occur in the pores of the material. This work proposes a stochastic model of porous material to predict the bone tissue healing process in the early period after the implantation surgery. The bone implant is assumed to be axisymmetric and the healing process is evaluated up to 8 weeks after the implantation, which is validated by the canine experiments. The porous dynamic model is coupled with biochemical equations to take into account the osteoblast cells migration and the growth factors diffusion. Using the polynomial chaos expansion method, the effects of uncertain biochemical factors on the distribution of the new-formed tissue around the bone implant are examined. Compared with Monte Carlo simulations, the stochastic model can obtain high accuracy with greatly improved computational cost. The spatial-temporal model presented here provides a tool to evaluate the highly complex implant healing process and the influences of different biochemical factors.

**Tuesday 13:40-15:20 Room 212**  
**Q7 Modal analysis**  
**Chair: Robert Randall, Stephen Conlon**

**783 Automotive cabin characterization by acoustic modal analysis**

*Peeters, Bart (1); El-kafafy, Mahmoud (2); Accardo, Giampiero (1); Bianciardi, Fabio (1); Janssens, Karl (1)*  
(1) LMS International, Belgium; (2) Vrije Universiteit Brussel, Belgium

**ABSTRACT**

The interior sound perceived in an automotive cabin is a very important attribute in vehicle engineering. Therefore, there is an industrial interest to be able to predict the interior acoustic behaviour by means of accurate simulation models. In order to understand the modelling challenges and improve the modelling know-how, experimental methods in which an acoustic characterization of the cabin is performed based on measurements play an important role. When performing an interior acoustic study, it is important to relate the acoustics responses to the intrinsic system behaviour of cabin cavity. This can be done by means of acoustic modal analysis, i.e. modal parameter estimation methods decompose the system behaviour into a set of individual resonance phenomena, each characterised by a resonance frequency, damping ratio, and mode shape. This paper will discuss the equipment requirements and advanced modal parameter estimation techniques. Specific acoustic modal analysis challenges are the high modal damping ratios resulting in highly overlapping modes with complex mode shapes and the use of a large number of references (sound sources) distributed around the cabin to get a sufficiently homogeneous sound field. The

performance of Maximum Likelihood Estimation will be examined and compared to more traditional approaches.

**159 Using frequency and modal analysis to attenuate low frequency waves**

*Ziaran, Stanislav*  
Slovak University of Technology, Slovakia

**ABSTRACT**

The paper analyzes the response of structures and machinery to low frequency vibration (LFV) such as low frequency waves (industrial seismic waves) generated by different machines, technological processes, etc. The principles of the analysis can be applied for different kinds of excitation (stationary – deterministic, random and non stationary – continuous and variable). Some sources, as a result of human activity, for LFV and their subsequent low frequency waves (LFW) were investigated and analyzed. The goal was to determine the Eigen frequencies and Eigen modes of the measured structure and/or machinery not only by identifying sources of vibration but also applying operational modal analysis which is important in designing suitable modal damping. The operational frequency spectrum with Eigen modes of the structure and/or machinery is compared by means of frequency and modal analyses. Through modal damping, levels of low frequency noise may follow, and the transmitted LFV can be the reason why resonance or excitation of the Eigen modes occur. In the conclusions, the measured results of the LFW caused by a vehicles combustion engine is analysed as well as its effect on the cabin of the vehicle. Similarly electromotor resonance is investigated as well. The results of the frequency analysis, and the resulting measurements show the most effective way to attenuate high energy LFW.

**994 Regeneration of frequency response functions from poles and zeros: a discussion with implications for cepstrum-based operational modal analysis**

*Smith, Wade A (1); Randall, Robert Bond (1)*  
(1) University of New South Wales, Australia

**ABSTRACT**

Operational modal analysis (OMA) seeks to determine a structure's dynamic characteristics from response-only measurements, which comprise both excitation and transmission path effects. The cepstrum has been used successfully in a number of applications to separate these source and path effects, after which the poles and zeros of the transfer function can be obtained via a curve-fitting process. The contributions from the individual poles and zeros can then be added (in log magnitude) to regenerate the frequency response function (FRF). This paper discusses a number of observations relating to this FRF regeneration process, as well as a number of broader points explaining FRFs from a pole-zero perspective. Among the topics covered in the discussion are: the required distribution of poles and zeros for the successful regeneration of FRFs; node points and weak modes in a pole-zero model; the differences in pole-zero distribution between receptance, mobility and inertance FRF forms; and, how to deal with the very low frequency region when regenerating FRFs. It is hoped that the discussion will assist in the application of cepstrum-based OMA methods and will lead to improved understanding of the FRF regeneration process and of frequency response functions more broadly.

**252 Removal of shaft speed related components from the response signals of a machine with varying speed prior to Operational Modal Analysis**

*Coats, Michael David (1); Randall, Robert Bond (1)*  
(1) UNSW, Australia

**ABSTRACT**

It is an advantage to remove discrete frequency components from response vibration signals before carrying out operational modal analysis (OMA), because they tend to disrupt the operation of normal OMA algorithms. The removal of such components can be achieved by carrying out order tracking, to remove the effects of speed variations by resampling with a fixed number of samples per period of the frequencies to be removed, so that they are in discrete lines in the order spectrum, and can then in principle be removed by techniques designed for constant speed machines. If the speed variations are greater than 1% or so, the spectrum of the order tracked signals is no longer a frequency spectrum, so modal properties, which are related to frequency, can no longer be obtained by OMA. This paper introduces a method where signals are transformed into the order domain, and after the removal of shaft speed related components are transformed back to the time domain to allow normal OMA to be applied. The method is demonstrated using signals from a gearbox casing excited (via a shaker) with a varying frequency signal containing 22 harmonics corresponding to speed variations of  $\pm 15\%$ .

**237 A detailed experimental modal analysis of a clamped circular plate**

*Matthews, David (1); Sun, Hongmei (2); Saltmarsh, Kyle (2); Wilkes, Daniel Ryan (3); Munyard, Andrew (1); Pan, Jie (2)*  
(1) DSTO, Australia; (2) UWA, Australia; (3) Curtin Uni., Australia

**ABSTRACT**

A detailed study has been made of the natural frequencies and modal shapes of a thin steel disc that is clamped at the edges by two steel flanges. The aim was to determine how accurately numerical modeling could be used to predict the results and to investigate the possibility of any new experimental observations even for this simple structure. A mechanical shaker and impact hammer were used to excite the plate to obtain the frequency response function of the structure. The first eight modal shapes at each of the resonant frequencies were then measured using laser scanning vibrometry. These results were compared with theoretical results obtained analytically and numerically using PAFEC. While part of the existing understanding of the plate vibration was confirmed, significant differences were found in the values of the modal frequencies. The experimental data also demonstrated a dependence of the mode shape orientations and splitting of degenerated natural frequencies on the shaker position and properties of the flanges. This paper will report on some interesting effects that need to be considered when doing such measurements and illustrate the risks of using numerical modeling without the use of experimental comparison.



**Tuesday 13:40-15:40 Room 211**  
**N6c Noise in lightweight structures**  
**Chair: Jeffrey Mahn, Jean-Luc Kouyoumji**

**919 A new building acoustical concept for lightweight timber frame constructions**

*De Geetere, Lieven (1); Ingelaere, Bart (1)*  
 (1) Belgian Building Research Institute, Belgium

**ABSTRACT**

In this paper, a new building concept for multi-family lightweight timber frame housing is proposed. This concept combines party walls, floors and façade elements ensuring comfort levels equal or better than currently encountered in typical Belgian heavy constructions. Low frequency behaviour and prefabrication potential were the key points in the design process of the new wall and floor types. Nevertheless, structural aspects, fire safety issues and thermal capacity have been taken into account as well. Solutions were found by maximally exploiting the mass-spring-mass mechanism. Finally, a holistic approach was followed to develop a building concept in which the walls, floors and façade elements are connected in an optimized way.

**998 The Optimization of a Wooden Floor Design Based on Validated Finite Element Models**

*Mahn, Jeffrey (1); Hopkins, Carl (2); Filippoupolitis, Marios (2); Schanda, Ulrich (3); Vörtl, Raphael (3); Krajči, Luboš (4)*  
 (1) National Research Council Canada; (2) University of Liverpool, UK; (3) Rosenheim University of Applied Sciences, Germany; (4) Soundtherm Ltd. Elgg Switzerland

**ABSTRACT**

This paper describes a research project to develop a dowelled joist floor design which has a similar thickness to typical concrete floor constructions in Switzerland but with better environmental life cycle impact and impact sound insulation below 200 Hz. The dynamic properties of the floor designs were evaluated using a systematic process of developing and then elaborating on initially simple finite element models which were validated based on experimentally determined material properties. This approach was successful with close agreement in both the mode frequencies and the MAC values. Results from the finite element analysis are presented as are the results from impact testing of full scale floor designs.

**10 Approximate formulae for the average one sided specific radiation wave impedance of a finite rectangular panel**

*Davy, John Laurence (1); Larner, David James (1); Wareing, Robin R (2); Pearse, John R (2)*  
 (1) RMIT University, Australia; (2) University of Canterbury, New Zealand

**ABSTRACT**

The authors have previously published approximate formulae for the average one sided specific radiation wave impedance of a finite rectangular panel mounted in a rigid infinite baffle. The panel's transverse vibration was due to a (possibly forced) two dimensional bending plane wave propagating in the panel without reflection at the edges of the panel. The average was

over all the surface area of the panel and over all possible azimuthal angles of propagation direction. The radiation from waves propagating in different directions was assumed to be uncorrelated. These approximate formulae were derived from the 1982 research of Thomasson whose approximate formulae only covered the high and low frequency regions and not the mid frequency region. This paper presents more accurate versions of some of the approximate formulae. When the bending wave number is larger than the wave number of sound, the real part of the impedance is smaller than that for the case studied by Maidanik and Leppington. This is because correlated reflections are not included the case analyzed in this paper. When the bending wave number is smaller than or equals the wave number of sound, the real part of the impedance is the same for both cases.

**802 Prediction of Acoustic Performance of Composite Steel Floors**

*Ballagh, Keith Orsourn (1); Chung, Hyuck (2)*  
 (1) Marshall Day Acoustics, New Zealand; (2) Auckland University of Technology, New Zealand

**ABSTRACT**

One method of constructing lightweight concrete floors in residential dwellings is to use a trapezoidal profile steel pan as a permanent form for a relatively thin pour of concrete. The resulting structure has enhanced stiffness to weight ratio due to the composite action between the steel and concrete, and the inherent improved stiffness of the profiled cross section. However the floor is strongly orthogonal and the composite action makes the bending stiffness's difficult to calculate. Common models for predicting the sound insulation of panels are not accurate. Heckl has provided a solution for the sound transmission of an orthogonal panel, which requires a double numerical integration, however this is time consuming to solve especially if accuracy at high frequencies is required. The current work reports a successful use of ANSI C-2011 Standard for Composite Floors to calculate the bending stiffness's of the floor in orthogonal directions and implementation of a Gauss-Legendre method for carrying out the double integration.

**324 Measurements of junction vibration level differences of timber framed constructions**

*Homb, Anders*  
 NTNU, Norway

**ABSTRACT**

Flanking transmission of supporting walls of timber framed constructions limits the sound insulation properties in multi storey buildings. Both transmission from the floor construction to the supporting walls and the transmission from wall to wall and to either floor or ceiling through the junction is a part of this challenge. This article presents a method of how to measure the vibration transmission properties well fitted for in-situ measurements. The method is applied on some common Norwegian solutions and results will be presented and compared with similar results from other investigations. There is also a lot of research going on to improve the calculation of sound insulation in lightweight constructions according to EN-ISO 12354. Beside the method itself it includes studies on necessary input data regarding the vibration index, Kij and vibration level difference. The article will give some

contribution regarding the distribution of the vibration level from the in-situ measurements.

**545 Flanking sound transmission in an innovative lightweight clay block building system with an integrated insulation used at multifamily houses**

*Buchegger, Blasius (1); Ferk, Heinz (1); Meissnitzer, Marlon (1)*  
(1) TU Graz, Austria

**ABSTRACT**

Accurate calculations in building acoustics depend amongst other on matching values of the vibration reduction index  $k_{ij}$  in component nodes. The usage of common calculation methods based on the mass-ratio of homogeneous materials may fail in complex wall and ceiling structures, so measurements of the values are necessary. In this paper, a comprehensive experimental determination and analysis of the vibration reduction index according to EN ISO 10848-1 on an innovative lightweight clay block building system with integrated thermal insulation is presented. For this purpose, a mock-up consisting of 3 rooms at 2 floors was created in real-size according to the standardized specifications. Investigation shows, that on the one hand, the increased inner damping due to the integrated thermal insulation and on the other hand, modal phenomena in the low-frequency range can cause problems by determining the necessary vibration level differences. To get reliable results, comprehensive analysis on the masonry are performed. A combination of experimental modal analysis and computer-based FEM-simulation models allows a deep insight into the resonant behavior of the entire wall structures, as well as the individual brick. It is shown that the positioning of the measurement positions possibly can have strong effects on the resulting values.

**Tuesday 13:40-15:40 Room 210**

**N8e Room acoustics**

**Chair: Toru Otsuru, Noriko Okamoto**

**254 Generalized alternative image theory to estimating sound field for complex shapes of indoor spaces**

*Kong, Byunghak (1); Lee, Kyuho (1); Jang, Seokjong (1); Park, Seo-Ryong (1); Lee, Soogab (1)*  
(1) Seoul National University, South Korea

**ABSTRACT**

An alternative image theory that can efficiently simulate sound propagation inside a closed space, especially multiple reflections, is proposed. This method defines image spaces according to configuration of a real space, and image receivers instead of image sources are allocated with respect to their local coordinates. As compared to the original image theory, the alternative theory is more effective to develop propagation paths involved with reflections regardless of condition variables such as the number of reflections and combinations of reflecting surfaces. The positions of image receivers located in an image space corresponds to where sound waves that experiences the specific number of reflections related to the order of the image spaces reach to real receivers. Therefore, the sound field inside the real space is obtained by inverting the entire image spaces into the real space, which implies superposition. Basically, it is applicable to convex spaces, e.g. a rectangular hexahedron. Also, concave spaces and spaces that

have partitioned into sub-spaces can be covered by the alternative theory.

**33 Theory and three-dimensional numerical simulation of sound propagation along a long enclosure with side opening**

*Chu, S H K (1); Tang, Shiu Keung (1)*  
(1) The Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

The sound properties along a long rectangular enclosure with a circular source on the top wall and rectangular opening at the side wall are studied. A mathematical model of average pressure at an opening contributed by the sound source and assuming air piston at the opening is derived in terms of the acoustic mode for a rigid duct. Three-dimensional numerical modelling is conducted to compare the theoretical prediction. The computational domain of interest is a long rectangular block associated with an opening connected to a free field environment. Non-reflecting portion is applied to each end of the domain. Sound pressure variations of discrete propagating mode are investigated. Interactions between the resonance of closed duct and effect of the opening are demonstrated at various frequencies. Comparisons indicate that the theoretical predictions give consistent results with that of numerical models. Precision of the radiation impedance of aperture is found crucial to the accuracy of mathematical model. This study approach including the theory and simulation provides a constructive framework for further examination of related subjects.

**568 Reducing Noise and Optimizing Sound within Working Spaces**

*Probst, Fabian*  
DataKustik GmbH, Germany

**ABSTRACT**

Caused by various studies underlining the negative effects of noise exposure and insufficient sound quality within workspaces, this topic receives a growing public attention. These negative impacts include stress symptoms, cardiovascular problems, communication problems and a reduced productivity. In contrary to environmental noise problems caused by infrastructure (aircraft noise, road noise etc.), the responsibility of noise problems within work spaces is distributed among millions of different companies which all require individual solutions. In order to tackle this problem, the German Ministry of Commerce commissioned a project with the objective to develop a procedure to efficiently assess the acoustical situation within workspaces and as a second step to enable the analysis of different measures for improvement. The modeling of complex machinery, speaker systems or people as a sound source must be enabled in order to meet the given objective. At the same time the process should facilitate the comparison of various measures for noise reduction like screens, absorbing baffle ceilings or different workshop layouts. Furthermore and in order to enable a wide base of usage, this procedure needs to be accurate and at the same time easy to apply. This paper provides an overview of research problems, possible solutions and existing techniques.

**1018 Parameters design of a nonlinear membrane absorber applied to an acoustic cavity**

*Shao, Jianwang (1); Wu, Xian (1)*  
(1) Tongji University, China

**ABSTRACT**

The targeted energy transfer (TET) phenomenon has been demonstrated and analyzed between an acoustic medium inside a parallelepiped cavity and a thin viscoelastic membrane that is mounted on one wall of the cavity and that is working as a nonlinear absorber or a nonlinear energy sink (NES). Based on the desired working zone of the NES and the two thresholds of the zone which have been obtained, this paper investigates the parameters analysis of a nonlinear membrane absorber to design the NES. The physical parameters of the membrane and the place of the membrane on the wall of the cavity are studied. It can finally provide us to determine where is the better place for the membrane and which parameter affects mainly the desired working zone for the NES.

**851 Development and sound absorption of interior adjustable acoustical panels**

*Chou, Chuan-wen (1); Lai, Rong Ping (2); Chien, Shao-Chun (1); Yeh, Po Hung (1)*  
(1) National Cheng Kung University, Taiwan; (2) NCKU Research and Development Foundation

**ABSTRACT**

Used the small scale listening room as the example, changed the interior sound field required to redecoration entire room also demand more construction budget; so it is important to development a product could adjustment the sound field also independent from the interior decoration. First, analysis sound absorption, installation, specification of existing acoustics panels on the marketing. Second, based on sound absorption theory to development acoustics panels what could adjustment the reverberation time. This subject designed an acoustical panel what could change the faceplate and structure for the condition without changing interior decoration to satisfy different interior acoustical demand, also maintain independence, include PP (Perforated Panel) and GMP (Geometry Micro-perforated Panel) as acoustics panel's faceplates. The experiments followed CNS 9056 (Measurement of sound absorption in a reverberation room) to evaluated acoustics panels sound absorption performance for the effect factors between installation modes and faceplates. The results of the measurement in the study were shown two parts. One was the influence of equivalent sound absorption area caused by acoustics panels installation modes, and the other was the influence of equivalent sound absorption area caused by changing the faceplate. Above all, the acoustics panel was suitable to adjust the reverberation time without redecorating entire room, and the adjustable interior sound field would be shown.

**654 Finite element sound field analysis for correction of absorption coefficient in reverberation room**

*Tomiku, Reiji (1); Otsuru, Toru (1); Okamoto, Noriko (2); Okuzono, Takeshi (3); Azechi, Yoshiki (1); Yoshida, Tsuyoshi (1)*  
(1) Oita University, Japan; (2) Ariake National College of Technology, Japan; (3) Kobe University, Japan

**ABSTRACT**

In this study, sound fields for the measurement of sound absorption coefficient by reverberation room method are analyzed by time domain finite element method. This study shows effectiveness of the analysis for investigation on causes of variation in the measurement results and improvement methods of the measurement. To evaluate an actual sound field for the measurement, the ratio of incident sound energy to the test material in those to all boundary of the measurement sound field is calculated from results of the finite element sound fields analysis. First, square sound pressure amplitudes of plane sound wave incident on absorption material are calculated in one-dimensional sound field. Next, the calculation method of the ratio of the measurement sound field is described. Finally, relationship among the ratio, shape of the measurement room, and characteristics of the test material is investigated, and it is shown that the bigger normal incident sound absorption coefficient of test material, the larger the change of the ratio for decay sound field regardless of room shape and surface area of test material.

**Tuesday 13:40-15:40 Room 209**

**D3a Electric / hybrid vehicles**

**Chair: Dong Chul Park, David Quinn**

**107 Vibration Control of In-Wheel SRM for Electric Vehicle Applications**

*Sun, Wei (1); Li, Yinong (1); Xu, Guangzhong (2); Zhang, Nong (2)*

(1) The State Key Laboratory of Mechanical Transmission, Chongqing University, China; (2) School of Elec, Mech and Mechatronic Systems, University of Technology Sydney, Australia

**ABSTRACT**

The Switched Reluctance Motor (SRM) processes great application potential in In-Wheel Motor (IWM) electric vehicles (EV). However the problem of vibration and noise is always a disadvantage of this kind of motor. By utilizing the analytical Fourier fitting method, a convenience method for modeling In-Wheel Switched Reluctance Motor (IW SRM) is proposed for EV applications. And the negative vibration and noise effect of IW SRM on vehicle is investigated according to the unbalanced residual lateral force. Then corresponding control methods are proposed, modified and compared. The proposed combined vibration feedback control of current chopping with PWM can effectively reduce the SRM residual force and ensure the required vehicle speed, though some small low frequency force response is induced.

**110 Measurement and analysis of the interior noise and the transfer path of acoustic phenomena into the driver cabin of a battery electric vehicle**

*Fischer, Jan (1); Behrendt, Matthias (1); Lieske, Dirk (2); Albers, Albert (1)*

(1) Karlsruhe Institute of Technology, Germany; (2) Daimler AG, RD/FNP

**ABSTRACT**

Driving comfort is an important factor for buying decisions. This is especially apparent in battery electric vehicles (BEV) where the acoustic quality is an elementary distinguishing feature, since the masking of an internal combustion engine (ICE) is no longer present. Despite the importance of the acoustic quality, there is a general lack of knowledge of how to measure and interpret the high frequency noise generated by an electric powertrain with respect to the NVH behavior influencing the passengers. In this contribution, the measurement results of the interior noise of a battery electric vehicle are analyzed. Specific methods for determining the torsional vibration of the powertrain as reference value are also presented. Furthermore, a method for measuring and interpreting the transfer path of acoustic phenomena from the drivetrain of a battery electric vehicle into the passenger cabin is presented. The measurements are performed in the context of the IPEK-X-in-the-Loop Framework on a roller test bench in a semi-anechoic chamber.

**578 Study of high frequency noise from electric machines in hybrid and electric vehicles**

*Bassett, Timothy Whitehead (1); Tate, Simon (1); Maunder, Matt (1)*

(1) Ricardo, UK

**ABSTRACT**

This study investigates the tonal high frequency noise characteristics which are present within the cabin of an electric vehicle. As the human ear responds differently to different frequencies of sound and this response varies with age, both the level and the frequency are considered. In addition, the amount of annoyance these sounds will cause for the occupants is a function of the tonality and the level of the noise compared to other masking noise sources present. Metrics for tonal noise taking account of these factors are evaluated for a vehicle creep load case and compared to subjective results to determine suitability for the evaluation of electric vehicles. The Stevens VI loudness metric is shown to give a good indication of the total tonal noise present in the cabin of an electric vehicle. The tone-to-noise ratio and prominence ratio are used successfully to compare the level of a tone to the masking noise present, although general prominence limits are shown to be unreliable for evaluation of electric vehicle tones. Finally the noise sources present in the vehicle are reviewed along with factors that must be considered for the diagnosis and mitigation of these different tonal noise sources.

**781 Vibro-acoustic measurements and techniques for electric automotive applications**

*Sarrazin, Mathieu (1); Gillijns, Steven (1); Janssens, Karl (1); Van Der Auweraer, Herman (1); Verhaeghe, Kevin (2)*

(1) LMS International, Belgium; (2) Inverto, Belgium

**ABSTRACT**

In this study, noise and vibration measurements were carried out on a multi-phase 12/8 switched reluctance (SR) motor and analyzed with vibro-acoustic techniques. When evaluating the behavior of electric powertrains for automotive applications, it is necessary to perform a vibro-acoustic analysis, particularly in view of the acoustic comfort perceived by the driver and passengers. High frequency tonal noise can be very annoying and even causes long term damage. Therefore, the noise and vibrations must be deliberately optimized. In case of a SR motor, the radial magnetic forces between the stator and rotor are the main excitation source, yielding large deformations of the stator housing and emissions of noise. Measurements and simulation results are compared for different load conditions. The dominant vibration modes are analyzed with modal analysis techniques. The unpleasant tonal noise of the motor is objectively quantified by noise metrics. Finally, the relationship between the current profiles, radial magnetic forces, and mechanical and acoustical vibrations is investigated in order to obtain a better understanding of the mechanisms underlying the vibro-acoustic behavior of the motor.

**467 Comprehensive Automotive Active Sound Design part 1: electric and combustion vehicles**

*Bodden, Markus (1); Belschner, Torsten (1)*

(1) neosonic, Germany

**ABSTRACT**

The optimization of vehicle sound does not only require the optimization of each component, but the optimization of the combination of the different sounds in order to achieve a homogenous and effective overall sound. Active Sound Design methods offer new possibilities to achieve this ambitious aim, and furthermore to align the overall sound to the Brand Identity. neosonic has developed the modular comprehensive Active Sound Design system elvis3 (ELaborate Vehicle Integrated Sound Signature System) which integrates all audio aspects of the vehicle into one comprehensive tool chain. One component of the system, elvis3 e-motion, is the world's first system used in series in an electric vehicle to create interior vehicle sound (AMG SLS ED Coupe). With the innovative signature-based approach the AMG sound of the 21st century has been realized. A second component, elvis3 Cesar, implements sophisticated support for vehicles with combustion engines using refined signal processing. These two components will be explained in detail along with the flexible system concept. Advanced system modules and applications are part of the second presentation.

**469 Comprehensive Automotive Active Sound Design part 2: Operational Sounds and Brand Sound**

*Belschner, Torsten (1); Bodden, Markus (1)*  
(1) neosonic, Germany

**ABSTRACT**

The basic approach for comprehensive Active Sound Design has been introduced in (1). In addition to the sound generation for electric and combustion vehicles discussed there, hybrid vehicles require specific treatment: on the one hand the transition between electric and combustion drive modes has to be harmonized, on the other hand the characteristics of the different modes have to be maintained. This is achieved by a combination of the signature-based approach and the order-based approach. Besides engine sounds the global approach proposed here also generates and supports operational sounds: it synthesizes feedback sounds aligned to the actual vehicle parameters, thereby optimizing the Sound Quality process in terms of time and costs. The harmonization of all vehicle sounds in combination with the sound signature approach allows the realization of a Brand Sound. Starting from verbal brand descriptors this specific approach transports the Brand Identity into each vehicle. Since such a comprehensive approach has to be implemented into the vehicles specific attention has to be paid to the possibilities of the vehicle adaptations.

**Tuesday 13:40-15:20 Room 208**

**D5 Ultralow noise surfaces**

**Chair: Truls Berge, Luc Goubert**

**9 Results from first Danish full scale test section with poroelastic road surface**

*Bendtsen, Hans (1); Stahlfest Holck Skov, Rasmus (1); Andersen, Bent (1); Cesbron, Julien*  
(1) Danish Road Directorate, Denmark

**ABSTRACT**

The first Danish test section with poroelastic road surface (PERS) was constructed on August 27th 2013 at the Kalvehave test site in Denmark, as a part of the EU project PERSUADE. The test section is 75 m long and has the width of one driving lane. The yearly daily traffic is 4000 with 10 % heavy vehicles. The speed limit is 80 km/h and the estimated real speed is somewhat lower. The pavement is optimized for low emission of tyre-road noise by using a high built in air void, small aggregates and elastic material. The pavement has a porous structure and is composed of stone and rubber aggregates with a maximum aggregate size of 5 mm and the binder used is polyurethane. The pavement type has been developed and tested in the laboratory. An intensive monitoring program was started at the Kalvehave test site even before the test section was opened for normal traffic. The monitoring program includes measuring noise, acoustical absorption, elasticity, permeability, friction, rolling resistance and visual inspections. Measurements of noise using the SPB road side and the CPX trailer methods have been repeated continuously over the first 9 months of the lifetime of the PERS pavement.

**13 Tyre/road noise reduction by a poroelastic road surface**

*Ejsmont, Jerzy (1); Swieczko-Zurek, Beata (2); Sandberg, Ulf (2); Mioduszewski, Piotr (1)*  
(1) Technical University of Gdansk, Poland; (2) Swedish National Road and Transport Research Institute, Sweden

**ABSTRACT**

Low noise road surfaces of existing types may in favourable cases and in new conditions provide up to 7 dB of noise reduction. For higher noise reductions, innovative solutions must be sought. Poroelastic road surfaces (PERS) may be such a solution, which currently is studied in the EU project PERSUADE. This paper presents results of trials with a PERS version prefabricated by one of the project partners. Tests were made in a laboratory at TUG, where different tyres were tested on drums covered with PERS, and later field tests were made on a local street in Sweden where VTI had constructed a 25 m long trial section. The field tests were made with a CPX trailer from TUG. Both laboratory and field results showed that tyre/road noise reductions of 9-11 dB were achieved compared to a dense asphalt concrete pavement with maximum aggregate size 11 mm. This is the best result so far in the project. At the same time, this PERS, despite being relatively soft, reduces rolling resistance of passenger car tyres to record-low values, which is important for reducing fuel consumption and CO2 emissions. It is concluded that this type of prefabricated poroelastic road surface offers a very efficient way of reducing tyre/road noise, provided current durability problems can be solved.

**704 Developing a durable and ultra low noise poroelastic pavement**

*Goubert, Luc*  
Belgian Road Research Centre, Belgium

**ABSTRACT**

Affordable and effective traffic noise mitigation measures are highly wanted, e.g. for the "action plans" which are due for the European Noise Directive in the EU MS. Low noise pavements are an interesting option as they are a "source measure" and relatively cheap compared to other measures. The problem with the conventional low noise pavements is that the obtained noise reduction (typical 2 to 7 dBA) is lower than what can be achieved with noise barriers (typical 7 up to 12 dBA). A poroelastic road surface (PERS), consisting of a significant amount of rubber and bound with an elastic polymer, such as polyurethane, has proven to be capable of reducing the tyre/road noise with 8 to 12 dBA. A limited durability was one of the major obstacles for its use. Since 2009 a consortium of twelve EU partners is working on the development of a useable type of PERS in the EU funded PERSUADE project. All relevant aspects are being considered and for all remaining problems one tried to find a solution. Mixes which at least perform well in the laboratory have been found and these are currently tested on road test tracks. This paper summarizes the current project status.

**719 Innovative low noise surfaces – comparison of damping and absorption**

*Freitas, Elisabete Fraga (1); Dias Rodrigues, José (2); Araújo, Jorge (1); Silva, Hugo (1)*

(1) University of Minho, Portugal; (2) University of Porto, Portugal

**ABSTRACT**

While sound absorption is an acoustic related property reasonably well known and currently used to characterize low noise surfaces, damping is a property commonly used in other domains to define the energy dissipation of a material but rarely used to characterize this important mechanism in road pavements. This paper compares noise related properties such as damping and absorption of five road pavement surfaces. Two of which are innovative and therefore expected to be low noise since they have high voids content, incorporate fine grading aggregates and expanded clay. Other two incorporate rubber and waste high-density polyethylene giving them an elastic and stiff behaviour respectively. The fifth is a conventional material, asphalt concrete, used for control. Sound absorption tests and mechanical impedance tests were carried out in 30x30 cm slabs at 20°C. To measure absorption, an impedance tube with an open end was put on the surfaces. To determine damping, the response of a hammer impact measured by an accelerometer on suspended slabs was analysed. Results show that the innovative surfaces have better acoustic related properties while the surface with high-density polyethylene provided the worst results. Furthermore, a strong correlation of damping and air voids was found.

**955 The best porous asphalt pavement in Sweden so far**

*Sandberg, Ulf (1); Mioduszewski, Piotr (2)*

(1) Swedish National Road and Transport Research Institute, Sweden; (2) Gdansk University of Technology, Poland

**ABSTRACT**

In 2010 a double-layer porous asphalt concrete (DPAC) pavement was constructed in various versions on the E4 motorway through the Swedish city Huskvarna. As a result of a court decision the Swedish Transport Administration had to reduce noise emission by applying a low noise road surface that would reduce A-weighted noise levels by 5 dB, as an average. Earlier experience in Sweden indicated that it was possible to obtain a high initial reduction but due to the widespread use of studded tyres in winter, clogging and ravelling created a loss of around 2 dB per year, with an acoustical lifetime of only 3 years.

However, the improved pavement in Huskvarna has exceeded lifetime and durability expectations by at least 100 %. The first three years noise reduction fell from the initial 7-8 dB by about 1 dB, compared to an SMA 16 pavement, and now in its 4th year the main pavement still performs well. This paper presents results of noise measurements over a 4-year period on various versions of the DPAC and single-layer porous asphalt which were tried at the site. This includes the effects of grinding, cleaning, and rejuvenation. Measurements were made by TUG using the CPX method and two reference tyres.

**Tuesday 13:40-15:40 Room 207  
R6a Underwater noise from pile driving  
Chair: Marten Nijhof**

**95 Analytical model for the sound pressure waveform radiated underwater when an offshore steel pipe pile is driven with an impact hammer**

*Hall, Marshall V*

Marshall Hall Acoustics, Australia

**ABSTRACT**

An analytical model has been developed for the pressure waveform radiated underwater when an offshore steel pipe pile is struck by a hammer. The model is based on the coupled equations of motion for axial and radial vibration of a thin shell and yields frequency-dependent phase velocity and attenuation of these vibrations. A harmonic solution is obtained for the radiated sound pressure, using Junger and Feit's "Transform formulation of the pressure field of cylindrical radiators", which uses a Fourier Transform over vertical wavenumber. The model is applied to a comprehensively described measurement of a 6-tonne hammer driving a pile 32 m long and 76-cm in diameter. The pressure waveforms at horizontal range 12 m are examined at two mid-water hydrophone depths. The correlations between the model waveforms and the measured waveforms are high. For the main positive and negative peaks, the present model yields an average Peak-SPL of 219 dB re 1 µPa, which is 2 dB higher than the average of the corresponding measurements. Possible causes of this small difference are discussed.

**308 A comparison of numerical methods for the time domain modelling of pile driving noise in the near field**

*Wilkes, Daniel Ryan (1); Gourlay, Tim (1); Gavrilov, Alexander N (1)*

(1) Curtin University, Australia

**ABSTRACT**

This paper presents a comparison of numerical methods for the modelling of pile driving noise in the near field of the pile. The numerical models considered consist of (1) an axisymmetric time domain finite difference method (FDM), developed by the Centre for Marine Science and Technology in the Matlab programming language, and (2) an axisymmetric time domain finite element method (FEM), which is available as part of the PAFEC-FE commercial software suite. The FDM employs thin-shell theory to model the cylindrical steel pile and the acoustic wave equation to model the water and fluid seabed, while the FEM employs the elastic and acoustic wave equations to model sound propagation in the pile and water/fluid seabed respectively. A one-way coupling of the pile displacements to the fluid pressures is utilised in the FDM to model the acoustic radiation from the pile excitation, while the FEM employs a fully coupled fluid-structure interaction at the solid-fluid interface. Numerical results for both models are presented in the form of pile radial displacement results and pressure results in the near field of the pile. Good agreement is observed between the FDM and FEM models, while the FDM is observed to be at least twice as fast as the FEM for the considered models.

**358 Overview of existing Noise Mitigation Systems for reducing Pile-Driving Noise**

*Bellmann, Michael*  
itap GmbH, Germany

**ABSTRACT**

Underwater noise caused by impulse pile-driving during the installation of offshore foundations is potentially harmful to marine life, especially marine mammals. In Germany the regulation authority (BSH) set following limit values: (i) Sound Exposure Level (SEL) = 160 dB (re 1  $\mu$  Pa<sup>2</sup>s) and (ii) Peak Level (L<sub>Peak</sub>) = 190 dB (re 1  $\mu$  Pa) which must be complied with at a distance of 750 m to the construction site. The experience over the last years shows that underwater sound during pile-driving mainly depends on pile diameter (currently up to 6.5 m) and the blow energy used. Measurements show values of up to 180 dB for the SEL and up to 205 dB for the L<sub>Peak</sub>. Therefore, Noise Mitigation Systems (NMS) are necessary to minimize the underwater noise significantly. Since 2011 NMSs have to be applied during noisy construction work at all OWFs in Germany. The itap measured the underwater noise and evaluated the sound reduction due to the NMS used during nine OWF construction phases and several substations as well as transformer platform installations. Additionally, itap was involved in many funded research projects dealing with the evaluation and enhancement of existing NMS like OFF BW II. Overall, more than 700 piles were installed in the German North and Baltic Sea by using different NMS in different system configurations over the last years. In this paper a general overview of existing and tested noise mitigation systems is given. The main results and general findings regarding the factors that influence noise reduction will be discussed. Finally, it will be discussed if a general State-of-the-Art exists regarding noise reduction and NMS from the acoustical point of view.

**690 Caltrans compendium of underwater sound data from pile driving – 2014 update**

*Rodkin, Richard (1); Pommerenck, Keith (1)*  
(1) Illingworth & Rodkin, Inc., USA

**ABSTRACT**

In 2009 the California Department of Transportation (Caltrans) published Technical Guidance for Assessment and Mitigation of Hydroacoustic Effects of Pile Driving on Fish (1). The purpose of the technical manual is to provide Caltrans engineers and biologists, and consultants with guidance related to the environmental permitting of pile driving projects in or near water. Appendix I – Compendium of Pile Driving Sound Data provides a summary of measured underwater sound levels for a variety of pile driving situations. The Compendium originally summarized and reported data from 36 projects between years 2000 – 2006. The Compendium was updated in 2012 with addition of 21 projects and updated again in 2014 with the addition of new data from 12 projects. The projects added in 2012 and 2014 included various types of pile driving for coastal and river bridges, harbors and wharfs, additional construction of the San Francisco – Oakland Bay Bridge, and a major structure over water being built for the US Navy. This paper highlights several interesting projects and updates analyses of the data base.

**743 The new noise mitigation system 'Hydro Sound Dampers': history of development with several hydro sound and vibration measurements**

*Bruns, Benedikt (1); Kuhn, Christian (1); Stein, Philipp (1); Gattermann, Jörg (1); Elmer, Karl-Heinz (2)*

(1) Technische Universität Braunschweig, Germany; (2) For some years, a noise prevention concept for the protection of marine animals exists in Germany. Based on that, the underwater sound exposure level SEL due to pile driving at offshore wind farms OWF is required to be less than 160 dB re 1  $\mu$ Pa<sup>2</sup>s at a distance of 750 m. This value, however, is often exceeded so that the use of a soundproofing system is necessary. The Hydro Sound Damper HSD is a new, versatile method to reduce noise levels during offshore pile driving. To achieve this, elements of different sizes and materials which are fixed to fishing nets are used. The principle of operation and the effectiveness of these HSD elements were investigated in the laboratory and in situ under offshore conditions during different pile installations. During these offshore applications thorough measurements were performed which metered the propagation of the hydro sound and the vibrations of the sea floor at various distances and directions from the source. The evaluation of these data led to very promising results concerning underwater noise reduction. This article describes the theory and implementation of the HSD and focuses on the interpretation of the data from the hydro sound and vibration measurements.

**ABSTRACT**

For some years, a noise prevention concept for the protection of marine animals exists in Germany. Based on that, the underwater sound exposure level (SEL) due to pile driving at offshore wind farms (OWF) is required to be less than 160 dB re 1  $\mu$ Pa<sup>2</sup>s at a distance of 750 m. This value, however, is often exceeded so that the use of a soundproofing system is necessary. The Hydro Sound Damper (HSD) is a new, versatile method to reduce noise levels during offshore pile driving. To achieve this, elements of different sizes and materials which are fixed to fishing nets are used. The principle of operation and the effectiveness of these HSD elements were investigated in the laboratory and in situ under offshore conditions during different pile installations. During these offshore applications thorough measurements were performed which metered the propagation of the hydro sound and the vibrations of the sea floor at various distances and directions from the source. The evaluation of these data led to very promising results concerning underwater noise reduction. This article describes the theory and implementation of the HSD and focuses on the interpretation of the data from the hydro sound and vibration measurements.

**769 New achievements in underwater noise modelling for offshore pile driving**

*Trimoreau, Benjamin (1); Smidt Lützen, René (1); Vindahl Kringelum, Jon (2); Shajarati, Amir (2); Skjellerup, Peter (3)*  
(1) Lloyd's Register Consulting, Denmark; (2) DONG Energy Wind Power, Denmark; (3) Geocos, Denmark

**ABSTRACT**

Underwater noise emission from pile driving within the offshore wind industry is becoming an increasingly important issue. To advance the understanding and ability to predict underwater noise emissions and associated control measures,

Lloyd's Register Consulting and DONG Energy Wind Power have initiated model development activities. Two procedures have been applied. First a technique based on empirical data and long range sound transmission models was successfully evaluated. The prediction is based on a semi-empirical source strength which may be re-used for another site, provided the piling setup is similar. Second, a modelling method was then initiated to account for any hammer and pile configurations and gain knowledge on the near-field sound generation. The method combines two techniques: stress-Wave Equation Analysis for Piles (WEAP) and vibro-acoustic Finite Element (FE). WEAP is a well-established geotechnical tool that calculates the stress wave in the hammer-pile system. A customized WEAP is implemented in order to output soil damping and loading function information. The time-domain FE model is then set up accordingly and predicts acoustic pressure data in the vicinity of the pile. Comparisons to measured hydrophone data are very promising and that bodes well for the next modelling steps.

**Tuesday 13:40-15:00 Room 206**  
**S4b Soundscape and methods of evaluation**  
**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**341 Aures – The Advanced Environment Noise Monitoring System – Leq(A) or new measurement technology?**

*Leskinen, Antti (1); Hjort, Roy (2); Saine, Kari (3); Gao, Zengxin (3)*  
 (1) APL Systems Oy, Finland; (2) APL Systems Oy, Finland; (3) Wärtsilä Finland Oy, Finland

**ABSTRACT**

Noise has become one of the major environmental pollutions in urban areas. To ensure that the environmental noise requirements are fulfilled, the noise emission from industries must stay within allowable limits under normal operating conditions. APL Systems has developed an automatic noise surveillance system "Aures" in close cooperation with Wärtsilä Finland. The system includes Aures 2.0 -units and a server operating the Aures Analyzer -software. The possibility of long-term recording and analysing the surrounding noise in frequency domain has enabled this application to be one of the best available environmental noise surveillance systems in the market. The technology of frequency domain measurement and analysis has made it possible to understand better the components of certain noise source. With this feature, it is also possible to get more reliable measurement data when comparing to calculations. This paper questions present environmental legislation it's compatibility with the present needs of the different stakeholders including industry and public authorities. The paper also discusses presenting noise data in frequency domain instead of overall levels and especially why it should be done so.

**656 WYSAHIWYG (What You See And Hear Is What You Get): Learning from photocartography in mapping the cross-modal features of the soundscape**

*Carter, J Parkman (1); Braasch, Jonas (1)*  
 (1) Rensselaer Polytechnic Institute, USA

**ABSTRACT**

"Measuring" the soundscape is like trying to measure the ocean, the forest, or the city—one dimensional metrics and color-coded maps are inadequate to meaningfully describe the myriad complex conditions, relationships, and effects which comprise the soundscape's impact upon us, and our impact upon it. In order to better understand the subjective experience of the soundscape, we need new methods to capture and represent the multisensory extents of the sonic environment. Much can be learned from the recent revolution in photocartography—which uses various forms of satellite and street view photography to generate interactive online maps. Photocartography is the new WYSIWYG (What You See Is What You Get) interface, and has rapidly proven to be more data-rich and more broadly accessible than conventional symbolic maps. This project proposes an interdisciplinary method to integrate multi-directional Ambisonic audio recordings of an environment with high dynamic range (HDR) spherical panoramic photography in the form of interactive maps and virtual tours. Case studies from both urban and park environments will demonstrate how this cross-modal mapping method can capture and reveal specific soundscape phenomena which elude conventional acoustic measurements.

**574 QUADMAP, three pilots and a methodology**

*Wolfert, Henk*  
 DCMR EPA, Netherlands

**ABSTRACT**

QUADMAP a LIFE+ project is running in three European cities, Bilbao, Florence and Rotterdam. The project aims to develop a methodology for identification, selection and management of quiet urban areas (QUA's). This because a methodology is still lacking. In the pilot various types of Quiet Urban Areas have been studied. The areas were analyzed by means of noise mapping, noise measurements and field surveys, asking visitors to their perception. An expert judgment was also conducted. Based upon these analyses interventions were proposed for the selected areas in order to improve the current soundscape, and the overall perception and valuation of the visitors of these areas. The aim of designating and protecting Quiet Urban Areas is that areas with a good acoustic quality and relatively low noise levels are beneficial for health because it offers relaxation and reduce stress levels. Some results are already available on the noise levels determined, perception of wellbeing and all kind of elements present in these areas. Interventions have been planned and employed. The QUADMAP pilot projects will comprise an ex-ante evaluation as well, giving more insight on the effects of various interventions such as noise barriers, low noise asphalt and nature features, on both acoustic and perception factors.



1038 **WithdrawnB**

*WithdrawnB,*

**ABSTRACT**  
WithdrawnB

**Tuesday 15:40-18:00 Room 220**  
**T6a Psycho-acoustics in noise evaluation**  
**Chair: Hugo Fastl, Joachim Scheuren**

941 **ISO 532 – Living and working with alternative loudness standards**

*Scheuren, Joachim*  
Müller-BBM, Germany

**ABSTRACT**

By its very nature, standardization claims to set unique rules and procedures, thus aiming unique, i.e. comparable and reproducible results. Also, to be effective, the standard and the underlying approach need to be broadly accepted by the addressed user community. To come up with such general agreement it is typically required that a "best" approach, covering all relevant applications of interest, has been established. If this does not apply, the existence of alternative standards in parallel may offer a way out. The revision process of ISO 532 "Acoustics – Methods for calculating loudness" showed that it was not possible to prove and agree on a single "best" approach. Acknowledging the legitimate demand of applicative continuity, the member bodies of ISO TC 43 "Acoustics" therefore decided to maintain the given situation by specifying two alternative approaches again. With reference to existing national standards (DIN 45631/A1 and ANSI S3.4), these are the Zwicker approach in an extended version for time-varying sounds and the Moore/Glasberg approach for stationary sounds at first. Based on a review of the revision process and a summarizing justification of the resulting decision, the discussion of practical and theoretical consequences of the renewed dualism will outline the chances for broader applications of loudness calculations. However, this dualism also establishes the commitment to thoroughly identify and seize the chance for final unification of the standard.

257 **Continuous judgment of sound quality of electric home appliances**

*Kuwano, Sonoko (1); Namba, Seiichiro (1); Fastl, Hugo (2); Putner, Jakob (2)*  
(1) Osaka University, Japan; (2) Technische Universitaet Muenchen, Germany

**ABSTRACT**

The sound quality of machinery noises is multi-dimensional and is often examined using semantic differential. In this case the overall impression of sound quality is judged. However, sound quality may vary according to the temporal stream of sounds. In this study, sound quality of electric home appliances was judged using the continuous judgment by line length. Forty-one kinds of the sound of home electric appliances were connected in random sequences with a slight interval between the sounds. The original sounds and their modified sounds were included in

the stimulus of 8 min. The experiment was conducted in Technische Universität München. Ten German participants joined the experiment. They conducted three sessions in which they judged the instantaneous impression of loudness, sharpness and unpleasantness, respectively. The subjective responses were sampled every 100ms. The values of every 100ms of LAeq, LLz(p), calculated sharpness and comfort index (CI) were measured. As a whole the physical metrics showed good correlation with subjective judgments. On the other hand, when the relation between physical metrics and subjective judgments was examined in a limited portion, different tendency was found. It would be better to examine the sound quality along the temporal stream in detail in order to find the clues to improve the sound quality.

331 **Psychoacoustic experiments on some unwanted interior car sounds**

*Fastl, Hugo (1); Beidenhauser, Georg (1)*  
(1) Technische Universität München, Germany

**ABSTRACT**

Unwanted components of car interior sounds include rattling, creaking, squeaking etc. which ideally should be inaudible. On the other hand, wanted sounds which convey information like the click of a switch should be audible also at typical driving speeds. Therefore, in psychoacoustic experiments the audibility of both unwanted and wanted sounds were studied in silence as well as in background noise typical for premium cars at driving speeds of 50 km/h or 120 km/h. In addition, 1/3-oct-band spectra were measured of all evaluated sounds in view of possible predictions of their audibility. The present pilot study features results of psychoacoustic studies on the audibility of unwanted and wanted interior car sounds and gives guidelines towards related algorithmic predictions. Approaches based on spectral displays like Zwicker's excitation pattern model or loudness patterns seem to be rather promising.

213 **Measurement of air-conducted and bone-conducted dental drilling sounds**

*Yamada, Tomomi (1); Kuwano, Sonoko (1); Yasuno, Yoshinobu (2); Kaku, Jiro (2); Ebisu, Shigeyuki (1); Hayashi, Mikako (1)*  
(1) Osaka University, Japan; (2) Kobayasi Institute of Physical Research, Japan

**ABSTRACT**

Patients in dental clinics perceive the bone-conducted sound via the teeth in addition to the air-conducted sound from the ear during the drilling of their teeth. In order to reduce the discomfort during treatment, it is necessary to find the characteristics of both the air-conducted and the bone-conducted dental drilling sounds. It was found in our former studies that rich high-frequency components up to 20 kHz are included in the air-conducted dental drilling sound. However the characteristic of the bone-conducted dental drilling sound is not well known. In this study, the air-conducted and the bone-conducted dental drilling sounds up to high frequency range were simultaneously measured by microphones placed near the participants and on the participants' foreheads during drilling dental materials covered on their teeth. Further, the bone-conducted sound was measured during the drilling of the artificial teeth on the measurement model using the twelve kinds of dental drills. As

the result, high frequency components up to 20 kHz in the bone-conducted dental drilling sound were observed.

**261 The comparison of psychological evaluation between military aircraft noise and civil aircraft noise**

*Morinaga, Makoto (1); Yamamoto, Ippei (1); Tsukioka, Hidebumi (1); Makino, Koichi (2); Kuwano, Sonoko (3); Matsumoto, Mitsuo (4)*

(1) Defense Facilities Environment Improvement Association, Japan; (2) Kobayasi Institute of Physical Research, Japan; (3) Osaka University, Japan; (4) Japan Ministry of Defense, Japan

**ABSTRACT**

It is reported that community response to military aircraft noise is severer than that to civil aircraft noise in some former studies. In the present study, psychological experiments were conducted including the stimuli of military aircraft noise and civil aircraft noise. Participants were not informed whether each noise source was a military or civil aircraft. It was found that perceived noisiness and subjective annoyance to aircraft noises were almost the same between noises from military and civil aircraft when single-event, A-weighted sound exposure levels were equal. This suggests that participants did not distinguish between military and civil aircraft noise. These results imply that overestimation of military aircraft noise is caused by not only acoustic properties but also non-acoustic factors, such as attitude toward military aircraft noise.

**486 Ground-borne vibrations, sounds and secondary airborne sounds from tramways: a psychoacoustic evaluation including health aspects**

*Cik, Michael (1); Lercher, Peter (2)*

(1) University of Technology, Graz, Austria; (2) Medical University Innsbruck, Austria

**ABSTRACT**

For decades, urban noise and vibration studies were mostly concerned with road traffic and trains. Tramway noise was rarely studied. Since the introduction of new types of tramways in the city of Graz strong complaints were brought up by local residents in certain areas. Typically, the annoyance by tramways results from a complex combination of sounds and vibration exposure depending on ground structure and building conditions. To sufficiently account for this complexity an integrated psychoacoustic approach was applied. In a free field study ground-borne vibrations and sounds as well as secondary airborne sound recordings were carried out for various tramway types. For this purpose a binaural dummy head measurement system for noise and a triaxial accelerometer for vibrations were used to operate in synchrony. In addition to standard sound parameters (SPL), psychoacoustic parameters were analyzed to learn more about the complex psychological and physiological responses associated with the introduction of the new tramway types in Graz. First results indicate differences between the different tramway types in both classical and psychoacoustic indicators. Preliminary analyses show slightly higher levels of loudness and roughness for the new tram pass-bys while mean vibration levels stay below the typical threshold values for the average human subject.

**378 Overall loudness of short time-varying sounds**

*Schlittenlacher, Josef (1); Hashimoto, Takeo (2); Kuwano, Sonoko (3); Namba, Seiichiro (3)*

(1) TU Darmstadt, Germany; (2) Seikei University, Japan; (3) Osaka University, Japan

**ABSTRACT**

When predicting the overall loudness of time-varying sounds, it is necessary to use a function which calculates an overall value based on instantaneous loudness. Although N5 and LL(P) correlate for many sounds, their concepts are rather different. N5 is the loudness which is exceeded in five percent of the time, thus it is an ordinal value. LL(P) is the energetic mean of all instantaneous loudness values. For the present set of experiments, sounds with orthogonal conditions were chosen. This means they vary in N5 in a dynamic range of about 30 phon but have constant loudness according to LL(P) or vice versa. Participants judged the overall and instantaneous loudness of the sounds with ten seconds duration by magnitude estimation using line length and continuous judgment. The results show that LL(P) has some advantages compared to N5. In contrast to N5, it correlates highly with the overall loudness for the present set of stimuli.

**Tuesday 15:40-18:00 Room 219**

**T2 Reaction to traffic noise**

**Chair: Truls Gjestland, Hans Bendtsen**

**741 Subjective experiment on auditory localization for traffic alarm sounds in a heavy truck**

*Yokoyama, Sakae (1); Tachibana, Hideki (2); Makinouchi, Hideo (3)*

(1) Kobayasi Institute of Physical Research, Japan; (2) University of Tokyo, Japan; (3) Hino Motors, Japan

**ABSTRACT**

When driving a road vehicle, it is often experienced that the judgment of directions of alarm sounds like horn and sirens of ambulance car, fire engine etc. becomes difficult. Especially in case of a heavy truck, the misjudgment of auditory localization of sirens is seriously related to traffic safety, because a road can be obstructed by a heavy truck. In this study, therefore, the auditory localization for traffic alarm sounds at driver's position in a heavy truck was examined by laboratory experiments. To perform the auditory tests in an anechoic room, the 6-channel recording/reproduction system as a 3-dimensional sound field simulation technique was applied. By using measured directional impulse responses from outside into a driver's head position in a heavy truck, the source position for localization tests was distributed at every 30 degrees in horizontal plane. Further, to see the influence of a connected loading space on driver's auditory localization, the experimental investigation was performed for two cases, with/without the loading space. In this paper, the results of the localization tests are presented and acoustic problems are discussed.

**7 Experimental study of traffic noise and human response in an urban area: deviations from standard annoyance predictions**

*Salomons, Erik M (1); Janssen, Sabine A (1); Verhagen, Henk L M (1); Wessels, Peter W (1)*  
(1) TNO, The Netherlands

**ABSTRACT**

Annoyance and sleep disturbance by road and rail traffic noise in an urban area are investigated. Noise levels  $L_{den}$  and  $L_{night}$  are determined with an engineering noise model that is optimized for the local situation, based on local noise measurements. The noise levels are combined with responses of 71 inhabitants to an annoyance survey to derive local exposure-response relations, using the regression method with censored normal distributions developed by Miedema and coworkers. It is found that the local exposure-response relations deviate considerably from the 'standard' relations derived from international annoyance surveys. Noise events reported by the inhabitants – such as freight trains passing through the area at night – are described to illustrate the local situation. Future scenarios for the urban area are also analyzed, including measures aimed at reducing road and rail traffic noise. Numbers of highly-annoyed inhabitants in the urban area are calculated for different scenarios by applying the local exposure-response relations to the total population in the area of about 1000 inhabitants.

**339 The influence of location of the privileged vehicle siren on the vehicle traffic safety**

*Gorski, Pawel (1); Zawieska, Wiktor M (1)*  
(1) Central Institute for Labour Protection - NRI, Poland

**ABSTRACT**

Audible emergency signals generated by sirens of privileged vehicles should be audible and recognisable by all participants of the traffic. Currently in Poland, A-weighted sound pressure levels of audible emergency signals generated by sirens of privileged vehicles range between 104 and 108 dB. In turn, the A-weighted sound pressure levels measured inside the privileged vehicles may exceed the value of 90dB. Such high sound pressure levels may adversely affect the working conditions of the privileged vehicle crew. A commonly applied solution, aimed at limiting the exposure of the privileged vehicle crew to noise, is fitting the siren in the engine compartment rather than in the vehicle roof lightbar. Changing the location of the siren can reduce the measured sound pressure levels inside the vehicles by about 10 dB. Changing the location of the siren has also a significant impact on the audibility of the emergency signal by the other participants of the road, and thus affects the vehicle traffic safety. It is necessary to initiate a discussion on improving the acoustic comfort of the vehicle crew, and at the same time maintain the informational function of the emergency signals.

**478 Noise annoyance for a motorway compared to urban roads**

*Bendtsen, Hans (1); Pedersen, Torben Holm (2); Le Ray, Guillaume (2); Kragh, Jørgen (1)*  
(1) Danish Road Directorate, Denmark; (2) DELTA SenseLab, Denmark

**ABSTRACT**

This study summarizes of the noise annoyance from road traffic noise from a motorway (M3) and two urban roads near Copenhagen. The urban roads are characterized by open urban areas with a substantial share of 3-5 storeyed residences (2870 respondents). The areas next to motorway M3 consisted mainly of 1-2 storeyed houses protected by noise barriers of 4 m height along the motorway (1410 respondents). At noise exposure levels,  $L_{den}$ , below approx. 55 dB the dose-response curves were not significantly different. At noise exposures above 55-58 dB the noise from the M3 is perceived as more annoying than the noise of urban roads at the same levels. At the high levels, this difference is equivalent to a difference of approximately 5 dB. The annoyance around the M3 motorway is significantly and substantially above the annoyance found in the European dose-response curves. The M3 study shows that at 50% annoyed the neighbours are so much more annoyed that it equivalent to 6-12 dB higher noise exposures. For the urban roads it was found that at 50% annoyed the annoyance compared the European curves was equivalent to 3-5 dB higher noise exposure.

**957 Using mathematical models to predict annoyance from combined noise sources in the city of Dubai**

*Elmedhi, Hussein*  
University of Sharjah, United Arab Emirates

**ABSTRACT**

Residents of major cities of the United Arab Emirates are exposed to multiple noise sources originating from road traffic, aircraft flyovers and various industrial activities. Predicting the contribution of each of these sources to public annoyance, and hence relating it to health effects on residents of these cities, is not an easy task because of the complex nature of these sources and their subjective contribution to community annoyance. In this paper, we report preliminary results of applying mathematical models to assess annoyance due to combined sources using data obtained from noise level measurements in combination with social surveys conducted near the selected sites. The models are based on the 24-h average sound levels  $L_{Aeq, 24h}$  and the measured annoyance scores for aircraft, road traffic, and combined noise. Models are based on the assumption that the annoyance caused by combined noise sources can be predicted by the total energy and separate sources make independent contributions to the total annoyance. Our results show that annoyance due to aircraft noise was slightly modified by additional road traffic noise. The results also indicate that road traffic noise exposure and annoyance were more dominant than those of aircraft noise at most sites.

**97 Structural equation model of road traffic noise annoyance in Vietnam**

*Nguyen, Thu Lan (1); Yano, Takashi (1); Yokoshima, Shigenori (2); Morihara, Takashi (3)*  
(1) Kumamoto University, Japan; (2) Kanagawa Environmental Research Center, Japan; (3) Ishikawa National College of Technology, Japan

**ABSTRACT**

The exposure-response relationships for road traffic noise annoyance in Vietnam were proposed according to over 4700 responses obtained in Hanoi, Ho Chi Minh, Da Nang, Hue and Thai Nguyen. However, the variation of the exposure-response curves found among the five cities implied that discrepancies could occur between different geographic regions like the north and the south of Vietnam. To assess the effects of acoustic and non-acoustic factors on road traffic noise annoyance in Vietnam, structural equation models were developed by linking the questionnaire items of the socio-acoustic surveys on road traffic noise annoyance conducted in the five cities. The sample sizes were 1174, 1403, 432, 592, and 633 to estimate the models for Hanoi, Ho Chi Minh, Da Nang, Hue and Thai Nguyen, respectively. The final model included three latent factors: activity interference; sensitivity; and satisfaction with living environment. Sensitivity to noise, vibration and heat are determinants of personal sensitivity. Activity interference was measured by awakening in the sleep, rest and listening disturbance. Evaluations on quietness of living areas, preference to the living areas and comfort in the dry season are loaded in satisfaction with living environment. The model provided good model fit and indicated that sensitivity and satisfaction with living environment were the main modifiers of road traffic noise annoyance in Vietnam

**109 Social surveys on community response to road traffic in five cities in Vietnam**

*Shimoyama, Koji (1); Nguyen, Thu Lan (1); Yano, Takashi (1); Morihara, Takashi (2)*  
(1) Kumamoto University, Japan; (2) Ishikawa National College of Technology, Japan

**ABSTRACT**

Social surveys on community response to road traffic noise have been performed since 2005 in five major cities in Vietnam: Hanoi, Ho Chi Minh City, Da Nang, Hue and Thai Nguyen. The total sample size and the average response rate were 4966 and 64%, respectively. The noise exposures ranged from 61 to 83 dB in Lden. The exposure-response relationship was drawn with logistic regression curve based on all the socio-acoustic survey data, which can be proposed as the representative exposure-response relationship for road traffic noise in Vietnam. This curve showed that Vietnamese respondents were about 5 to 10 dB less annoyed by road traffic noise than those of EU and Japan. Exposure-response curves for general annoyance, awaking, falling asleep, conversation, telephone-listening, TV/Radio listening, reading/thinking, and rest disturbances were also drawn. Annoyance in the two largest cities, Hanoi and Ho Chi Minh City, were higher than those in the other three cities. Sleep disturbance was severer than listening and the other activity disturbances in all the cities. The distribution pattern of annoyance was consistent with those of environmental factors such as residential satisfaction. This finding suggests that noise annoyance is

strongly affected by or interacted with the evaluation of residential environment.

**Tuesday 16:00-18:00 Room 218**  
**L3b Applications and systems for active control**  
**Chair: Xiaojun Qiu, Woon Seng Gan**

**346 A new structure for nonlinear narrowband active noise control using Volterra filter**

*Liu, Jian (1); Xiao, Yegui (2); Chen, Hui (1); Liu, Wenbo (1)*  
(1) Nanjing University of Aeronautics and Astronautics, China;  
(2) Prefectural University of Hiroshima, Japan

**ABSTRACT**

Many structures and algorithms have been developed for linear narrowband active noise control (NANC) systems, which are effective in suppressing sinusoidal noise generated by rotating machines and devices with reciprocating motion. However, the conventional linear NANC systems may seriously suffer from performance degradation due to the nonlinear distortions which, large or small, usually exist in real-life sound fields. Development of nonlinear NANC systems to solve the above-mentioned problems has recently attracted a great deal of attention and several structures and algorithms have been proposed based on the use of adaptive Volterra filter. In those systems, the sinusoidal noise at the reference point is distorted by the nonlinear part of a primary path, eventually adding some high-order harmonic components to the primary noise being targeted. But the main body of the primary noise is still dominated by linearity of the primary path. This paper presents a new structure for a nonlinear NANC system, where the largest portion of the primary noise power can be reduced by the conventional adaptive linear filter and the remaining portion due to high-order harmonics may be effectively suppressed by an adaptive Volterra filter. Numerical simulation results reveal that the proposed system is very effective in suppressing sinusoidal noise distorted by nonlinearity of the primary path.

**483 Basic study on active acoustic shielding: phase 6 improving the method to enlarge AAS window-2**

*Murao, Tatsuya (1); Nishimura, Masaharu (1); Sakurama, Kazunori (1); Nishida, Shinichiro (1)*  
(1) Tottori University, Japan

**ABSTRACT**

In this paper, it was proved to be useful to use  $M[(1-1)-L']$  FX-LMS algorithm for Active Acoustic Shielding (AAS) window to enlarge the window size. The AAS is a system that can attenuate the sound passing through an open window. The AAS system is composed of many AAS cells set in an array. Each AAS cell consists of approximately collocated a microphone and a speaker. However, a size of existing type AAS window is 250mm square. Therefore, we proposed  $M[(1-1)-L']$  FX-LMS algorithm (M: number of AAS systems, L': number of error signals used for controlling one AAS cell) for controlling a large size window and large number of AAS cells. This algorithm is a kind of FX-LMS algorithm, each AAS cell is controlled individually by its own reference microphone and neighboring error sensors. In the previous work, 6 AAS cells is set on rectangular window (125 x 750mm square) and controlled by  $6[(1-1)-3']$  FX-LMS. As

a result, this system was proved to be useful for controlling AAS cells, In this paper a simulator of  $M[(1-1)-L']$  FX-LMS algorithm was constructed, and the simulation results by  $6[(1-1)-3']$  FX-LMS algorithm well coincided with the above experimented results. This suggests that large AAS window feasible.

#### 540 Active noise control in practice: transformer station

*Buikema, Edwin (1); Van Der Ploeg, Fokke D (1); Granneman, Jan H (1)*  
(1) Peutz, The Netherlands

##### ABSTRACT

Based on literature and extensive measurements at a specific transformer two concepts regarding anti noise have been developed. These concepts have been tested in the Peutz acoustical laboratory, and on site with an experimental setup for anti noise at large transformers. Noise measurements show that a reduction of 5 dB can be achieved in all directions. Additionally, by directing the noise emission, a reduction of 10 dB can be achieved in one specific direction. This experimental project was part of a broader demonstration project regarding the practical application of different types of sensor technology.

#### 730 An integrated passive and active control system for reducing haul

*Lin, Zhibin (1); Zhang, Limin (2); Qiu, Xiaojun (1); Pan, Jie (3)*  
(1) Key Laboratory of Modern Acoustics Institute of Acoustics, Nanjing University, Nanjing, China; (2) School of Electronic Science and Engineering, Nanjing University, Nanjing, China; (3) School of Mechanical & Chemical Engineering, University of Western Australia, Australia

##### ABSTRACT

This paper is concerned with the analysis and design of an integrated passive and active control system for reducing the haul truck noise. By using a passive enclosure with two open ends and fiberglass inner surface, a three-dimensional noise radiation problem of the engine noise is shaped to a simple problem of noise radiation from the open ends above 200 Hz. Below 200Hz where the transmission loss of the lightweight enclosure is low, a spatial global active noise control (ANC) system is constructed inside the enclosure. To improve the performance of the system, the open ends are divided into four equal diameter size ducts each followed by a louver. A single channel ANC system is set up in each duct to eliminate the noise in the frequency range from 200 Hz to 400 Hz. Experimental results demonstrate that more than 20 dB insertion loss is achieved with such a passive enclosure at frequency band above 400 Hz, and 8 dB noise reduction with global ANC systems at frequency band below 200 Hz, and 4 dB noise attenuation with single channel ANC systems between 200 Hz and 400 Hz. The results this investigation show the feasibility of hybrid noise control technique for reducing the haul truck noise.

#### 855 Applying an active noise barrier on a 110 KV power transformer in Hunan

*Zou, Haishan (1); Huang, Xiaofan (1); Hu, Sheng (2); Qiu, Xiaojun (1)*  
(1) Nanjing University, China; (2) Hunan Electric Power Corporation Research Institute, China

##### ABSTRACT

There are increasing needs to reduce the transformer noise recently in China because some residential buildings developed recently are located more and more close to the pre-existing substations. Passive barriers are often used around the outdoor transformers to block the noise. However, the noise reduction performance of the barriers is poor in low frequency range, especially when the noise wavelength is larger than the height of the barrier. Consequently, active noise control (ANC) system has been investigated to enhance the insertion loss of traditional barrier in low frequency. In this paper, a prototype active noise barrier (ANB) was developed and applied to a practical case. Physical system of the ANB was designed in first. Then a decentralized feedforward ANC system composed of the cascaded active units was developed, and the waterproof structures were developed to protect the elements of the system. Again, experiments were carried out on the rooftop of a five-floor building to verify the effectiveness of the system. Finally, the practical application in Hunan is investigated, in which the noise reduction of the 110kV power transformers was needed.

#### 635 Virtual sound barrier for indoor transformers

*Tao, Jiancheng (1); Wang, Shuping (1); Qiu, Xiaojun (1); Han, Ning (2); Zhang, Linke (3)*  
(1) Nanjing University, China; (2) Southeast University, China; (3) Wuhan University of Technology, China

##### ABSTRACT

Power transformers sometimes locate in an enclosed room with an opening surface for the ventilation purpose. Under these situations, most noise radiates out from the opening, so a virtual sound barrier can be built to suppress the sound radiation outside by employing a multiple-channel active noise control system. Based on the sound radiation model of indoor monopoles, the noise reduction performances of both centralized and decentralized control systems are investigated and compared. Considering the channel number requirement, a virtual sound barrier is built for an actual indoor transformer, where both the centralized and the decentralized strategies are investigated. Simulation results show that the fully independent virtual sound barrier is effective for the indoor transformer noise control.

**Tuesday 16:00-17:40 Room 217**  
**G4 Measurement - Infrasound, LFN, Tonality**  
**Chair: Mark Bastasch**

**52 Infrasound and blade pass frequency levels in areas adjacent to wind farms**

*Lenchine, Valeri V (1); Song, Jonathan (1)*

(1) SA Environment Protection Authority, Australia

**ABSTRACT**

Concerns have been expressed by sections of surrounding community about infrasound produced by wind farm renewable energy facilities from specific nearby wind farm locations in Australia. This has received regular media attention. There are various methods which can be used to determine the contribution of infrasound by wind farm facilities. However sometimes they do not produce conclusive results. This paper discusses the use of statistical hypothesis tests to determine infrasound contributions of wind farms. Verification of equivalency of means and equivalency of variance hypotheses were used on several shutdown and similar operational periods to check for infrasound impact. The data sets were collected during infrasound measurements performed at 3 different locations with a distance range of approximately 1.3km to 3.5km. Results show that the wind farms tested can contribute to infrasound at large distances but levels were significantly lower than the conservative perception threshold of 85dB(G). The blade pass frequencies were also analysed for the same set of data to detect any potential to exacerbate human perception of infrasound. It was found that the blade pass frequency was not very prominent at all monitoring locations and was detected at levels significantly below the perception threshold. There was also a minimal difference in blade pass frequency magnitudes and its prominence for indoors and outdoors measurements. In general infrasound impact from modern turbines at the distant receivers cannot be considered excessive and its magnitudes are significantly below the perception threshold.

**813 Investigation of the time dependent nature of infrasound measured near a wind farm**

*Zajamsek, Branko (1); Hansen, Kristy (1); Hansen, Colin (1)*

(1) University of Adelaide, Australia

**ABSTRACT**

It is well-known that wind farm noise is dominated by low-frequency energy at large distances from the wind farm, where the high frequency noise has been more attenuated than low-frequency noise. It has also been found that wind farm noise is highly variable with time due to the influence of atmospheric factors such as atmospheric turbulence, wake turbulence from upstream turbines and wind shear, as well as effects that can be attributed to blade rotation. Nevertheless, many standards that are used to determine wind farm compliance are based on overall A-weighted levels which have been averaged over a period of time. Therefore the aim of the work described in this paper is to investigate the time dependent nature of unweighted wind farm noise and its perceptibility, with a focus on infrasound. Measurements were carried out during shutdown and operational conditions and results show that wind farm infrasound could be detectable by the human ear although not perceived as sound.

**599 Propagation thresholds and measurement of infrasound to establish separation distances from wind farm turbines to residences**

*Thorne, Bob*

Noise Measurement Services Pty Ltd, Brisbane, Australia

**ABSTRACT**

Of all the issues surrounding noise emissions from wind farms, the question of the potential for annoyance and adverse effects from low frequency sound is one of the most topical. Anecdotal literature is replete with statements concerning the effects of infrasound and low frequency noise. In this paper we present objective methodologies to measure and assess infrasound and low frequency noise in the context of wind farm emissions. The methodologies are reviewed with respect to three wind farms: one each in New Zealand, Victoria (Australia) and South Australia. The South Australian review incorporates data from a recent South Australian EPA wind farm study. The calculations for recommended stand-off distances from wind turbines to residences are presented. The distances are based on the threshold of annoyance and physiological effects threshold anticipated for different turbines and frequencies.

**197 Analysis of wind turbine low frequency noise prediction accuracy**

*Evans, Tom (1); Cooper, Jonathan (1); Alamshah, Vahid (1)*

(1) Resonate Acoustics, Australia

**ABSTRACT**

Some regulatory authorities in Australia have recently proposed low frequency noise assessment criteria for wind farms based on C-weighted noise levels. This involves the specification of an outdoor night time trigger level of 60 dB(C), above which further investigation may be required. While the accuracy of noise model predictions of A-weighted noise levels is well established for wind turbines, less information is available on the accuracy of low frequency noise predictions. This paper presents an analysis of approximately eight months of low frequency noise measurements at a location near a wind farm, conducted using appropriate windshields and at locations away from extraneous noise sources. The measured low frequency noise levels are compared to predicted levels to assess the accuracy of conventional noise modelling techniques for low frequency wind farm noise. Changes in low frequency noise levels with wind direction, wind speed and wind shear are also analysed.

**790 Comparison of the noise levels measured in the vicinity of a wind farm for shutdown and operational conditions**

*Hansen, Kristy (1); Zajamsek, Branko (1); Hansen, Colin (1)*

(1) Adelaide University, Australia

**ABSTRACT**

Outdoor and indoor microphone measurements have been taken in the vicinity of the Waterloo wind farm at a number of locations during periods when the nearby wind farm was operational as well as when it was shutdown. The majority of the shutdowns were of short duration and deliberate on the part of the wind farm operator, as they were associated with the recent EPA noise impact study. However, one of the shutdowns lasted for several days as it was related to a cable fault. Comparisons are made between both the third-octave

spectra and narrowband spectra measured during the shutdown and operational periods. Operational times immediately adjacent to the shutdown times, as well as at other times when the wind conditions at hub height and at the residence matched the conditions recorded during a shutdown time, are considered in the analysis. It is shown that there are consistent and significant differences in noise spectra at the residence for the shutdown and operational cases, particularly for frequencies below 100 Hz. These differences can be observed at distances up to 8.7 km from the wind farm.

**Tuesday 16:00-17:40 Room 216**  
**C4b New experimental techniques**  
**Chair: Vincent Valeau, Carsten Spehr**

- 81 **On the effect of mean flow profile, wavelength and array length on focal-resolution of a quadrupole source using aeroacoustic time-reversal**

*Mimani, Akhilesh (1); Doolan, Con J (1); Medwell, Paul R (1)*  
 (1) The University of Adelaide, Australia

**ABSTRACT**

This paper analyses the effect of the mean flow field, source wavelength and array length on the focal-resolution characteristics of an idealised lateral quadrupole source obtained using aeroacoustic Time-Reversal (TR). The TR simulations were implemented by numerically solving the 2-D Linearised Euler Equations (LEE) and enforcing the time-reversed acoustic pressure (stored during forward simulation) at the nodes of two Line Arrays (LAs) located outside the flow and on opposite sides. The TR simulation in a stationary medium and in a uniform mean flow indicates that interaction between the converging and diverging waves in the vicinity of quadrupole focal spots perpendicular to the LAs leads to the reinforcement of acoustic power at these regions. This results in formation of side-lobes of a relative magnitude larger than the quadrupole focal spots in the source maps, thereby making it difficult to characterise a quadrupole. During TR simulation of a quadrupole in a fully-developed non-uniform shear flow, refraction of the back-propagated waves through the shear-layer forces the acoustic fluxes to be focused almost completely at the focal spots, thereby significantly improving the quadrupole focal-resolution characteristics.

- 96 **Aeroacoustic time-reversal in the presence of a reflecting surface**

*Mimani, Akhilesh (1); Doolan, Con J (1); Medwell, Paul R (1)*  
 (1) The University of Adelaide, Australia

**ABSTRACT**

The influence of a rigid-wall reflecting surface on aeroacoustic Time-Reversal (TR) is investigated in this work. To this end, a forward simulation of a Gaussian pulse propagation in 2-D computational domain with a uniform mean flow was implemented by numerically solving the Linearised Euler Equations subject to a rigid-wall condition (by setting the normal velocity to zero) at the bottom boundary modelling the reflecting condition. The anechoic conditions were implemented at the remaining three boundaries, thereby modelling a semi-infinite 2-D free-space. The acoustic pressure time-history was stored at all boundaries during the forward simulation. A set of TR simulations were carried out wherein

rigid-wall condition was implemented at bottom boundary in each of the test-cases and time-reversed acoustic pressure was enforced at (1) all four boundaries, (2) three boundaries excluding the bottom boundary, (3) the top and bottom boundaries and (4) only the top boundary in the first, second, third and fourth test-case, respectively. It was observed that the initial emission point of the pulse was accurately predicted in all four test-cases, thereby demonstrating that acoustic pressure need not be measured at the rigid-wall. Rather, taking advantage of wave-reflection, only one microphone Line Array located outside flow can be used during aeroacoustic TR for source localisation.

- 586 **Detection and quantification of building air infiltration using remote acoustic methods**

*Raman, Ganesh (1); Chelliah, Kanthasamy (1); Prakash, Manisha (1); Muehleisen, Ralph T (2)*  
 (1) Illinois Institute of Technology, USA; (2) Argonne National Laboratory, USA

**ABSTRACT**

Air infiltration in residential and commercial buildings of the United States are estimated to cost approximately 23% of the total amount of heating energy used (for cooling, this estimate is approximately 14%). The aim of the current work is to apply non-intrusive acoustic techniques to detect and quantify specific envelope leaks in buildings. Noise sources associated with the leakage air flow can be localized using a compact microphone array with advanced beamforming algorithms. Also, an idea of using a synthetic acoustic source inside the building instead of pressurization of the building is discussed. Finally, attempts are made in a laboratory level to quantify leakages using the nearfield acoustic holography technique.

- 93 **Identification of acoustic event of selected noise sources in a long-term environmental monitoring systems**

*Klaczynski, Maciej (1); Wszolek, Tadeusz (1); Cioch, Witold (1); Wszolek, Wiesław (1); Pawlik, Pawel (1); Mleczko, Dominik (1); Grzeczka, Anna (2)*  
 (1) AGH University of Science And Technology, Poland; (2) Gdansk University of Technology, Poland

**ABSTRACT**

Undertaking long-term acoustic measurements on sites located near an airport is related to a problem of large quantities of recorded data, which very often represents information not related to flight operations. In such areas, usually defined as zone of limited use, often other sources of noise exist, such as roads or railway lines treated in such context as acoustic background. Manual verification of such recorded data is a costly and time-consuming process. However, the use of special systems or devices that support the recognition of noise sources is an additional high cost. Thus, the said problems bring up an idea to use automated methods to identify noise sources and time of such events. The proposed solution is to use pattern recognition techniques for acoustic signal recorded by the monitoring station, without the need for additional equipment. Methods based on an automatic "meaning" of sounds recorded by measuring microphone (included monitoring station) and refer to the advanced techniques of cognitive referring to the human auditory perception. In this way will be possible to assign markers to acoustic events and calculate an acoustic indicator of environmental assessment.

The recordings from the stations of long-term acoustics monitoring have been used while classifying the traffic noise - aircraft operations, movement of trains or cars.

**740 Sound source localisation using a single acoustic vector sensor and multichannel microphone phased arrays**

*Jing, Wen-Qian (1); Fernandez Comesaña, Daniel (2); Perez Cabo, David (2)*

(1) Microflown Technologies, The Netherlands, Hefei University of Technology, China; (2) Microflown Technologies, The Netherlands

**ABSTRACT**

In recent years, there has been growing interest in the development of noise prediction and reduction techniques. The ability to localise problematic sound sources and determine their contribution to the overall perceived sound provides an excellent first step towards reducing noise. Several well-known methods can be applied in order to achieve a detailed acoustic assessment using microphone phased arrays. However, pressure-based solutions encounter difficulties assessing low frequency problems and their performance is often limited by spatial coherence losses. Alternatively, the use of acoustic vector sensor (AVS) offers several advantages in such conditions due to their vector nature. Each AVS is comprised of a pressure microphone and three orthogonal particle velocity sensors, allowing for the sound direction of arrival to be determined at any frequency within the audible frequency range. Sound localisation techniques using AVS are evaluated in this paper, comparing the characteristics of this innovative solution with respect to traditional microphone phased arrays.

**Tuesday 15:40-16:40 Room 215**  
**U2 Noise management in challenging industries**  
**Chair: Pam Gunn, Emma Shanks**

**223 Development of an Occupational Noise Exposure Reduction Project for Defence in Australia**

*Teague, Peter (1); Conomos, James (1); Alexandrou, Vasos (1); Jennings, Martin (2)*

(1) Vipac Engineers & Scientists Ltd, Australia; (2) Department of Defence/DCOHS, Australia

**ABSTRACT**

Noise is the most prominent and widespread hazard to which Australian Defence Organisation (ADO) personnel are exposed. Recent advances have been made through the development of a 5 year Noise Exposure Reduction Project for occupational/workplace noise for the ADO by Vipac Engineers & Scientists Ltd. This project was informed by an initial Exposure Reduction Plan (ERP) phase that included a complete review and assessment of noise management practices across Defence and identified a range of deficiencies and recommendations for action. The ERP is based upon a continuous improvement approach and its goals are initially to ensure compliance with Work Health & Safety (WHS) legislation, then to proactively deliver minimisation of noise exposure and management of hearing loss risk throughout the whole of Defence. A coordinated and systematic approach, including best-practice noise surveys and assessments at a

representative sample of Defence Bases, has provided an evidence-based dataset to inform effective noise control actions. The project and noise survey findings to date are highlighted. Tailored Noise Management Plans (NMP), with prioritised and practical noise control measures, and innovative noise management tools have been formulated to improve noise control practices across Defence.

**795 Defending workers against hearing loss: Why aren't workers hearing our message?**

*Elsey, Benjamin (1); Jennings, Martin (2)*

(1) Hearing Conservation Australia, Australia.; (2) Department of Defence, Australia

**ABSTRACT**

It is well known that hearing can be damaged by noise. Noise exposure limits, engineering controls, work rotations and hearing protection are well understood and applied in the workplace; however the incidence of noise induced hearing loss continues to increase. This paper examines likely reasons why our current training of workers exposed to noise in the workplace is possibly 'falling on deaf ears'. Is the message too complicated? How can it be simplified? How can we make the hearing conservation message resonate more personally within the worker? Noise injury is currently the second biggest cost to business in general workplaces but is the number one cost for organisations supporting Defence Veterans. The human cost is also high, as shown by the diminished quality of life for the affected persons. The Australian Department of Defence has responded to this challenge by forming a 'Noise Exposure Reduction Program' taskforce charged with revamping noise and hearing conservation policies and training. This paper will showcase some of the creative yet simple techniques Defence is deploying to create more engaging training experience for servicemen and women. This is taking an important step towards changing worker's authentic engagement in personal hearing conservation.

**196 Noise in the United Kingdom printing industry: then and now**

*Shanks, Emma*

Health & Safety Laboratory, UK

**ABSTRACT**

Over 2 million people in the United Kingdom (UK) are exposed to potentially harmful workplace noise levels. There are about 130,000 employees in the UK printing industry many of whom have traditionally worked in noisy environments. Anecdotal evidence suggests there is a widely held belief that the issue of noise is no longer a problem in the UK printing industry. Noise measurement and exposure data from the industry, gathered by the Health & Safety Executive (HSE) in 2010 and 2011 to inform new and updated industry specific guidance, would suggest otherwise. This paper compares and discusses the noise levels in the industry around the time of the introduction of the Control of Noise at Work Regulations 2005 and the preceding Noise at Work Regulations 1989. Both sets of regulations were born of European Union Directives requiring equivalent basic laws throughout the Union on protecting workers from the risks caused by noise. The 2005 regulations introduced lower noise exposure action values than those in the 1989 regulations. The paper identifies the noisy and quiet processes at both points in time and also looks at some of the



changes in the industry that have affected the noise levels and exposures.

**Tuesday 16:40-17:40 Room 215**  
**B5 Buy quiet**  
**Chair: John Macpherson, Pam Gunn**

**198 Sound pressure level and sound power level declarations: navigating the maze**

*Shanks, Emma*  
 Health & Safety Laboratory, UK

**ABSTRACT**

Under European law, high noise machinery supplied in Europe must be accompanied by a noise declaration. Declarations usually consist of a workstation emission sound pressure level (LpA) and, for the noisiest machines, an emission sound power level (LWA). Unexpected conflicts, confusion and inconsistencies have been observed for the declared LpA and LWA. The European NOMAD (Noise and the Machinery Directive) project reported that 80% of noise information supplied with machinery was inadequate, often because of weaknesses in the declared LWA and/or LpA. About 600 European (EN) standards contain the phrase "noise emission" and about 300 of those consider noise as a "significant hazard". The Health and Safety Laboratory (HSL) is currently investigating the practical challenges of measurement and declaration of LWA and LpA. So far, HSL has found difficulties when machines fall under multiple European Directives, when the EN standard test codes used do not provide data that represents real-use risk, or declarations that are difficult to make because the standards are ambiguous. The top priority for manufacturers is to reduce the noise emission of the machinery at source, through technical and design methods. The noise declarations should be a suitable means of verifying that this has been achieved.

**276 Is the airborne sound power level of a source unambiguous?**

*Kurtz, Patrick*  
 BAuA, Germany

**ABSTRACT**

Sound power levels are used as key parameters describing the noise emission of machines in the European Machinery Directive 2006/42/EC (1) and the Outdoor Equipment Directive 2000/14/EC (2). The purpose is to require machine manufacturers to provide noise emission declarations thus allowing potential purchasers to buy quiet. To support this approach for noise reduction noise emission measurement standards providing measurement methods for determining the sound power level have been constantly developed on ISO level since many years. Although the sound power level methods described in these standards are based on different concepts they claim to result in comparable sound power levels of a source when the grade of accuracy of the standard is the same. However, it is known for long that this is not really the truth. In order to get more information on this differences systematical measurements were carried out on a reference sound source using sound pressure and sound intensity discrete measurement positions as well as scanning methods on different surfaces and at different distances from the source

under free-field conditions. First results of a respective EMRP project are given in this paper.

**371 New York City's New Noise Code and NYU's Citygram-Sound Project**

*Shamoon, Charles (1); Park, Tae Hong (2)*  
 (1) New York City, USA; (2) New York University, USA

**ABSTRACT**

Honk – bang – whirl – whiz – roar – ding – beep – chug – boom – rattle – hum – screech – boom. More than 2000 years ago, the residents of Rome, Italy complained about the disturbing noise from chariots racing through the city's cobbled streets at night. Ever since then the sound of civilization's progress and development have led to the recognizable sounds of construction and manufacturing noise, exhausts and impact noise, horns, and sirens, etc. Also with the development of musical instruments musical sounds became an issue. Some of these sounds were welcome and some were not. Civilization's "progress" can at times seem to disturb the general tranquility of everyday life. Each observer makes the determination of the difference between "sound" and "noise." For example a perennial source of tension between parent and child is the optimal level at which music or television is enjoyed. As technology advanced so did methods to measure sound and a determination of what types of sounds created a nuisance and also at which levels noise disturbed people and effected their ability to work or rest. The City of New York is the most populous city in the United States, with its metropolitan area ranking among the largest urban areas in the world. Its size and population brings with it its own set of unique and challenging noise issues. Almost everyone enjoys certain sounds of the City. The bustle of kids playing and laughing in a park is welcome. Also welcome are the happy cheers at sporting and other public events. However, blasting stereos, honking horns, un-muffled exhausts and ear-splitting jack-hammering can ruin a good night's sleep and diminishes the city's quality of life.

**Tuesday 16:00-17:40 Room 214**  
**H4b Airport noise modelling and measurement**  
**Chair: Ichiro Yamada, Chris Middleton**

**498 Practical method of considering effects of terrain and building structures on sound propagation**

*Yamada, Ichiro*  
 Aviation Environment Research Center, Japan

**ABSTRACT**

This paper discusses practical methods of calculating adjustments for sound insertion loss due to terrain/building structures in airport noise modelling. The Japanese revised noise guideline "Environment Quality Standard for Aircraft Noise," requires sound exposure evaluation of aircraft ground activities like taxiing and using APU. This paper first makes a brief review of technical aspects of developing airport noise modeling in Japan, secondly describes the way of considering aircraft ground operation noise, thirdly discusses practical ways of calculating adjustments for sound insertion loss due to terrain/building structures and excess ground attenuation, and finally it discusses future issues. It also refers to examination of

the validity of such practical ways by applying numerical calculation as well as by measurement.

**397 Experimental study of meteorological and ground effects on outdoor sound propagation for developing aircraft noise prediction model**

*Yokota, Takatoshi (1); Makino, Koichi (1); Matsumoto, Toshio (1); Yamamoto, Kohei (1); Ishii, Hirokazu (2)*  
(1) Kobayasi Institute of Physical Research, Japan; (2) Japan Aerospace Exploration Agency, Japan

**ABSTRACT**

JAXA has been developing an aircraft noise propagation model by applying the GF-PE method. To predict aircraft noise propagation precisely, it is necessary to assume meteorological condition and ground property in the sound field appropriately. In order to study how to model those conditions in the predictions and to verify the model, outdoor sound propagation experiments were conducted in November 2012 and in July 2013 at Taiki Aerospace Research Field in Hokkaido, Japan. In the experiments, receivers were lined up on the 1000-meter long runway and on the grass-covered flat ground in the test field. An elevated sound source was hanged from a tethered balloon, while other sound sources were placed at ground level. Air-to-Ground and Ground-to-Ground impulse responses were measured under various meteorological conditions. In this paper, we introduce variations in excess attenuation due to the meteorological and ground effects. By comparing the experimental results and the calculation results of the GF-PE method, we also discuss appropriateness of the modeling of meteorological conditions and ground property in the developing aircraft noise prediction model.

**307 Including atmospheric propagation effects in aircraft take-off noise modeling**

*Arntzen, Michael (1); Hordijk, Martijn (2); Simons, Dick G (2)*  
(1) NLR, The Netherlands, TU Delft, Aerospace Engineering, Aircraft Noise & Climate Effects, Netherlands; (2) TU Delft, The Netherlands

**ABSTRACT**

Aircraft noise is frequently calculated by models using Noise-Power-Distance relations (NPD-tables). Such an approach is common in the Integrated Noise Model (INM) or the method outlined in ECAC Doc. 29. Only a limited correction for atmospheric propagation effects is available through empirical lateral attenuation functions that are intended, as is the model, for multi-event calculations. A new feature, developed at the NLR, is to include the results of ray tracing in a Doc.29-based calculation. As such, the noise model is augmented by detailed propagation effects on a single-event level. Results are demonstrated for two different take-off procedures as Sound Exposure Level (SEL) contours. Consequently, the effects of wind on departure procedures are illustrated and further quantified by predicting awakenings in fictitious communities. The results show that the effects of sound refraction are the largest as the aircraft is low. Therefore, a departure procedure featuring a shallow climb angle shows more effects than procedure with a steeper climb. It is shown that wind effects can clearly lead to asymmetrical contours and awakenings. The results show that there is a potential for noise mitigation based on ambient atmospheric conditions.

**557 Influence of the atmospheric stratification on the sound propagation of single flights**

*Zellmann, Christoph (1); Wunderli, Jean Marc (1)*  
(1) Empa, Switzerland

**ABSTRACT**

Aircraft noise models generally simplify the atmosphere as homogenous and constant over time. However, momentary local conditions of wind, humidity and temperature influence the sound exposure level and become relevant for the calculation of single flights. This paper presents a method to classify the atmospheric conditions with idealized vertical profiles derived from weather data of a monitoring station in combination with a radiation balance. The differences of the propagation in a homogenous and a stratified atmosphere are analyzed by exemplary overflights. Additionally, the attenuations due to idealized profiles are compared to those of vertical profiles obtained from flight data records and profiles from a meteorological prediction model. The comparison between the different profiles shows good agreement for temperature, except for the transition between stable and unstable stratification, but larger deviations for humidity. Furthermore it can be shown that the reproduction of a stratified atmosphere in the propagation calculation has a beneficial effect on the accuracy of the resulting sound exposure level and should therefore be taken into account for sophisticated aircraft noise modelling. Therefore, input data of a meteorological prediction model should be used where available, as idealized profiles do not always reproduce the atmosphere accurately.

**679 Assessing all noise sources in one model. Implementation of INM and ECAC 3rd Edition in Noise Mapping Software**

*Notario, Antonio*  
DataKustik GmbH, Germany

**ABSTRACT**

Legal circumstances, political motivations and technical reasons led in many countries to a separated approach for the calculation, assessment and handling of infrastructure noise caused by road and railway on the one side and the analysis of aircraft noise on the other side. Specific Research efforts analyzing the perception of noise led to guidelines like the German VDI 3722 (Effects of traffic noise/Characteristic quantities in case of multiple sources). Next to other approaches this guideline focuses especially on the annoyance of different noise types and derives a single number value, representing the overall perception of all noise sources, for each affected inhabitant. In order to enable an efficient overall evaluation of noise levels within urban areas, each infrastructural source must be handled within one noise model. The implementation of INM and ECAC 3rd Edition within Noise Mapping software opens various possibilities for an integrated approach to the noise assessment within cities.

**Tuesday 15:40-17:00 Room 213**  
**Q3b Vibro-acoustic methods for noise control treatments**  
**Chair: Nourredine Atalla, Stephen Hambric**

**170 Modeling and experimental validation of cellular porous material with large resonant inclusions**

*Doutres, Olivier (1); Atalla, Nouredine (1); Osman, Haisam (2)*  
 (1) Université de Sherbrooke, Canada; (2) United Launch Alliance, USA

**ABSTRACT**

Porous materials are widely used for improving sound absorption and sound transmission loss of vibrating structures. However, their efficiency is limited to medium and high frequencies. A common solution for improving their low frequency behavior while keeping an acceptable thickness is to embed resonant structures such as Helmholtz resonators. This work investigates the absorption and transmission acoustic performances of a cellular porous material with large resonator inclusions. The homogenization theory cannot be applied to cellular material made of such large periodic unit-cell (e.g., cube of side  $L \sim 100$  mm). A low frequency model of a large resonant unit-cell based on the Parallel Transfer Matrix Method is proposed in this work. The proposed model is validated by comparison with impedance tube measurements and finite element calculations. At the Helmholtz resonance frequency; (i) the transmission loss is greatly improved and (ii) the sound absorption of the host material is decreased if it is made of a highly sound absorbing material.

**519 Prediction of Sound Transmission through Elastomeric Bulb Seals**

*Atamer, Serkan (1); Çaliskan, Mehmet (1); Özgen, Gökhan O (1)*  
 (1) Middle East Technical University, Turkey

**ABSTRACT**

Doors are the weakest parts of the buildings in terms of sound transmission. Examination of sound transmission loss characteristics of doors reveals two separate transmission paths to be considered. First one is transmission through door leaf and the second one is leak transmission through elastomeric bulb seals. Seals are the important parts of the sound transmission loss characteristic of door structure. Hence, their insulation capability should be analyzed and optimized to improve sound transmission loss of an acoustical door. The aim of this research is to predict sound transmission loss of elastomeric bulb seals. This assessment includes two main steps. A static analysis is required to determine the seal shape under compression. Seals are made of elastomers which display nonlinear mechanical behavior. This requires hyperelastic material modeling and nonlinear finite element analysis (FEA). An acoustic analysis calculating the sound transmission is then carried on deformed geometry acquired from the first phase of the research. A sample seal geometry, which is already being used in industry, is considered as the case study. Influences of different hyper elastic material models on sound insulation are also studied.

**426 Applying dynamic mechanical analysis to research & development for viscoelastic damping materials**

*Rasa, Alexander*  
 Pyrotek Noise Control, Australia

**ABSTRACT**

Dynamic mechanical analysis (DMA) is a versatile method that can provide results for a wide array of parameters relating to material behaviour. In this paper it is used as a method to investigate and characterise the damping properties of viscoelastic materials. Investigations on polymer based viscoelastic damping material samples with varying formulations have been conducted using DMA. Results have been presented and discussed, highlighting the efficiency, accuracy and resolution of the DMA method. The differences in product formulation across the samples and the effect on material characteristics has also been discussed. The results supplied using the DMA method have been shown to be beneficial to research and development for viscoelastic damping materials.

**402 Optimization design method for Constrained Damping layer's noise reduction based on the Hoff sandwich plate theory**

*Shi, Dongyan (1); Wang, Qingshan (2); Shi, Xianjie (3)*  
 (1) College of Mechanical and Electrical Engineering, Harbin Engineering University, P. R. China; (2) College of Mechanical and Electrical Engineering, Harbin Engineering University, P. R. China; (3) Institute of Systems Engineering, China Academy of Engineering Physics, P. R. China

**ABSTRACT**

Based on Hoff sandwich plate theory, an analytical method is proposed for predicting the loss factors of constrained damping layer. The application of the current approach in the engineering application of acoustic radiation optimization is examined. Numerical examples regarding isotropic sandwich plate with simply supported boundary conditions are carried out to demonstrate the accuracy and reliability of the current approach. It is shown that the current method has a good accuracy in determining loss factors of constrained damping layer. On this basis, optimization design of constrained damping layer is implemented. The effects of main parameters of damping layer on the loss factors are investigated. Then, the current approach is utilized to application of vibration and noise reduction for gearbox housing. Results show that parameters of damping layer have different effect on the vibration and noise reduction. The optimum design parameter of damping layer can be obtained through comprehensive comparison analysis. This investigation can provide an efficient design scheme of acoustic protection with damping layer for vibration and noise reduction.

**Tuesday 17:00-18:00 Room 213**  
**Q4a Vibration and vibro-acoustic experiments**  
**Chair: Stephen Conlon, Stephen Hambric**

**160 Analysis of seismic response on the excitation of support structures**

*Ziaran, Stanislav (1); Cekan, Michal (1); Chlebo, Ondrej (1); Musil, Milos (1)*  
 (1) Slovak University of Technology, Slovakia

**ABSTRACT**

Improving the safety of nuclear power plants requires seismic testing of key components. Ever increasing demands on components, devices, and machinery within nuclear power plants, necessitates testing with more extreme loading conditions at low frequencies of vibration. Frequency and modal analyses are very powerful tools for determining excessive or harmful vibration. The goal of the paper is, by means of frequency and modal analyses, to compare the operational frequency spectrum with the Eigen frequencies of an existing support structure. After a suitable measurement point is selected, a frequency analysis is performed and the main sources of vibration are detected. Modal analysis is performed by simulation and measurement. The excitation was generated by a low frequency shake table (up to 100 Hz) capable of generating random and deterministic signals. The Eigen values of the tested structure were compared with the Eigen values obtained by Finite Element Analysis (FEA) of the support structure as well as the response (displacement). For the detection of low frequency waves resulting from vibrating sources, the Fast Fourier Transform (FFT) and modal analysis, in the frequency domain, was used.

**405 Assessment of Vibrations from a Seismic Test Facility**

*Lee, Yong Keat (1); Mackenzie, Neil (1)*  
 (1) Aurecon, Australia

**ABSTRACT**

The recent earthquakes in Christchurch led to the redevelopment of the University of Canterbury's Seismic Equipment Laboratory (SEL). The SEL facility will involve the testing of building structures subject to simulated static and dynamic displacements from earthquakes, with a reaction wall and floor used to exert loads by way of hydraulic actuators on test specimens, and shaker tables used to test built forms separately or in combination. These tests can generate significant ground vibration, which has the potential to affect the use of nearby buildings housing sensitive equipment. This paper will outline measurements and analysis carried out to predict the likely vibration levels at the footings and within adjoining buildings. It also outlines methods to mitigate vibration in excess of relevant criteria.

**147 An approach to optimal sensor placement for vibration tests on large structures**

*Yuan, Chunhui (1); Zhang, Junjie (2)*  
 (1) National Key Laboratory on Ship Vibration & Noise, China;  
 (2) China Ship Development and Design Center, China

**ABSTRACT**

The critical issue of vibration test on hull structures with large size is the numerous amounts of sensors. Too many sensors lead to excessive consumption whereas notable error would come from reducing the number of sensors. An approach is proposed to reconstruct the complete structural vibration via much fewer sensors. This iterative progress eliminates the sensor location that contributes the most significantly to the condition number of modal matrix in each cycle. Along with the iteration, the condition number goes down quickly to a certain level, but rises suddenly after lots of calculating cycles. The optimal number of sensors is the one before the condition number zooming. The corresponding sensor locations are also optimal. An experiment on cylindrical shell demonstrates that vibration responses reconstructed from the data of 26 optimal sensors are consistent with the responses measured by 200 initial sensors. The vibration error is only 2.4 dB. This approach may be applied to vibration test and measurement on large structures.

**Tuesday 15:40-17:40 Room 212**  
**B3 Machinery N&V - Computations**  
**Chair: Xia Pan**

**85 Acoustic radiation response prediction of thin-walled box with particle dampers using multiphase flow theory of gas-particle**

*Wu, Chengjun (1); Wang, Dongqiang (1); Yang, Ruichao (1); Lei, Xiaofei (1)*  
 (1) Xi'an Jiaotong University, China

**ABSTRACT**

In this paper, acoustic radiation response of thin-walled box with particle dampers is predicted. First, the effect of the collisions and friction between the granular inter-particles is interpreted as an equivalent nonlinear viscous damping based on multiphase flow theory of gas-particle. Then the contribution of particle damper is estimated as an equivalent mass-damper system. And the acoustic radiation response of thin-walled box with particle dampers is predicted in the finite element method. Finally, an originality and novelty simulation method is developed to evaluate acoustic radiation response characteristics of particle damping composite structure by COMSOL. With this as a base, detailed numerical studies using the originality simulation method are also carried out to analyze the acoustic radiation response characteristics of the particle-damping thin-walled box. An experimental verification is conducted, and a good agreement between the theoretical results and the experimental data shows that the theoretical work in this paper is valid

**675 Sound radiation from a water-loaded cylinder due to machine noise**

*Pan, Xia (1); Tso, Yan (1); Forrest, James (1); Peters, Herwig (2)*  
(1) DSTO, Australia; (2) The University of New South Wales, Australia

**ABSTRACT**

This paper presents the modelling and analysis of the noise radiation due to internal acoustic excitation of a cylinder submerged in a heavy fluid. The cylinder consists of a cylindrical shell filled with air and attached to rigid end plates. The acoustic excitation is modelled as monopoles to simulate the operation of a machine noise source in the cylindrical shell. In order to model the noise transmission and radiation, the machine noise is characterised as multiple monopole sources with random amplitudes and random phases on the surfaces of an imaginary component boundary. An initial study including the effect of absorbing material on noise radiation is presented. Some of the analytical results are compared with those from numerical finite element / boundary element models. Excellent agreement is obtained between the analytical results and results from the numerical method.

**353 A Rayleigh-Ritz method based on improved Fourier series for vibration analysis of cylindrical shell coupled with elastic beams**

*Zhang, Runze (1); Cao, Yipeng (1); Li, Liaoyuan (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

A finite circular cylindrical shell model coupled with elastic beams is built in this paper. The beam-shell structure is connected with linear springs and rotational springs. Considering different structural coupling conditions, the Rayleigh-Ritz approach based on improved Fourier series method is employed to analyze the free vibration properties of the calculation model. The improved Fourier series method is used to describe the displacements of the coupling structure, while the Rayleigh-Ritz method is utilized to solve the coefficients. The important advantage of this approach is that it can be universally applied to the coupling structure with a variety of different boundary and coupling conditions. The results are verified by the finite element method. It's shown that the proposed approach is a convenient, efficient and accurate one for determining the modal behavior of such a complex structure system.

**566 Vibration Input Identification using Dynamic Strain Measurement**

*Itofuji, Takumi (1); Yoshimura, Takuya (1)*  
(1) Tokyo Metropolitan University, Japan

**ABSTRACT**

Transfer Path Analysis (TPA) has been conducted in order to improve the noise and vibration quality of mechanical structures. However, the force identification in the TPA is still challenging problem and its accuracy has to be improved. The Matrix Inversion Method and the Apparent-Mass Matrix Method are approaches for force identification. The Matrix Inversion Method estimates the excitation force by the product of an inverse matrix of accelerance and a vector of actual operational acceleration. It is known that the Matrix Inversion

Method is very sensitive to measurement noise especially at the resonance. Apparent-Mass Matrix Method has been recently proposed, which provides more accurate results than the Matrix Inversion Method. However, these methods are still insufficient in accuracy, and improvement of identification accuracy is required. This paper proposes a new force identification method by using strain measurement. The method estimates the force using the Strain Frequency Response Function (SFRF) instead of acceleration or Apparent-Mass Matrix. It is shown that SFRFs are more strongly affected by higher-order modes than accelerance FRF. Therefore, we considered that more accurate force identification can be obtained by using SFRF than the conventional method.

**94 Analytical model for the airborne sound pressure waveform radiated when an offshore steel pipe pile is driven with an impact hammer**

*Hall, Marshall V*  
Marshall Hall Acoustics, Australia

**ABSTRACT**

An analytical model has been developed for the airborne sound pressure waveform radiated when an offshore steel pipe pile is struck by a short hammer. The model is based on the coupled equations of motion for axial and radial vibration of a thin shell, and yields frequency-dependent phase velocity and attenuation of these vibrations. A harmonic solution is obtained for the radiated sound pressure, using Junger & Feit's "Transform formulation of the pressure field of cylindrical radiators". The model is applied to a measurement of a 10- tonne hammer with cushion driving a pile 91 cm in diameter and 38 m long, in water 17 m deep. The height of the pile face above the water surface is estimated to have decreased from approximately 15 to 3 m during its driving. SPL (Leq) is examined at the measurement range (15 m) and microphone height (1.5 m). The present model predicts SPL would have ranged between 104 and 109 dB re 20  $\mu$ Pa as the pile face descended. The measured SPL data had an average of 103 dB and a maximum of 111 dB re 20  $\mu$ Pa. Possible reasons for the smaller spread of the model predictions are discussed.

**698 The new method for focusing properties of the acoustical steady field in room**

*Liu, Song (1); Li, Sheng (1)*  
(1) DUT, China

**ABSTRACT**

The phase conjugation method used for the identification and reconstruction of the acoustical steady propagation field in room is studied numerically. The planar array forms of phase conjugation are studied for sound source localization. The numerical results show that: The phase conjugation method can completely achieve the identification and location of the acoustical source in room.

**Tuesday 16:00-18:00 Room 211**  
**N6d Noise in lightweight structures**  
**Chair: Rikard Öqvist, Heinz Ferk**

**548 Vibration reduction in lightweight floor/ceiling systems with a sand-sawdust damping layer**

*Chung, Hyuck (1); Emms, Grant (2)*

(1) Auckland University of Technology, New Zealand; (2) NZ Forest Research Institute Ltd, New Zealand

**ABSTRACT**

This paper shows how to use a mathematical model to predict the vibration of lightweight timber-framed floor/ceiling systems (LTFSs) caused by mechanical excitation. The LTFS considered here is made up of an upper floor layer, a cavity space with timber joists and a ceiling. These components are joined by timber battens, ceiling furring channels and ceiling clips. The vibration in the structure is caused by a localized excitation on the top surface and the resulting vibration level of the ceiling surface will be analysed. The cavity space is filled with fibre infill for damping the sound transmitting through the cavity. A unique feature of the design and the model is the sand-sawdust mixture in the upper layer. The theoretical model and the experimental measurements show that the sand-sawdust dampens the vibration in the frequency range between 10 and 200 Hz. The damping by the sand-sawdust and the fibre infill are found by comparing the numerical simulations against the experimental measurements. We show that the simple linear frequency dependent loss factors can be used to predict the low-frequency vibrations of LTFSs.

**588 Noise control by design: A tool intended for architectural use**

*Sentop, Ayca (1); Tamer Bayazit, Nurgun (2); Altun, M Cem (2)*

(1) Istanbul Bilgi University, Turkey; (2) Istanbul Technical University, Turkey

**ABSTRACT**

This study aims to present a building elements selection tool, which has been generated to assist architects with determination of acoustically appropriate assemblies at the preliminary design stage. In order to succeed, practicality, easy usage and reliability are considered essential for every step. In this context a catalogue and a calculator are generated as components of the tool. The catalogue constitutes a database in which building elements are subcategorized according to their constructional and acoustical characteristics. Acoustical measurement results of 587 different assemblies are collected from relevant literature and their technical drawings are prepared in order to provide easy selection. The calculator serves to simplify the calculations by giving the sound insulation requirement according to outdoor noise levels and acceptable background noise levels. The calculator also determines composite (average) sound insulation value of building elements composed of multiple components. Background noise criteria and data from the catalogue are predefined in the calculator, simplifying data insertion and parallel usage of the catalogue and the calculator. In order to prove efficiency and practicality of the building elements selection tool, its usability by architects is tested on subjects with a sample design problem and outcomes are discussed.

**376 Design of a standalone, modular test facility for measuring sound transmitted through a common ceiling plenum**

*Barclay, Edward A (1); Wareing, Robin R (1); Pearce, John R (1)*

(1) University of Canterbury, NZ

**ABSTRACT**

The design of a modular ceiling test facility is described. The University of Canterbury's acoustic test facilities are undergoing substantial renovation and in some cases replacement. A number of new test facilities are being constructed. These test facilities must be relatively low cost, and be able to be easily stored. A facility for testing suspended ceilings to ASTM E1414 and ISO 10848 has been developed. The reverberation time within the facility was modelled utilising measured absorption data to ensure the design was within acceptable levels. The direct and indirect sound transmission paths were assessed.

**1017 Research on sound insulation of multiple-layer structure with porous material and air-layer**

*Bai, Guofeng (1); Zhan, Pei (1); Sui, Fusheng (1); Yang, Jun (1)*

(1) Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, China

**ABSTRACT**

Sound insulation performance of multiple-layer structure is investigated which consists of elastic solid, fluid and porous material. The Biot theory of sound propagation in elastic porous medium and the method of transfer matrix are used to derive the transmission loss of typical layered-structure. The influence of air-layer and porous material on sound insulation performance of multiple-layer structure had been discussed by numerical calculation and experimental testing. The result indicates that the air-layer and porous material can improve sound insulation performance of multiple-layer structure and their distribution also has great influence on the sound insulation performance.

**723 The equivalent translational compliance of steel studs and resilient channel bars**

*Hirakawa, Susumu (1); Davy, John Laurence (1)*

(1) RMIT University, Australia

**ABSTRACT**

A number of recent papers have determined the compliance of steel studs for use in a model for predicting the sound insulation of cavity stud walls. Previously, the steel studs have usually been modelled as line connections. In this paper, they are also modelled as point connections where the points are the screws attaching the wall leaves to the steel studs. The compliance of the combination of resilient channel bars and wooden or steel studs, modelled as point or as line connections, is also presented. The values of compliance which make a theoretical model agree with the experimental data have been calculated. The experimental sound insulation data were measured by the National Research Council of Canada. There were 126 steel stud walls, 78 resilient channel bar and wooden stud walls, 15 resilient channel bar and steel stud walls and 4 walls with resilient channel bars on both sides of wooden studs. Linear regressions of the logarithm of the compliance against the logarithms of frequency, reduced surface density, cavity depth and number of point connections or stud spacing,

were conducted in a low frequency range and in a high frequency range. The equations produced by these linear regressions can be used in sound insulation prediction models.

**861 Sound insulation of application for composite wood panel**

*Chou, Chuan-Wen (1); Chen, Chen Yu (1); Lai, Rong Ping (2); Sun, Philip (3)*

(1) National Cheng Kung University, Taiwan; (2) NCKU Research and Development Foundation; (3) Ping Shen Enterprises Co., Taiwan

**ABSTRACT**

Glued laminated timber, also called Glulam, was applied on various building components, space products, and decoration materials. The extensively application of Glulam was attributed to its feature with durable, ease processing, attractive appearance, and sustainability. According to the feature of Glulam, in present the Glulam was frequently used to combine with multiple materials such as metal, gypsum panel, rubber, and even paper materials. The composite wood panel with multiple materials would be effective to fire prevention and sound insulation. However, the analysis of sound insulation of composite wood panel was still focused on the surface density but no more controlling factors of sound insulation for quantitative analysis. By the new technique of composite wood panel, the uncertain of quality analysis would cost wasting from repeatedly replacement during construction just because of the ineffective sound insulation analysis. This study was focused on Glulam. The composite wood panel would be combined with different material. Furthermore, it was confirmed for the influence of sound insulation with various factors, such as the location of material, rigidity, and simple mechanism. The raising surface density for the material near the median of panel section would promote the sound insulation between 500 Hz to 2000 Hz with about 5 dB. In the other side, the raising rigidity and resonance frequency for the material near the surface of panel to 7 dB. Above this study, it could extend to more analysis for composite wood panel, and would make more effective accuracy for sound insulation analysis.

**Tuesday 16:00-18:00 Room 210**  
**N5 Propagation and generation of low**  
**frequency noise in buildings**  
**Chair: Delphine Bard, Klas Hagberg**

**839 Comparison of the results of a laboratory experiment and a field study with regard to acoustic quality in wooden buildings and recommendations for classification of acoustic quality**

*Liebl, Andreas (1); Späh, Moritz (2); Bartlomé, Olin (1); Kittel, Maria (1)*

(1) Fraunhofer Institute for Building Physics, Germany; (2) Lignum Holzwirtschaft, Switzerland

**ABSTRACT**

Within the European research project AcuWood a questionnaire-based field study in Germany and Switzerland as well as laboratory listening tests were conducted which aimed at the evaluation of low frequency impact noise in wooden buildings. Different building and construction types were

reconsidered. Since the laboratory listening tests partly included recordings from buildings that were also included in the questionnaire-based field study, it is possible to compare the long-term acoustic satisfaction of inhabitants with the short-term subjective impression during the laboratory listening tests. The results which were already reported at the Internoise 2013 have been enriched by another dataset. Recordings and listening tests of a lower quality wooden building were added in order to test the reliability of the comparability between the laboratory test and the field study. It is also discussed to use data from listening tests as a basis for the classification of acoustic quality in order to ensure for the perceptibility of defined different acoustic qualities.

**935 Low frequency sound transmission in multifamily wooden houses**

*Hagberg, Klas (1); Bard, Delphine (2)*

(1) WSP, Sweden; (2) Lund University

**ABSTRACT**

In the recently finished research projects, AkuLite and AcuWood, it is clearly stated that low frequencies should be considered far more, prior to design new wooden structural building system. Lower than 50 Hz is preferable, and the most annoying frequencies appear between 20 and 50 Hz. However, it is still a long way to go in order to convince acousticians, the entire global industry and authorities that these frequencies have to be considered in order to build wooden structures which are experienced by the habitants as equally good as heavy structures. To "save" the industry, a lower limit of at least 50 Hz at least for impact sound should be mandatory in the near future globally, in spite of the fact that the new standard ISO 16717 will not be reality. This paper describes the main reasons why it is needed to include these low frequencies in residential buildings. It describes different constructions and their appearance due to low frequency impact sound transmission. The paper comprises some examples designed to fulfill the Swedish requirements, which equals  $L'_{n,Tw}$  and  $L'_{n,Tw+Cl,50-2500} \leq 56$  dB between dwellings. It comprises also a discussion regarding optimizing constructions for various uses, e.g. different types of housing.

**819 Acoustic Solutions for Wooden Intermediate Floors**

*Bartlomé, Olin (1); Liebl, Andreas (1)*

(1) Lignum, Switzerland

**ABSTRACT**

In Switzerland multi-storey timber construction has been very successful in recent years. This is primarily due to the 2005 amended fire safety regulations. This development brought with it new challenges with regard to sound mitigation. Apart from requirements governed by national standards, there are requirements driven by occupants. These are based on subjective human perception and can lead to complaints about low-frequency sound even if the values specified in the standard are met. Research was therefore carried out on the subjective assessment with in-situ measurements, a broad survey and auditory tests. Additionally common details and their robustness where evaluated and within 4 case studies examined. The results of the research project in short are:

- The frequency range for sound insulation needs to be considered from 50 Hz
- Building elements show a wide range of construction

principles and acoustic properties. A structured online catalogue with robust details was developed

- With good floor build-ups, the flanking transmission is of minor importance
- One main reasons for the small sound insulation properties of timber constructions in the low frequency range is the low mass
- The quality of elements/buildings must be guaranteed. Timber constructions can be controlled significantly in industrialised building systems

**939 Challenges for acoustic calculation models in "Silent Timber Build", Part 1- FEM**

*Bard, Delphine (1); Negreira, Juan (1); Kouyoumji, Jean-Luc (2); Borello, Gérard (3); Guigou, Catherine (4)*  
(1) Lund University, Sweden; (2) FCBA, France; (3) InterAC, France;; (4) CSTB, France

**ABSTRACT**

The project "Silent Timber Build" will develop new prediction tools for timber structures. There are several challenges that have to be overcome to provide a full prediction tool. The differences in weight, stiffness and density for wooden structures compared to traditional, heavy and more homogeneous structural material have repercussions on how the sound propagates throughout the structures, affecting the sound and vibration insulation performance and also theories to be used in prediction models. Finite element simulations have proved to be useful in the design phase in a certain low and very low frequency range. By further developing reliable finite element tools for low frequencies, the performance of future wooden constructions can be predicted in a full frequency range, saving both time and money as all calculations, and modifications can be done during the design phase. However the upper limit for using FEM has to be further investigated and then be merged with statistical methods. This article, following another article Part 2, will focus on medium and high frequency range calculations. For full-scale building, Virtual SEA method, as analytic and SEA approaches will be used in frequencies low enough in order to optimize the overlap to FEM.

**609 Cost benefit analysis of acoustic treatments for inner-city residential premises near entertainment venues**

*Borgeaud, David*  
Air Noise Environment Pty Ltd, Australia

**ABSTRACT**

Brisbane's Fortitude Valley is an inner city area combining retail, commercial, residential, and entertainment uses. For many years it has been the starting point for major Australian bands. The Valley's "Urban Renewal" has seen a large increase in the number of residential apartments, which has led to concerns regarding the impact this may have on the future of live music in the Valley. Brisbane City Council has developed entertainment precincts with specific noise criteria within the Valley (as part of the Valley Music Harmony Plan). Earlier papers by the Author addressed the ambient noise mapping and treatment of venues investigation, and this paper discusses the cost benefit study undertaken of acoustic treatment for existing residential premises. The purpose of this work was to provide Council with information on both the feasibility of

treating the apartments to control low frequency noise and the order of cost for the treatments. The study found that attenuation of 2 – 16dB(C) could be achieved using a variety of site specific treatments with costs ranging from \$34,000 to \$64,000. The costing work proved an invaluable piece of knowledge in the implementation of the Valley Music Harmony Plan.

**409 Improvement effect of the infrasound and vibration due to repair of the bridge**

*Fukada, Saiji (1); Kaneishi, Yoshimune (2); Hama, Hirokazu (3); Okada, Hiroyuki (3)*  
(1) Kanazawa University, Japan; (2) West Nippon Expressway Co., Japan; (3) Fujiengineering Co., Japan

**ABSTRACT**

Recently, increasingly heavy traffic flow volumes have led to fatigue damage in the deck and pavement of bridges. Heavy trucks are a major contributor to such damage, causing environmental vibration problems such as infrasound and ground vibration. These vibrations are known to be transmitted through bridges to nearby houses. This study investigated bridges that caused such problems in nearby houses. Bridge repairs were performed to solve these problems. The improvement in infrasound and ground vibration upon bridge repair was investigated using a test truck and ordinary trucks. The ground vibration of the abutment with frequencies of 10 Hz or more decreased greatly as did the ground vibration outside the houses. Furthermore, infrasound with frequencies of 10–20 Hz decreased.

**Tuesday 16:00-18:00 Room 209**  
**D3b Electric / hybrid vehicles**  
**Chair: Dong Chul Park, David Quinn**

**306 Subjective evaluation of additive sound designed to reinforce acoustic feedback of electric vehicle**

*Gwak, Doo Young (1); Yoon, Kiseop (1); Seong, Yeolwan (1); Lee, Soogab (2)*  
(1) Seoul National University, Republic of Korea; (2) Center for Environmental Noise and Vibration Research, Engineering Research Institute, Seoul National University, Republic of Korea

**ABSTRACT**

Because booming sound of internal combustion engine is eliminated in electric vehicle (EV), it has been complained that EV is not fun-to-drive and drivers cannot get information of driving speed by its sound. In order to overcome this problem, signal processing method of additive engine sound has been suggested. However, because it strongly affects interior sound quality and so does brand image, this strategy must be carefully evaluated before applied. In this study, two types of signal processing methods were adapted to recorded EV sound and subjective evaluation was conducted. Total 10 stimuli were judged by 30 drivers in terms of sensation of acceleration, sound image, and preference. Effects of each signal processing method are compared and advantages and disadvantages of each method are discussed.



**515 Sound design of electric vehicles - Challenges and risks**

*Genuit, Klaus (1); Fiebig, André (1)*  
(1) HEAD acoustics GmbH, Germany

**ABSTRACT**

Sound quality depends on cognitively processed features referenced to an assigned set of expectations. It describes the perception of suitability and desirability of a sound attached to a certain product. However, since experiences of electric vehicle technology and established expectations rarely exist, several questions remain unanswered. What are the references customers use to evaluate sound quality of electric vehicles? How to meet customers' needs without established targets? Is it possible to simply set sound quality standards, where customers will increasingly adapt to? Experiments and interviews are needed to answer reliably these questions. It is evident that successful sound design of electric vehicles depends on several aspects. Besides customer preferences, technology image, strategies of car manufacturers, economic and ecological factors, the social discussion of electric vehicle technology will contribute to the acceptance or rejection of sound design concepts. In fact, expectations are socially shaped and the impact of public discourse on expectations must be considered. The paper will present results gained in test drives, where subjects drove electric vehicles and commented different sound concepts. Moreover, the experimental results will be discussed from a broader contextual perspective.

**753 Urban environment audio simulation for contextual evaluation of Quiet Vehicles' sound design**

*Misdariis, Nicolas (1); Gerber, Julien (1); Aleonard, Julien (2)*  
(1) UPMC, France; (2) Ircam, France

**ABSTRACT**

The silence of Quiet Vehicles – especially, Hybrid or Electric Vehicles – is a crucial issue in terms of safety, ergonomics or even ecology which becomes to be largely studied either in a research or development point of view. Most of the works done in that domain are based on experiments which try to measure presence and emergence of such vehicles in real, or simulated, environment and to evaluate their detectability, in the same contexts, while being equipped with extra sounds specifically designed for fulfilling basic functional conditions with regards to nearby pedestrians or other road users. In this necessary experimental workflow, we assume that simulation approach – or, more generally, virtual reality – is a potentially powerful and valid paradigm to test the contextual impact of a large number of propositions and to conduct controlled laboratory experiments for evaluation. This paper will then present the first step of the development of an audio simulation based on Ambisonics field recordings in various urban locations, multi-channel audio rendering and mock-up of different audio scenarios for insertion of one or multiple QV sound signatures in a given sound scene. Next steps – together with general stakes and perspectives – of this approach will also be presented and discussed.

**668 Designing and delivering the right sound for quiet vehicles**

*Allman-Ward, Mark (1); Williams, Roger (2); Heinz, Thorsten (1); Demontis, Maurizio (3)*  
(1) Bruel & Kjaer, UK; (2) Bruel & Kjaer, USA; (3) Bruel & Kjaer, AUS

**ABSTRACT**

Creating the right sound for quiet vehicles is extremely important. External warning sounds must reflect the vehicle brand image and be accepted by owners, whilst having good warning characteristics and harmonising with the environment. Internal sounds can be used to convey vehicle status, whilst enhancing the brand and driving pleasure. Since these vehicles are quiet, there is much broader scope for styling the sound that they should make. However, evaluating and selecting alternative sounds is extremely time and labour intensive if done in the real world because of the large number of vehicle and environmental factors which can influence the perception of the sound, especially outside the vehicle. This paper outlines a process where the exterior and interior sounds of vehicles are evaluated efficiently in the virtual world. The consensus derived from subjective jury can be gathered quickly and cheaply, leading to a shortlist of sounds to be tried on a real vehicle. It introduces a toolset which uses the same data and algorithms for designing sounds in the virtual world and validating them in the real world. The same data can also be used directly in a production series by embedding the software algorithms into the production vehicle hardware.

**808 Detectability and hearing impression of additional warning sounds for electric or hybrid vehicles**

*Yamauchi, Katsuya (1); Sano, Takaichi (2); Hasegawa, Shin (2); Tamura, Fumio (2); Takeda, Yuichiro (2)*  
(1) Nagasaki University, Japan; (2) Pioneer Corporation, Japan

**ABSTRACT**

Electric or hybrid electric vehicles (EVs/HEVs) have the advantages that they make lesser noise compared to conventional engine vehicles. This quietness is, however, a matter of concern for pedestrians because the sound of EVs/HEVs may be inaudible in urban backgrounds. Hence, the application of additional sound-emitting device has been studied. Gathering wide range of acoustic knowledge on feasible design of the additional sounds is crucial for developing regulations or designing the device itself. Through the authors' re-searches, it has been revealed that the type of warning sounds significantly affected the required sound level as well as background levels. A warning sound stimulus, which had lesser loudness level, had lesser detectability. In this present study, the authors confirmed that the warning sounds could have similar detectability if they have similar loudness level. The frequency characteristics of the stimuli were varied while having equivalent powers in each 1/3 octave band so that they shall have equivalent loudness level. Moreover, the hearing impression of the stimuli were examined. The results showed that the impression of warning sounds could be varied while having equal detectability.

**15 Development of a next-generation audible pedestrian alert system for EVs having minimal impact on environmental noise levels project eVADER**

*Quinn, David C. (1); Mitchell, Josh; Clark, Paul*  
(1) Nissan, UK

**ABSTRACT**

The silent operation of Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs), at low speeds, has provoked significant concern regarding increased risk to pedestrian safety. Conversely, the relative silence of EVs is seen by others as a positive feature and a rare opportunity to reduce environmental traffic noise levels. The prevailing solution to the pedestrian safety concern is to add artificial sounds to EVs, in order to improve their detection by pedestrians and other vulnerable road users. However, this approach may not satisfy the need to reduce environmental traffic noise pollution levels, unless a solution can be found which satisfies these conflicting requirements.

eVADER (electric Vehicle Alert for Detection and Emergency Response) is a European Commission, part funded, project which is developing a next-generation audible alert system solution for EVs and HEVs. The prime objective of eVADER is to develop a practical solution whereby effective audible alert systems added to EVs can have minimal impact on environmental noise levels. This paper describes the eVADER pedestrian alert system concept and practical installation of the system into a Nissan LEAF demonstrator car, together with initial results of system performance.

**Tuesday 15:40-17:20 Room 208**  
**D7 Modelling and mapping traffic noise**  
**Chair: Ben Hinze, Kym Burgemeister**

**626 Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the Acoustical Society of Japan – Part 1: Outline of the calculation model**

*Sakamoto, Shinichi (1); Matsumoto, Toshio (2); Tajika, Terutoshi (3); Fukushima, Akinori (4)*  
(1) Institute of Industrial Science, The University of Tokyo, Japan; (2) Kobayashi Institute of Physical Research, Japan; (3) Environmental Technical Laboratory, Japan; (4) NEWS Environmental Design Inc., Japan

**ABSTRACT**

The Acoustical Society of Japan organizes the Research Committee on Road Traffic Noise to develop a prediction model of the road traffic noise. As results of the continuous research activities, the road traffic noise prediction model has been continuously published. Especially since 1993, the model has been released every five years. In this April, the latest version, "ASJ RTN-Model 2013", was published. It is an up-grade version of the previous model, ASJ RTN-Model 2008, and it was revised based on new knowledge and novel technology. In this paper, the calculation principle, the general procedure of the prediction calculation, the outline of the revision of the ASJ RTN-Model 2013 are introduced.

**536 Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the Acoustical Society of Japan – Part 2: Study on sound emission of road vehicles**

*Okada, Yasuaki (1); Tajika, Terutoshi (2); Sakamoto, Shinichi (3)*  
(1) Meijo University, Japan; (2) Environmental Technical Laboratory, Japan; (3) University of Tokyo, Japan

**ABSTRACT**

The Acoustical Society of Japan (ASJ) has published a new revised version of road traffic noise prediction method "ASJ RTN-Model 2013", in which the calculation formulas for the A-weighted sound power level of each type of road vehicle are specified. The sound power level is given simply as a function of the running speed in consideration of practicality and convenience. The several calculation formulas in this model had been developed using the measured data in 1991–1998. Since 2009, the Research Committee in ASJ has been accumulating new data about noise emission of road vehicles. In this study, the A-weighted sound power levels measured during the 1990's were compared with those in recent years. In addition, during the last decade, hybrid and electric vehicles are becoming popular and the number of production is rapidly increasing. The noise reduction effect of these low-emission vehicles was examined. As a result, it has been found that there are not any remarkable differences between the sound power levels measured in the 1990's and those in recent years, and the noise reduction effect of low-emission vehicles could be applied to the noise prediction in the vicinity of signalized intersections or expressway tollgates.

**83 The effects of vegetation on road traffic noise**

*Peng, Jeffrey (1); Bullen, Robert (1); Kean, Simon (2)*  
(1) Wilkinson Murray Ptd Ltd, Australia; (2) Roads and Maritime Services, Australia

**ABSTRACT**

In Australia road traffic noise is generally described as LAeq, and is typically assessed using the Calculation of Road Traffic Noise (CoRTN) standardised calculation procedures (with some modifications). However, the CoRTN methodology, like most other noise propagation algorithms, neglects the effects of highly vegetated areas on sound propagation. The aim of this study was to review available literature as well as to obtain specific experimental data to provide a better understanding of noise transmission when significant vegetation is present. The excess attenuation of traffic noise through 10 to 20m of trees (tree spacing <0.5m) was found to be typically 2 to 3dB(A), and up to 7dB(A) through 120m of eucalypts (spacing >0.5m), relative to CoRTN predictions. After bushfire, it was found that excess attenuation can still be expected as a result of multiple scattering by tree trunks. The conclusion of the data analysis and literature review has shown that vegetation has the potential to inform urban design and compliment other forms of noise mitigation.

**403 Noise modelling of road intersections**

*Lau, Akil (1); Lee, Yong Keat (1); Dawson, Bill (1); Name, Neil (1)*  
(1) Aurecon, Australia

**ABSTRACT**

Road traffic noise modelling is usually performed with statistical models (e.g. Calculation of Road Traffic Noise

"CORTN" algorithm) and calibrated based on experimental data related to standard conditions and assumptions such as free flow constant-speed traffic with uniformly distributed vehicles. However, as the standard modelling approach does not take into account traffic dynamics, traffic noise emission from intersections are not always modelled correctly. In this paper, analysis of an intersection is presented based on a case study. Noise measurements were conducted to characterize the existing noise environment. The measurement data was compared against the simulated noise model. The study outlines a method to account for traffic dynamics such as deceleration / acceleration / stop / start and low speed of traffic at junctions to improve predictions of traffic noise.

**687 Effects upon the urban noise of prioritizing bicycle traffic at intersections**

*Cueto, Jose Luis (1); Hernandez, Ricardo (1); Fernandez, Francisco (1); Sales, Diego (1); Priego, Javier Cristino (1)*  
(1) University of Cadiz, Spain

**ABSTRACT**

The term "Smart-Mobility" will probably be commonly used in traffic management in the cities in the twenty-first century. But this concept not only involves issues related to mobility, but also sustainability and efficient use of information technology. In this sense, urban experts have lately paid great attention to the promotion of cycling as a daily mode of transport. This paper aims to explore the possibilities of establishing the right of way to the flow of cyclists at signalized junctions and to describe the consequences it may have on environmental noise. However, this strategy of urban mobility would not have been feasible without the prior development of increasingly more reliable detection technologies of bikes as part of intelligent control systems at intersections. Considering that these intelligent systems have traditionally been used to avoid traffic jams as well as to give priority to public transport, this approach could involve new ways of thinking and imagining the modern city. This work is developed in a simple arterial where upon it is studied under which conditions these traffic control systems are more or less efficient through the network. For this purpose, a VISSIM traffic micro-simulation model has been applied.

**Tuesday 16:00-17:40 Room 207**  
**R6b Underwater noise from pile driving**  
**Chair: Joe Cuschieri**

**847 An efficient model for prediction of underwater noise due to pile driving at large ranges**

*Nijhof, Marten J J (1); Binnerts, Bas (1); De Jong, Christ A F (1); Ainsle, Michael A (1)*  
(1) TNO, The Netherlands

**ABSTRACT**

Modelling the sound levels in the water column due to pile driving operations nearby and out to large distances from the pile is crucial in assessing the likely impact on marine life. Standard numerical techniques for modelling the sound radiation from mechanical structures such as the finite element (FE) and boundary element method are not well suited to predict the sound field efficiently at large ranges. Models better suited for prediction of sound propagation in waveguides over

large distances, such as wavenumber integration and ray tracing, require careful attention in order to capture the source characteristics of a complex source such as a pile radiating from both water and sediment. To circumvent these issues, a new hybrid model is proposed using a local FE model that accurately captures the source characteristics of the pile which is coupled to a normal mode based model for efficient evaluation of the sound propagation over large distances in a range dependent environment. The model is validated using the well-known solution for a point source in a Pekeris wave guide. Results are shown for a generic pile driving scenario that was used in the international benchmarking workshop COMPILE for underwater pile driving models.

**854 New Hydro Sound Dampers to reduce piling underwater noise**

*Elmer, Karl-Heinz (1); Savery, John (2)*  
(1) Offnoise Solutions GmbH, Germany; (2) Savery and Associates Pty Ltd, Australia

**ABSTRACT**

Underwater noise is a severe annoyance and danger to marine life. The innovative Hydro Sound Dampers (HSD) lead to an effective general method to reduce piling underwater noise. HSD were developed between 2007 and 2010 by K.-H. Elmer to reduce marine and offshore piling noise. The theory and the acoustical background of the new noise mitigation method will be presented. HSD systems use nets with air filled elastic balloons and special PE-foam elements with high dissipative effects to reduce continuous and impact noise. The resonance frequency of the HSD-elements, the optimum damping rate for impact noise, the distribution and the effective frequency range can be fully controlled. Offshore tests and serial applications in offshore wind farms in Germany and Great Britain demonstrate this new effective way to reduce the very high offshore piling noise. It is also intended to use systems of Hydro Sound Dampers in Australia to reduce high underwater piling noise levels in coastal ports and harbours. HSD-systems are very small systems and easy to handle. They are more effective than air-bubble curtains, independent of compressed air, not influenced by tidal currents, not expensive and easy adaptable to different applications. Measured results of underwater noise reductions between 10dB (SEL) and more than 20dB (SEL) will be presented and discussed.

**864 Hydro sound measurements during the installation of large diameter offshore piles using combinations of independent noise mitigation systems**

*Bruns, Benedikt (1); Stein, Philipp (1); Stein, Philipp (1); Kuhn, Christian (1); Gattermann, Jörg (1)*  
(1) TU Braunschweig, Germany

**ABSTRACT**

During the installation of pile foundations for offshore wind farms (OWF) in the German North Sea, hydro sound emissions occur which are harmful to marine life. Limiting values defined by German authorities could not be met by the use of single noise mitigation systems (NMS) in past wind farm installations with large diameter monopiles. To improve noise reduction, combinations of several NMS are used in recent projects. Different NMS taking affect in different frequency ranges can reduce noise caused by impact driving more effectively. During offshore measuring campaigns at an OWF in the German North

Sea, hydro sound measurements have been carried out in 7 distances from 15 m to 1500 m and in 5 depths from 1 m to 17 m over ground simultaneously. Results of these measurements will be shown in the time and frequency domain. Pile driving noise emissions with single NMS and combinations of NMS will be compared with reference measurements without NMS to evaluate different setups. The influence of the subsoil will be discussed as well as it has a significant influence on hydro sound propagation in general and the effectiveness of NMS in particular.

**866 Dynamic measurements of pile deflections as a source of underwater sound emissions during impact driving of offshore pile foundations**

*Kuhn, Christian (1); Sychla, Hauke (1); Stein, Philipp (1); Bruns, Benedikt (1); Gattermann, Jörg (1); Degenhardt, Jan (2)*  
(1) TU Braunschweig, Germany; (2) E.ON Climate & Renewables Central Europe GmbH, Germany

**ABSTRACT**

Open ended tubular steel piles are used as a state of the art technique for the foundations of offshore wind turbines (OWT). The commonly used means of installation, impact driving, results in massive sound emissions into the seawater and the subsoil which are harmful for marine life. Current research carried out at the Institute for Soil Mechanics and Foundation Engineering of the Technische Universität Braunschweig covers wave propagation in and between driven piles, subsoil and water. This paper focuses on the properties and the propagation of the elastic waves through an impact driven monopile during its installation and the mechanisms of noise induction into water and subsoil. Within the scope of a research project funded by the German federal government measurements have been carried out during the erection of large diameter monopiles for an offshore wind farm (OWF) in the German North Sea. Axial and tangential strains as well as axial and radial accelerations along the length of the piles will be evaluated concerning the noise generating interactions between pile and water and pile and soil respectively.

**771 On the estimation of prediction accuracy in numerical offshore pile driving noise modelling**

*Lippert, Tristan (1); Heitmann, Kristof (1); Ruhnau, Marcel (1); Lippert, Stephan (1); Von Estorff, Otto (1)*  
(1) Hamburg University of Technology, Germany

**ABSTRACT**

Due to the massive, worldwide increase in the number of constructed offshore wind farms, the ecological impact of construction sites has become an important issue. Hereby, the topic of sound radiation from the needed pile driving procedures for the pile foundations of the turbines has gained a lot of attention lately. Therefore, several numerical models are currently developed to accurately predict sound pressure levels (SPLs) in several kilometers distance to the pile. The topic of parameter uncertainties, being important for every numerical model, is of special significance for these predictions. The extremely large dimensions of the domain of interest and the difficulties in determining, for example the bottom parameters, inevitably lead to a significant degree of uncertainty for the input parameters of the model. In this contribution, a coupled finite element/wavenumber integration model is presented and validated by measurements. Subsequently, the validated

model is used to exemplify the effect of parameter uncertainties on the resulting SPLs in the water column, using Monte Carlo simulations. Hereby, the sensitivity of the model to different input parameters is given, as well as a quantification of the resulting prediction accuracy.

**Tuesday 16:00-18:00 Room 206**  
**S3 Soundscape and noise control**  
**Chair: Brigitte Schulte-Fortkamp, Paul Schomer**

**516 The measurement of soundscapes – Is it standardizable?**

*Genuit, Klaus (1); Fiebig, André (1)*  
(1) HEAD acoustics GmbH, Germany

**ABSTRACT**

Beyond doubt, soundscaping is on the rise. Soundscape investigations are increasingly performed and soundscape research takes place extensively in recent years. Unfortunately, there is little agreement about adequate measurement procedures, reporting requirements and soundscape indicators. Although the general openness, interdisciplinary roots and multi-dimensionality of the soundscape approach are very important to preserve, a certain consensus about measurement procedures, reporting requirements and analyses tools is needed. In particular, a common denominator with respect to measurement procedures is required, since due to the diversity of measurement procedures the comparability and compatibility of soundscape investigations is very limited. The paper will refer to recent soundscape studies and their outcomes and will discuss the applied methods and procedures. Since the standardization of soundscape aspects is already under way (ISO/DIS 12913), e.g. regarding terms, minimum reporting requirements and measurement protocols, a thorough discussion of soundscape methods and procedures is imperative.

**651 On seeking methodology to "measure" a soundscape**

*Schomer, Paul D*  
Schomer and Associates Inc. USA

**ABSTRACT**

For the soundscape concept to be of practical use it must be able to "measure" the contribution of various contexts to the overall resulting soundscape. The metric used in the "measurement" has at least one requirement. That is, it must be such that if A is better than B and is better than C than A is better than C. Recently Schomer et al. showed that at least for soundscapes not judged positively that the single number given by CTL Fidell et al. represents and effectively quantifies the sum of all community contexts. This is a start in that in these instances we know the sum but to make improvements in understanding soundscape it is necessary to know how each piece contributes so that in the future we can tailor the contexts to improve the overall outcome. In this paper we examine these issues and suggest some contexts that currently can be at least estimated.

**246 How do ordinary people evaluate noise pollution in the context of environmental issues?**

*Nagahata, Koji*  
Fukushima University, Japan

**ABSTRACT**

Noise pollution is an environmental issue, and noise policies should thus be developed in the context of such issues. Noise policies also need to reflect public opinion; thus, in developing noise policies, it is important to understand the opinions of ordinary people. This study investigates the evaluation by ordinary individuals of the importance of and their familiarity with noise pollution in the context of environmental issues. A two-dimensional mapping method, which was developed in the field of health education and health promotion, was employed. Participants were asked to evaluate eight items—air pollution, water pollution, soil pollution, odor, noise pollution, ground subsidence, greenhouse gasses, and radioactive pollution—in terms of their importance and familiarity. Noise was most frequently evaluated as the least important environmental issue by the participants, though familiarity with noise pollution varied widely among them. Some participants did evaluate noise pollution as an important and familiar issue: those participants also tended to regard odor as an important issue and to evaluate greenhouse gasses and radioactive pollution, which cannot be sensed directly, as unimportant and unfamiliar.

**871 Sharing ideas about noise management and community design**

*Dubbink, David*  
Noise Management Institute, USA

**ABSTRACT**

Noise control has an established role protecting the public from annoying or damaging sounds. But protection from harm is not the same as the promotion of good. The Soundscape concept adds this essential linkage; providing insights and technologies that help communities construct improved acoustic environments. It expands ways of evaluating sound; moving beyond traditional descriptors to include a rich consideration of the diverse ways people experience sound. The paradigm shift in community noise management is occurring simultaneously with the explosion of mobile and web technologies. These also are changing established approaches to noise control. Phones or tablets can be turned into sound level meters so anyone can measure sound exposure levels. Individuals can record their audio and visual experiences, replicating the "soundwalk", that is a fundamental tool of Soundscape analysis. At some point, expert studies or crowd-sourced measurements by individuals must be consolidated so the diversity of experiences can be interpreted into designs and policies. The Interactive Sound Information System, developed by the author, was designed to produce shared aural experiences and a way of collectively imagining future sound environments. It provides one example of how sound management issues can be presented to concerned communities and decision makers.

**826 Soundscape Identification in Noise Annoyance Evaluation**

*Yu, Lei (1); Kang, Jian (2); Liang, Hong (2); Xie, Charles (2)*  
(1) UK; (2) China

**ABSTRACT**

Living in modern cities is being interfered by ambitious noise more and more seriously. Present controlling approach is to monitor sound pressure level, which only describes one characteristic of a sound environment and ignores its influence on people too. Many studies proved that noise annoyance is not only determined by sound pressure level but also by soundscape that a person identifies. Since a bird singing or water babbling is perceived quieter than a traffic roaring even both having the same sound pressure level, it is considered that soundscape identification plays an important role in subjective evaluation of noise annoyance. Therefore, this study is going to explore how soundscape identification in determining noise annoyance evaluation within a city context. The study investigates four places in an ecological residential area that contains completely nature, nature mixed with man-made, and complete man-made soundscapes. Using recordings of the four study-sites, physical characteristics of a diversity soundscape have been analyzed and relationships of a soundscape's physical characteristics with noise annoyance evaluation have been studied.

**564 Soundscape mapping in urban contexts using GIS techniques**

*Hong, Joo Young (1); Jeon, Jin Yong (1)*  
(1) Hanyang University, South Korea

**ABSTRACT**

Urban acoustic environments consist of various sound sources including traffic noise, human-generated sounds, and natural sounds that affect the soundscape perception of a given location. However, these sound sources are indistinguishable by noise maps that are based on sound pressure levels. Hence, soundscape maps based on the perception of sounds are necessary to describe an acoustic environment more accurately. Presented herein is a study of soundscape perception, which employs GIS techniques to generate soundscape maps in various urban settings including commercial, business, recreational, and residential spaces. Soundscape perceptions and physical characteristics of the acoustic environments pertaining to these urban settings were evaluated from questionnaire surveys and acoustic measurements, respectively. The results demonstrate how soundscape perceptions and spatial variation in urban soundscapes are closely related to their corresponding urban contexts.

**Wednesday 08:20-10:40 Room 220**  
**T6b Psycho-acoustics in noise evaluation**  
**Chair: Hugo Fastl, Sonoko Kuwano**

**430 A Study on sound quality evaluation index of car door latch and improving sound quality by modifying door latch assembly design**

*Jo, Hyeonho (1); Seong, Weonchan (1); Lee, Hyeongrae (1); Kim, Seonghyeon (2); Park, Dongchul (2); Kang, Yeon June (1)*  
 (1) Seoul National University, Republic of Korea; (2) Hyundai Motor Company, Republic of Korea

**ABSTRACT**

The purpose of this study is to develop an index that evaluates the sound quality of the door latches and improves the sound quality based on the results. To conduct the jury evaluation, various operating sounds of door latches were used. Through the results of the jury evaluations, loudness and sharpness related metrics are dominant in the sound quality index we developed. This research investigates the main transfer path of operating sounds through sound field visualization and concludes what could reduce the impact sound of the door latch. Therefore, we could verify the sound quality improvement of modified products by using the sound quality index.

**627 Evaluation of Diesel powertrain noise -Difference between Professional and Non-professional-**

*Hashimoto, Takeo (1); Hatano, Shigeko (1); Shin, Sung-Hwan (2)*  
 (1) Seikei University, Japan; (2) Kookmin University, South Korea

**ABSTRACT**

The evaluation of Diesel powertrain noise on unpleasantness for good sound quality is different between professional and non-professional due to the difference of the key sounds to evaluate. The professional pays more on the frequency component related to the sensation of annoyance caused by the Diesel knocking. To compare the professional evaluation, the one obtained by the non-professional is based on the overall impression of test sound. In order to match the evaluation between the professional and non-professional, training session for correct evaluation is required for non-professional subject. If non-professional subject experiences the training session to know the point of evaluation, the evaluation obtained after the training is well match with the professional subject.

**667 Simulation of gear rattle to aid in the development of sound quality metrics for diesel engine component specification**

*Sobecki, Brandon (1); Davies, Patricia (1); Bolton, J. Stuart (1)*  
 (1) Purdue University, USA

**ABSTRACT**

Noise produced by components in a diesel affect the quality of the engine noise. One component source related to consumer complaints is gear rattle. Gear rattle is caused by gear tooth impacts resulting from fluctuations in differential torsional acceleration of the driving gears. Previous work in this area has focused on rating the overall sound quality of diesel engines

without specifically focusing on models for predicting the perception of gear rattle. Here, a method to generate sounds having different levels of gear rattle is described. First, diesel engine noise recordings are analyzed to determine the engine speed time histories; they are then used to guide gear impact timing and to generate gear noise components. The gear noise transfer paths have been tuned to improve the quality of the gear noise predictions. The gear noise simulation tool is being used to generate sounds for subjective tests designed to quantify the detectability, perception of growth, and annoyance of gear rattle. The noise prediction coupled with the sound quality models based on the analysis of the subjective data will provide a way to predict how people perceive gear rattle so that component noise targets can be set directly related to human perception.

**674 In-service measurement of heavy vehicle engine brake noise**

*Kean, Simon (1); Bullen, Robert (2); Arredondo, Jose (3)*  
 (1) Roads and Maritime Services, Australia; (2) Wilkinson Murray Pty Ltd, Australia; (3) National Transport Commission, Australia

**ABSTRACT**

Heavy vehicle engine compression brake noise is a major source of community annoyance due to its modulated characteristic. Traditional acoustic measurement approaches using A-weighted Sound Pressure Level have had moderate success but remained problematic. A new approach has been developed using instantaneous loudness to more accurately measure how the community hears the noise. From this an in-service test procedure and criterion has been developed to assist with potential compliance and enforcement processes. The proposed criterion was established by reviewing 170,000 roadside vehicle passbys and controlled tests using various engine silencer designs and is based on the RMS modulation of loudness in Sones. The controlled tests established the modulation scores that could reasonably be achieved with the current heavy vehicle fleet.

**316 Influence of low SPL and bird twittering sounds on the loudness for road traffic noise**

*Kuwano, Kazuki (1); Yoshida, Junji (1)*  
 (1) Osaka Institute of Technology, Japan

**ABSTRACT**

In this study, an influence of the frequency of low sound pressure level (SPL) on the loudness for road traffic noise was investigated. Road traffic noises were recorded and edited to have the same equal equivalent noise level (LAeq) and having different frequency of low SPL. Through a subjective loudness evaluation test, road traffic noises having more frequency of low SPL were evaluated significantly softer even though all sounds had the same LAeq. Improvement of the memory to the low SPL sound was considered to be an important role for the result. Subsequently, several bird twittering sounds were inserted to a road traffic noise to change the attention and memory of the participants. The twittering sounds were added in high or low SPL section of the road traffic noise and subjective evaluation was performed again. Results show the sound including the twittering sounds were not evaluated softer, oppositely, the loudness decrease effect by the increase of the low SPL frequency was reduced.

**298 Influences of Vehicle Exterior Images on Sound Quality Ratings: German vs. Japanese Drivers**

*Yoshida, Junji (1); Volk, Florian (2); Fastl, Hugo (2); Rigoll, Gerhard (3)*

(1) Osaka Institute of Technology, Japan, AG Technische Akustik, MMK, Technische Universität München, Germany; (2) Technische Universität München, Germany; (3) MMK, Technische Universität München, Germany

**ABSTRACT**

In this study, influences of vehicle exterior images on sound quality ratings of acceleration sounds were investigated. Luxury and sporty vehicle images were presented to German or Japanese frequent drivers, while listening to acceleration sounds. Subsequently, loudness, luxury, and sportiness of the sounds were rated. The results indicate that the German drivers tended to rate loudness lower and luxury higher when the sounds were presented with images of luxury cars, compared to images of sporty vehicles. As expected, sportiness was rated higher when an image of a sporty vehicle was presented. Oppositely the Japanese drivers indicated higher loudness and lower luxury when the sounds were combined with luxury vehicle images. Further, comparable to the German drivers, they rated higher sportiness when presented with sporty vehicle images. Consequently, it appears that sound quality ratings can be affected by the vehicle exterior design, but the average tendencies suggest different effect directions for German vs. Japanese drivers.

**131 A psychoacoustic assessment of road traffic noise for indoor aural comfort in high-rise built environment**

*Sheikh, Mahbub Alam (1); Lee, Siew Eang (1)*

(1) National University of Singapore, Singapore

**ABSTRACT**

Research over the past few decades investigated noise annoyance in indoor residential settings and related it to several physical noise indicators such as LAeq, LA1, LA10, LAmx, LD, LN, LDEN etc. Recent researches show that A-weighted level is unable to consider mutual masking among the components in a complex sound and also the asymmetry of masking patterns produced in the auditory system. Rationally, A-weighted noise level is found as a poor indicator of loudness and annoyance. In contrary to the negative evaluation, research on the positive assessment of indoor aural environment and its association with different psychoacoustic parameters are very limited in the literature. This research investigates the indoor aural comfort in high-rise residential setting and its correlations with several psychoacoustic indicators. A psychoacoustic experiment was carried out to investigate indoor aural comfort subjected to road traffic noise and its relationships with different psychoacoustic indices. Loudness and Roughness were found significantly correlated with the assessment of 'Noisiness of Apartment' and 'Noise Disturbance' in indoor environment subjected to road traffic noise. Road traffic noise with a maximum Loudness of 9 Sone and a maximum Roughness of 27 centi-Asper were found attributing to a 'quiet' indoor aural environment. This paper presents statistical models for subjective 'noisiness of apartment' and 'noise disturbances' and discusses their relationships with these psychoacoustic quantities.

**Wednesday 08:20-10:20 Room 219  
V2b Sound visualization and manipulation  
Chair: Yang-Hann Kim, Jung-Woo Choi**

**44 Wideband acoustical holography**

*Hald, Jorgen*

Brüel & Kjaer Sound & Vibration Measurement A/S, Denmark

**ABSTRACT**

Patch NAH methods like SONAH and ESM are limited to relatively low frequencies where the average array inter-element spacing is less than half a wavelength, while beamforming provides useful resolution only at medium-to-high frequencies. With adequate array design, both methods can be used with the same array. But for holography to provide good low-frequency resolution, a small measurement distance must be used, while beamforming requires a larger distance to limit sidelobe issues. Wideband Holography was developed to overcome that practical conflict. Only a single measurement is needed at a relatively short distance and a single result is obtained covering the full frequency range. The underlying problem solved is that at high frequencies, the microphone spacing is too large to meet the spatial sampling criterion, and thus there is no unique reconstruction of the sound field. A reconstruction must therefore have a built-in "preference" for specific forms of the sound field. Doing just a Least Squares solution will result in reconstructed sound fields with sound pressure equal to the measured pressure at the microphones, but very low elsewhere. By building in a preference for compact sources, a smoother form of the reconstructed sound field is enforced.

**823 Development of the Double NAH method**

*Nagamatsu, Masao*

Hokkaido University of Science, Japan

**ABSTRACT**

There are several types of sound localization methods. But in sound localization of low frequency noise, all methods do not have enough resolution in reconstructed images. In this paper, the new localization method, Double Nearfield Acoustic Holography method is proposed. This method is converted method of conventional Nearfield Acoustic Holography method, and the purpose of this method is to improve the resolution of low frequency sound localization. In this paper, the theory of proposing method is explained. The several numerical simulations are done to verify the resolution of reconstructed images about sound localization in low frequency. In this paper, some numerical simulation results are explained. As a result, It is verified that the proposing method has better resolution on reconstructed images compared with conventional Nearfield Acoustic Holography method, in sound localization of low frequency sound sources.

### 381 Multi-spectral acoustical imaging

*Nakamura, Kentaro (1); Guo, Xinhua (2)*

(1) Tokyo Institute of Technology, Japan; (2) Wuhan University of Technology, China

#### ABSTRACT

Visualization of object through acoustic waves is generally called as acoustical imaging. This concept contain noise source localization, ultrasonic non-destructive testing, medical ultrasound, underwater sonars, etc. In these conventional imaging techniques, frequency information has not yet utilized effectively, though shape, material and even structure behind the surface reflect on the frequency characteristics of their acoustic responses. In this report, we introduce a concept of multi-spectral acoustical imaging, where wide range of frequency responses are investigated with a fine frequency pitch. As typical examples, we demonstrate the responses from a surface with several different holes for the frequency band from 1 to 20 kHz with 30-Hz pitch. The position and depth of the holes are clearly identified by their resonance frequencies. The volume of a small droplet in a well can be precisely measured using the present method. A method for displaying the multi-spectral acoustical data is also discussed.

### 253 A microphone position calibration method in a reverberant environment for a randomly distributed array

*Teng, Pengxiao (1); Xiao, Ying (2); Yang, Yichun (1)*

(1) Chinese Academy of Sciences, China; (2) Shandong University of Science and Technology, China

#### ABSTRACT

distributed large-size array in this paper. The microphone positions need to be known exactly in order to localize sound sources. Time delay estimation (TDE) is an important step in calibrating the microphone positions using a few calibrating sound sources for a randomly distributed array. However, TDE method degrades severely in a reverberant environment which can introduce serious position errors. The microphone position error analysis is made due to misleading estimation of time delay. In this paper, impulsive sound source as a calibrating source is investigated compared with chirp source and white noise. The direct sound from an impulsive sound is isolated to calculate exact time delay in a reverberant environment while early reflection and reverberation sound are cut off. The simulation experiments are carried out to demonstrate that accurate microphone positions can be obtained using the proposed method. The proposed method is also applied in a project to calibrate the microphone positions for a spiral-like ceiling-mounted array with 64 elements and aperture of 3.5m, which proves the effectiveness.

### 885 Virtual in-ear microphone for in-vehicle noise control based on array technology and modified zero point attraction LMS algorithms

*Adnadjevic, Mirjana (1); Botteldooren, Dick (1)*

(1) Ghent University, Belgium

#### ABSTRACT

Measuring in the ear of an operator of a vehicle or heavy duty machine may be useful in several applications such as noise assessment, adaptive communication, headphone-less binaural

sound reproduction, or active noise control. However, wearing in-ear microphones is not very comfortable for the operator. Therefore, we investigated the possibility to replace these microphones by virtual microphones based on an array of microphones optimally located in an enclosure. Several modifications to LMS based algorithms for sparse MISO system identification were proposed and adopted at the one hand to eliminate as many of the filter taps as possible to reduce the computational load, and at the other hand eliminate as many microphones as possible to reduce hardware costs. Identification methods are evaluated through the simulations based on the experimental measurements performed in the real size driver's cabin constructed for the purpose of active noise control (ANC). Forty six microphones were initially positioned at the cabin roof, while virtual location is chosen to be ear of the seated observer. It is shown that these algorithms indeed reduce the set of microphones, still providing acceptable fitting performance when compared to the reference NLMS technique where all available microphones are used. Sensitivity of converged coefficients to natural head movements is evaluated for the head rotations of 20, 45 and 60 degrees in horizontal plane.

### 289 Creation of a single sound field for multiple listeners

*Poletti, Mark Alister (1); Betlehem, Terence (1)*

(1) Callaghan Innovation, New Zealand

#### ABSTRACT

Sound reproduction systems are limited in their ability to create sound fields over large areas and over wide bandwidths, because the required number of loudspeakers becomes prohibitive. This limits the ability of surround systems to create sound fields large enough to be heard by multiple listeners. This paper considers an alternative approach to the creation of a single sound field for multiple listeners in which reproduction is accurate in a number of small zones of sufficient size for each listener. This results in a significant reduction in loudspeaker requirements compared to the creation of a single zone that encompasses all listeners. The approach is based on conversion of the sound field coefficients of the global field into localized coefficients within each zone and a mode-matching method for simultaneously reproducing the local fields in each zone. The theory is developed for the 2D case, for simplicity, and simulations are presented to demonstrate the effectiveness of the approach. Such a system would require a tracking system to determine the position of each listener, but the tracking requirements would be less stringent than are required for binaural reproduction using a cross talk canceller.



**Wednesday 08:20-10:40 Room 218**  
**L4a Active vibration control and active**  
**structural acoustic control**  
**Chair: Li Cheng, Youngjin Park**

**575 Analysis of frequency-domain active noise control algorithm with parallel structure**

*Lee, Nokhaeng (1); Park, Youngjin (1)*  
 (1) KAIST, Republic of Korea

**ABSTRACT**

Active noise control is a noise reduction technique introducing a canceling anti-noise wave. Recently, it is widely used in industrial operations, manufacturing, and consumer products. In many cases, periodic noise occurs because most applications include engines, compressors, motors, fans, and propellers which have reciprocating motion. The noise usually contains tones at the fundamental frequency and at several higher harmonic frequencies in practice. For this type of noise, we developed a frequency-domain active noise control algorithm and determined that it's effective before. In practice, however, some errors can occur and deteriorate the performance of the algorithm. In this paper, we consider that practical condition and have an analytical approach to the property of frequency-domain active noise control algorithm. We achieved the dynamics of the algorithm and predict the performance in practice.

**817 Active Noise Control Experiments for an Acoustic-Structural Coupled Enclosure using Structural-Based Virtual Sensors**

*Halim, Dunant (1); Cheng, Li (2)*  
 (1) Department of Mechanical, Materials and Manufacturing Engineering, University of Nottingham Ningbo, China; (2) Department of Mechanical Engineering, Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

This work was focused on the implementation of an active noise control strategy for an acoustic-structural coupled enclosure using structural-based virtual sensors. A virtual sensing system was developed to estimate the broadband sound pressure at virtual interior locations in the enclosure based on structural vibration measurement of its flexible structure, instead of using acoustic sensors. Experiments on a panel-cavity test rig were performed and an active control system using the FX-LMS algorithm was used to minimize the noise at a virtual location based on accelerometer measurements. Experiment results showed that the broadband noise level at the virtual location was suppressed even when the actual system dynamics was perturbed from the original one, demonstrating the robustness of active noise control system.

**665 On synchrophasing control of vibration for a floating raft vibration isolation system**

*Yang, Tiejun (1); Zhou, Liubin (2); Brennan, Michael J (3); Zhu, Minggang (1); Liu, Zhigang (1)*

(1) Harbin Engineering University, China; (2) Wuhan Second Ship Design and Research Institute, China; (3) UNESP, Brazil

**ABSTRACT**

A large-scale floating raft vibration isolation system installed on a flexible hull-like structure is described in this paper. Four vibration exciters, in which two counter rotating shafts with the same balanced masses are driven by a phase asynchronous motor, are used to simulate rotating machines on the raft. The phase of the electrical supply to the motors is adjusted by synchrophasing control scheme to reduce the vibration transmitted to the host structure to which the machinery raft is attached. This kind of synchrophasing control for the floating raft vibration isolation system is investigated theoretically and experimentally. At last some results are presented and discussed.

**556 Semi-active noise suppression based on SSD technique using piezoelectric elements**

*Ji, Hongli (1); Cheng, Li (2); Qiu, Jinhao (3); Nie, Hong (3)*  
 (1) Nanjing University of Aeronautics and Astronautics, China, Hong Kong Polytechnic University, Hong Kong; (2) Hong Kong Polytechnic University, Hong Kong; (3) Nanjing University of Aeronautics and Astronautics, China

**ABSTRACT**

Noise suppression using piezoelectric elements has received extensive attention in recent years. Traditional active noise control methods usually require the use of microphones as sensors to directly measure the sound pressure in either feed-forward or feedback control schemes. This makes the traditional active noise isolation more difficult to implement in some practical applications. Nonlinear semi-active Synchronized Switch Damping (SSD) approaches are typical switched-voltage control methods, which have recently been a topic of active research in the field of vibration control. In this paper, SSD method is proposed for the suppression of noise transmission through an aluminum panel. In a typical SSD setting, microphones are not required for feedback control, but are used merely as sensors to evaluate the control performance. The layout of the piezoelectric elements on the panel has been optimized based on the mode shape dominating the noise radiation. SSDV (SSD based on voltage sources) was used to improve the control performance. Experimental results show that the proposed control approach exhibits good performance in suppressing noise transmission.

**680 Active vibration control using compliant-based actuators**

*Mareta, Sannia (1); Halim, Dunant (1); Popov, Atanas (2)*  
 (1) University of Nottingham Ningbo, China; (2) University of Nottingham, UK

**ABSTRACT**

In this work, an active vibration control method using compliant-based actuators is proposed for controlling a wide range of vibration and its noise-associated applications. The compliant-based actuator combines a conventional actuator

with elastic elements, such as passive springs, that can be demonstrated to have better accuracy and robustness for force control compared to conventional stiff actuators. At high frequencies, the actuator behaves like a passive spring with low impedance, providing a better shock resistance to the actuator than the stiff actuator. These capabilities are beneficial for developing an effective vibration isolation system, particularly for controlling the vibration transmissibility at important low frequencies. The effect of compliant stiffness on the vibration control performance is investigated. It is shown that Proportional-Derivative (PD) control method using a compliant-based actuator can be used to obtain effective control of force transmissibility at low frequencies.

#### 865 Combined force-moment actuator for ASAC

*Jiricek, Ondrej (1); Jandak, Vojtech (1); Brothnek, Marek (1)*  
(1) CTU in Prague, Czech Republic

##### ABSTRACT

This paper deals with a recently developed actuator based on piezoelectric bimorphs which are useful for ASAC applications. The actuator takes the form of two channels with pairs of bimorphs. Each of the bimorph transducers in the couple is connected separately so that the actuator can act in both moment and force configurations simultaneously. The control algorithm allows the ratio between the moment and force excitation to be adapted according to the desired mechanical output. The ASAC system using this actuator was tested on a simple structure in the form of a fixed beam. Configurations with maximum attenuation were selected and discussed.

#### 1016 A study on the influence of model uncertainties on the performance of a feedback control based ASAC system

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(1) Department of Mechanical Engineering, Indian Institute of Technology Delhi, Hauz Khas, New Delhi-110016, India

##### ABSTRACT

An important problem in systems such as aerospace interiors, automobile passenger compartments and other cavities is the control of low frequency interior noise. Active control of this noise may offer a potentially better alternative to passive control due to constraints of weight and space. Active structural-acoustic control (ASAC) is considered as an attractive strategy especially for controlling structure-borne noise. LQG based feedback control is one of the popular strategies that has been used in the context of ASAC. The LQG based strategies utilize an observer that estimates the states of the plant for feedback and therefore is a key element in the whole control loop. Since it uses a copy of the model of the plant for estimation, the accuracy of the model is crucial for its performance. This paper reports a study on the influence of the model uncertainties on the LQG based ASAC system. The influence of the uncertainties on the accuracy of the estimated states as well as on the closed loop system performance is studied. Uncertainties in material properties, geometry and boundary conditions are considered. Study on a rectangular box cavity with a flexible plate is reported.

**Wednesday 08:20-10:20 Room 217**  
**G5 Evaluation of wind turbine noise source mechanisms**  
**Chair: Lars Sondergaard**

#### 490 Application of stochastic wind model to investigate swishing characteristics of infrasound and low frequency noise from wind turbine

*Lee, Gwang-Se (1); Cheong, Cheolung (1)*  
(1) Pusan National University, South Korea

##### ABSTRACT

Swishing characteristics of infrasound and low frequency noise radiating from a modern large horizontal-axis wind turbine are investigated by employing stochastic wind model to reproduce realistic incident wind conditions upstream of the wind turbine. The stochastic wind is generated through the superposition of colored noise on mean wind profile. The colored noise is computed by applying low-pass filter to white noise. The filter represents the geometric and atmospheric conditions around the target turbine. The wind profiles generated in this way are applied to compute aerodynamic response on blades of the wind turbine by using the XFOIL code. The computed airfoil response is finally incorporated to predict the infrasound and low frequency noise of the wind turbine by using the Lowson's acoustic analogy. When only the mean wind profile is applied, the swishing effects in the predicted time-frequency maps of the wind turbine noise are clearly identified. However, unsteadiness in the incident wind profile leads to more complex swishing characteristics, which are often found in the noise signals obtained from field measurements. This result implies that operational condition on site in which the wind turbine is installed needs to be taken into account to more accurately assess the sound quality of wind turbine noise due to its swishing.

#### 551 Cyclic pitch for the control of wind turbine noise amplitude modulation

*Bertagnolio, Franck (1); Madsen, Helge Aagaard (1); Fischer, Andreas (1); Bak, Christian (1)*  
(1) DTU Wind Energy, Denmark

##### ABSTRACT

Using experimental data acquired during a wind turbine measurement campaign, it is shown that amplitude modulation of aerodynamic noise can be generated by the rotating blades in conjunction with the atmospheric wind shear. As an attempt to alleviate this phenomenon, a control strategy is designed in form of a cyclic pitch of the blades. As a side effect, it is shown that it is also possible to reduce fatigue load on the blade using this cyclic pitch. The main goal is to reduce both amplitude modulation and fatigue load without compromising the energy harvested from the wind. A simulation tool that can model the different aerodynamic and aeroacoustic aspects of the study is presented. Parameters controlling the cyclic pitch are optimized in order to reduce amplitude modulation and/or fatigue load to a minimum. It is shown that such a minimum can be found and that benefit may be achieved if such a strategy is to be implemented on an actual wind turbine, though at the expense of an increased wear and tear of the pitch control system.

### 385 Tonal characteristics of wind turbine drive trains

*Dawson, Bill (1); Mackenzie, Neil (1)*  
(1) Aurecon, Australia

#### ABSTRACT

Wind turbines use a drive train incorporating a rotor, gearbox and generator to harness power from turning of the turbine blades. Modern wind turbine drive trains utilise a multi-stage gearbox, typically involving a planetary gear stage (low speed shaft) and two parallel stages (mid and high speed shafts). These gearboxes have natural frequencies and mode-shapes dependent upon the stiffness of gear shafts and tooth pairs, which can interact with tonal sources such as gear meshing frequencies to result in audible tones, and greatly increase the annoyance factor of wind farms and adversely impact on human health. This paper examines the drive train of a wind turbine, the impact on environmental noise emissions from the turbine, and how tonal characteristic issues associated with its operation may be avoided.

### 972 Wind Turbine Tower Resonance

*Sjöström, Anders (1); Novak, Colin (2); Ule, Helen (3); Bard, Delphine (1); Persson, Kent (1); Sandberg, Göran (1)*  
(1) Lund University, Sweden; (2) University of Windsor, Canada; (3) Akoustik Engineering Limited, Canada

#### ABSTRACT

Wind turbine towers are large structures designed to withstand the unique loading conditions imposed on them by the turbine's nacelle and dynamic forces from the rotating blades. Observations and noise measurements of a particular wind turbine showed high noise levels at approximately 48 Hz, which could not be explained from the usual known potential noise sources. Correlated far field noise measurements and vibration measurements collected on the turbine tower, structural base and nearby ground have shown the source to be a resonance of the tower structure.

### 296 Numerical simulation and aeroacoustic noise modelling of a wind turbine using a blade section in an annulus

*Wasala, Sahan Hasaranga (1); Norris, Stuart Edward (1); Cater, John Edward (1)*  
(1) University of Auckland, New Zealand

#### ABSTRACT

Noise disturbance from wind turbines is one of the major factors which slows wind farm development near populated areas. Therefore, it is important to have an accurate estimate of the noise generated before production and installation of wind turbines. Large Eddy Simulation (LES) can be used to determine the aerodynamic sound produced by a moving surface, but LES of a whole wind turbine is computationally expensive. However, Oerlemans' field measurements show that most of the noise from wind turbines is generated at 75%-95% of the span of the blade. This suggests that simulation of a section with the most significant noise sources could lead to a useful overall noise estimate in the far field. The present work is focused on noise prediction from a wind turbine using a rotational annulus containing a section of a wind turbine blade, which leads to a significant reduction of computational expense. LES with the Ffowcs-Williams and Hawkings acoustic analogy is used to predict the far field acoustic noise. Initial

results with rotational CART-2 wind turbine blade show good agreement with the available experimental data.

### 451 Classification of damage for planetary gear of wind turbine simulator

*Seo, Yun-Ho (1); Kim, Sang-Ryul (1); Kim, Bong-Ki (1); Lee, Seong-Hyun (1); Kim, Jae-Seung (1)*  
(1) Korea Institute of Machinery and Materials, South Korea

#### ABSTRACT

A planetary gear of a wind turbine is a critical component in the view of condition monitoring and fault detection because the fault of the gear needs much cost and time to fix or replace it. In this paper, classification of damage for a planetary gear is proposed and validated by the experiment of wind turbine simulator in order to evaluate the possibility of the application to fault detection of a real wind turbine. Vibration data for various faults of a gear are acquired in wind turbine simulator. Then, effective metrics induced by the gathered vibration data are determined by using vibration data with constant rotational speed. Finally, classification of damage is performed by using neural network with normalized features and bin concept when rotational speed of wind turbine simulator is varied.

**Wednesday 08:20-09:40 Room 216**

**C5 Aircraft engine noise**

**Chair: Michael Bauer, Luís Campos**

### 633 Aeroacoustic source localization on open rotor aircraft model in wind tunnel tests

*Chiariotti, Paolo (1); Martarelli, Milena (2); Tomasini, Enrico Primo (1); Castellini, Paolo (1)*  
(1) Università Politecnica delle Marche, Italy; (2) Università degli Studi e-Campus, Italy

#### ABSTRACT

Phased Array aeroacoustic measurements are gaining an increasing interest in automotive and aeronautic design. This paper describes the beamforming approaches used for characterizing acoustic sources on an counter rotating open rotor (CROR) installed on a 1/7th scale model of an advanced regional air-craft design. The tests were conducted in a large Low Speed Wind Tunnel (WT) at The Pininfarina Aerodynamic and Aeroacoustic Research Center in Turin, Italy, within the framework of the FP7 EU Clean-Sky WENEMOR (Wind tunnel tests for the Evaluation of the installation effects of Noise Emissions of an Open Rotor advanced regional aircraft) project. Three planar microphone arrays were installed in Pininfarina WT: a wheel array (3m diameter) placed at the ceiling of the WT (Top), a half-wheel array positioned broadside and parallel to the axis of the open rotor (Lateral) and a spiral array (2.5m aperture) placed upstream the blade plane and at an angle of 10 degrees to the blade plane (Upstream). Measurements were performed for a variety of aircraft geometries (involving different fuselage and rotor configurations), angles of attack and wind speeds. Preliminary beamforming results obtained processing the Top and Lateral arrays are presented and discussed.

**791 Adapting a propeller noise model for aircraft at cruising altitudes**

*Blunt, David M (1); Jones, Adrian (1); Mewett, David (1)*  
(1) DSTO, Australia

**ABSTRACT**

An existing propeller harmonic noise model is adapted to incorporate the effects of a stratified atmosphere so that predictions can be made of the ground-level noise for an aircraft flying at cruising altitudes. Specifically, the speed of sound and the atmospheric absorption are both made functions of altitude. The effects of refraction and ground reflection are examined, but deemed small enough to exclude from the initial model adaptation. The adapted model is applied to long-range acoustic data for a turboprop aircraft at three different cruising altitudes. The results show that a relatively good fit can be found between the model and the experimental data at the Doppler-shifted blade passing frequency within a range of source radiation angles from 30° to 110° with respect to the aircraft's direction of travel. The results also highlight the influence of molecular oxygen on the atmospheric absorption of the propeller harmonics. Recommendations are made for further improvements to the model.

**732 Lattice Boltzmann Study of the Geometric Effect of a Perforated Orifice on Its Damping Performance**

*Ji, Chenzhen JI (1); Zhao, Dan (1); Li, Shihuai (1); Li, Xinyan (1)*  
(1) Nanyang Technological University, Singapore

**ABSTRACT**

The present work considers the geometric effect of a perforated orifice on its noise-damping performance by conducting 2D lattice Boltzmann simulations. The damping effect of a rounded orifice is characterized by using power absorption coefficient by applying an acoustically-excited flow consisting of multiple tones. Comparison is then made between the damping performance of the rounded orifice and a square one. It is found that the rounded orifice is associated with lower damping effect than that of the square one. This is due to the different intensity vorticities generated, as visualized in the vortex shedding contours. To gain further insight on the damping mechanism and performance of the orifices, the orifice thickness effect is studied. As the orifice diameter remains constant, the damping performance of the orifices becomes deteriorates in terms of the effective frequency bandwidth with the increased thickness. The present work confirms the effect of the orifice shape and geometry plays an important role in its noise-damping performance.

**949 A Coherence Approach to Characterizing Broadband Sound Fields in Ducts**

*Joseph, Phillip*  
University of Southampton, UK

**ABSTRACT**

This paper describes a new measurement technique that allows the model amplitude distribution to be determined in ducts with mean flow and reflection based only measurements of the two-point coherence made at the duct wall. The technique is primarily applicable to broadband sound field in the high frequency limit and whose mode amplitudes are incoherent.

The technique makes the assumption that the relative mode amplitude distribution is independent of frequency.

**Wednesday 09:40-11:00 Room 216**

**C6 Jet noise**

**Chair: John Cater**

**55 Challenges associated with studying nonlinear distortion of acoustic waveforms emitted by high-speed jets**

*Baars, Woutijn J (1); Tinney, Charles E (2); Hamilton, Mark F (2)*  
(1) University of Melbourne, Australia; (2) University of Texas at Austin, USA

**ABSTRACT**

Discrepancies between linear predictions and direct measurements of the far-field sound produced by high-speed jet flows are typically ascribed to nonlinear distortion. Here we employ an effective Gol'dberg number to investigate the likelihood of nonlinear distortion in the noise fields of supersonic jets. This simplified approach relies on an isolated view of a ray tube along the Mach wave angle. It is known that the acoustic pressure obeys by cylindrical spreading in close vicinity to the jet before advancing to a spherical decay in the far-field. Therefore, a 'piecewise-spreading regime' model is employed in order to compute effective Gol'dberg numbers for these jet flows. Our first-principal approach suggests that cumulative nonlinear distortion can only be present within 20 jet exit diameters along the Mach wave angle when laboratory-scale jets are being considered. Effective Gol'dberg numbers for full-scale jet noise scenarios reveal that a high-degree of cumulative distortion can likewise be present in the spherical decay regime. Hence, full-scale jet noise fields are more affected by cumulative distortion.

**809 Using Post analysis of a noise sample stream in place of noise monitor based thresholds in the detection of aircraft noise**

*Harding Ferrier, Myles (1); Ferrier, Douglas (1)*  
(1) Brüel & Kjær EMS, Australia

**ABSTRACT**

Aircraft noise monitoring systems typically use a fixed threshold on noise monitors for varying times of the day to define what periods of time are to be analysed as possible aircraft noise events. The setting of thresholds leads to significant drawbacks in the continuous measurement of aircraft noise such as:  
☐ Missed aircraft noise due to the threshold being above quieter aircraft levels  
☐ Non aircraft noise being associated as aircraft noise  
The experience and capability of personnel that are responsible for the monitoring therefore become paramount in adapting to a continually changing sound environment to ensure reasonable accuracy in reporting aircraft noise. The objectives of the research undertaken by B&K has been to improve the accuracy of recorded aircraft noise and to minimise reliance on personnel, by replacing threshold based measurements with a recursive searching algorithm based on post analysis of a noise sample continuum. The outcome of this work has resulted in an aircraft noise event extraction methodology which mitigates the aforementioned drawbacks of existing systems while

minimising the dependency on personnel operating aircraft noise monitoring systems.

#### 766 Acoustic characteristics of annular jets

*Bellidega, Krishna Chaitanya (1); Dhamanekar, Abhijit (1); Srinivasan, K (1)*  
(1) Indian Institute of Technology Madras, India

##### ABSTRACT

Annular jets are widely used in gas turbines and burner due to stability over free jet; it introduces highly strained, recirculated turbulent flows and low NO<sub>x</sub> emissions. Present article compares acoustic features of annular jets formed with different blockage area and free jet. This study is carried out for nozzle pressure ratio (NPR) varying from 1.5 to 5. Various noise parameters such as turbulent noise, broadband shock associated noise and screech are compared separately. It is found that increase in blockage area reduces the overall noise except small region and occurrence of screech shifts to higher NPR. Addition to this directivity study is carried out for specific NPR. Further flow visualization is carried out to support acoustic data.

#### 4 Severity assessment of circular orifice synthetic jet based on sound pressure level

*Kanase, Mahesh (1); Mangate, Laxmikant (1); Chaudhari, Mangesh (1)*  
(1) Vishwakarma Institute of Technology Pune, India

##### ABSTRACT

Severity Assessment from the viewpoint of noise exposure is the preliminary stage for application of noise reduction technique to solve noise problems. In this paper, the severity assessment of circular orifice synthetic jet is presented based on sound pressure level. Synthetic jet generates substantial noise when operated in air as surrounding fluid. The effect of orifice diameter, orifice height and excitation voltage on sound pressure level of circular orifice synthetic jet is experimentally documented here. The excitation frequency to the synthetic jet actuator for the present study is 100 – 700 Hz. This parametric study is valuable from viewpoint of selection of synthetic jet configuration without violating Environmental Protection Agency standard and for obtaining maximum jet velocity and minimum sound pressure level. Keywords: Synthetic Jet, Acoustic Test Chamber, Sound level meter

**Wednesday 08:40-10:20 Room 215**  
**W1 Instrumentation**  
**Chair: Sebastian Oberst**

#### 670 Controlling Cyanobacteria with ultrasound

*Leclercq, Damien J J (1); Howard, Carl (1); Hobson, P (2); Dickson, S (2); Zander, Anthony C (1); Burch, M (2)*  
(1) University of Adelaide, Australia; (2) SA Water, Australia

##### ABSTRACT

Cyanobacteria present a risk to drinking water supplies when large blooms occur in reservoirs in warmer months. High concentrations affect water quality, increase risk to public health, and present a significant financial liability to water

utilities, which must meet stringent standards. The treatment of cyanobacterial blooms has traditionally been carried out using copper algicides, which also affect non-target species and can result in metal residue in the reservoir sediments. As an alternative, ultrasound treatment has been the subject of research, and treatment units are commercially available. This paper presents a brief review of the scientific literature and published field trial reports, a desktop analysis of patents and commercial brochures, and a review of the limitations that the technology is currently facing.

#### 450 Report of low power noise monitoring system using solar panel

*Sato, Naru (1); Kazama, Ryosuke (1); Ohya, Masaharu (1)*  
(1) RION, Japan

##### ABSTRACT

Last year, we have reported an overview of a new compact noise monitoring system of low power consumption with solar cell, multi-point noise monitoring system in wide areas, to monitor such as environmental noise, road traffic noise and aircraft noise. We report experiment results with the system in detail. The system is different from a conventional system in point of charging the battery with solar power. Therefore, we conducted experiments on acoustic effects of the solar panel. Also, we measured the temperature inside of the system and the outside air temperature, and examined what battery to use by the system.

#### 50 An innovative signal processing technique for the extraction of ants' walking signals

*Oberst, Sebastian (1); Enrique, Nava Baro (2); Lai, Joseph C S (1); Evans, Theodore A (3)*  
(1) UNSW Australia, Australia; (2) Departamento de Ingeniería, UNSW Australia, Australia de Comunicaciones, ETSI Telecomunicación, Campus de Teatinos s/n, Universidad de Málaga, 29071 Málaga, Spain; (3) National University Singapore, Singapore

##### ABSTRACT

Eusocial insects such as bees, ants and termites communicate multi-modally using chemical, visual, tactile and vibrational cues. While much work has been done on chemical and visual communications, the tactile and vibrational communication channel is somewhat neglected. Recent research indicates that structural vibrations caused by ants can be used to identify their activity level. However, these structural vibrations are caused by the response of the substrate excited by ants walking. The objective of this study is to determine the footprint of ants walking by separating the response of the substrate from the walking signal. The vibration of the substrate (in this case, a wooden veneer) caused by ants walking is measured by a laser vibrometer in an experimental setup isolated from environmental vibrations. By filtering the recorded vibration signal using a technique based on the dynamics in phase space followed by deconvolution from the response of the veneer using TIKHONOV regularisation, the ant's walking signal is extracted and its nature determined.

**503 Measurement Examples of a New Wireless Measuring System**

*Yonemoto, Yuichi (1); Kurosawa, Yu (1); Nakajima, Yasutaka (1); Ohya, Masaharu (1)*  
(1) Rion Co., Japan

**ABSTRACT**

There are various demands of multi-point measurements in measurements of noise and vibration. We have developed a new wireless measuring system. The system has functions such as one-third octave band analysis, Fast Fourier transform analysis, waveform recording in one single instrument, which provide an intuitive operation with a touch panel for users. Wireless multi-point measurement doesn't need any cable connection which significantly reduce time and cost required for real situations. We report some measurement examples in a field such as road traffic noise measurement and architectural acoustic measurement with the new measuring system and effects of wireless measurement compared with conventional measurement methods.

**153 Infrasound sensors and their calibration at low frequency**

*Larsonnier, Franck (1); Uszakiewicz, Hans-Günter (2); Mende, Michael (2)*  
(1) CEA, France; (2) SPEKTRA, Germany

**ABSTRACT**

Considering acoustic metrology in the infrasound field, sensors design and their calibration at low frequency is a challenge. The CEA designs for several years infrasound sensors named microbarometers MB2000, MB2005 and now the new one MB3, uses them in international networks like for the Comprehensive Nuclear Test Ban Treaty Organization (CTBTO) and maintains them in operational condition. Their response is calibrated during their operational life to ensure that they fulfill their metrological requirements using an infrasound calibrator designed by CEA. Furthermore thanks to the CS18 SPL-VLF infrasound calibration system developed by SPEKTRA, a measurement comparison has been performed in the frequency bandwidth [1 Hz; 20 Hz] with a new MB3 and a MB2005 microbarometer. The authors present the infrasound microbarometer sensors, the two calibration devices and the associated measurement results.

**Wednesday 08:20-10:40 Room 214**  
**H5 Numerical methods for predicting outdoor sound propagation**  
**Chair: Maarten Hornikx**

**164 Effect of input data in the impact studies of road traffic noise in a time-domain model**

*Guillaume, Gwenaél (1); Gauvreau, Benoit (1)*  
(1) Lunam Université, France

**ABSTRACT**

The design of efficient screens for preventing noise exposure close to road lanes with high traffic flow is both a technical and an economical stake. This design (including material properties) is usually carried out upstream to in-situ realizations through

numerical predictions. However, the uncertainties concerning the input data can lead to strong discrepancies in SPL predictions that are not considered in such impact studies. For instance, the modelling of the road traffic flow stands for a key point. Likewise, the surfaces properties (ground, screens materials, etc.) and the atmospheric conditions (inside and outside the urban canopy) can affect the sound propagation at relatively short distance when considering urban areas. Those scientific topics are currently under consideration in the framework of a french national project called EUREQUA. Thus, the present work treats about this project results by focussing on the effect of such input data in a time-domain model based on the transmission line matrix method.

**529 Incorporating directivity in the Pseudospectral time-domain method by using spherical harmonics**

*Georgiou, Fotis (1); Hornikx, Maarten (1)*  
(1) Eindhoven University of Technology, The Netherlands

**ABSTRACT**

A technique to incorporate directivity in the Pseudospectral time-domain method (PSTD) for auralization purposes is presented. The Pseudospectral time-domain method is a numerical method for solving the wave equation that requires only two spatial points per wavelength, making it more efficient compared to other wave based methods. The effect of source directivity as well as the head-related directivity have a clear influence on the perceived sound field and have to be included for the purpose of auralizations. In the less efficient finite difference time-domain method, directivity has been incorporated. Thus far, no such developments to incorporate directivity in PSTD have appeared. In this paper, directivity has been modeled by composing initial spatial distributions from spherical harmonic profiles and with the use of filters in order to achieve a frequency dependent directivity. The method is described in detail, drawbacks of the method and suggestions for further improvements are included.

**461 Three-dimensional wave-based simulation of outdoor sound propagation using the constrained interpolation profile method with a variable-grid technique**

*Ishizuka, Takashi (1); Okubo, Kan (2)*  
(1) Shimizu Corporation, Japan; (2) Tokyo Metropolitan University, Japan

**ABSTRACT**

In the present report, a variable-grid technique for the CIP (constrained interpolation profile) method is applied to three-dimensional wave-based simulation of sound propagation in an outdoor field. This technique is based on the sub-grid technique and provides a procedure for dynamic setting of subgridded areas according to wave propagation to achieve high accuracy with low computational costs. The effectiveness of proposed technique is examined in a practical outdoor field including a complex topography and a building. Sound propagation in the three-dimensional outdoor field and how the subgridded areas follow waves are visualized and shown. The examinations reveal that proposed technique has almost the same accuracy with that the normal CIP simulation with a finer uniform-grid system has. Also, the simulation applying the variable-grid system requires about one-fourth of computer memory and one-fifth of computational time relative to those the normal finer simulation requires.

**222 Noise propagation simulation in and around buildings using improved integral energy equations**

*Masuda, Kiyoshi*  
Taisei Corporation, Japan

**ABSTRACT**

If the calculation conditions for noise propagation in and around buildings are perfectly simple, the image-source method or ray-tracing method can be applied. However, conditions in reality are too complicated to apply these methods, because the combination of multiple reflections and diffraction must be taken into account. We have developed an extended integral energy equation method to solve these problems. In the extended integral energy equations, all energy flows between the boundary elements of a calculation model are obtained by solving simultaneous equations that take multiple reflections, multiple diffractions and sound transmission into consideration. To improve the precision of the method, the calculation of first reflections is separated from the calculation of multiple reflections, and the first reflections are calculated by the approximated method derived from the wave theory. This method is applied to the calculation of sounds transmitted through small openings. Predictions using this method corresponded well with measurements from actual sound fields.

**5 Calculation of Acoustic Green's Function using BEM and Dirichlet-to-Neumann-type boundary conditions**

*Harwood, Adrian R G (1); Dupère, Iain D J (1)*  
(1) University of Manchester, UK

**ABSTRACT**

Hybrid computational aero-acoustic (CAA) solution schemes rely on the knowledge of a scattering function known as a Green's function to propagate source fluctuations to the far-field. Presently, these schemes are restricted to relatively simple geometries. We present here a computational method for evaluating Green's functions within more geometrically complex regions, as a means of extending the versatility of existing hybrid schemes. The direct collocation implementation of the Boundary Element Method used in truncated, semi-infinite domains, introduces additional unknowns on the boundary. In this paper we develop a modified boundary element formulation to efficiently incorporate approximate Non-Reflecting Boundary Conditions for an arbitrary number of truncation boundaries. The boundary condition is based on the Dirichlet-to-Neumann mapping operator. Results are compared to known analytical Green's functions for an infinite pipe as a means of validating the new code. The method achieves relative errors of less than 1% compared with the analytical solution for the highest mesh density tested. Execution time, known to be large for acoustic problems, is minimised through the use of multi-threading.

**195 Acoustic Green's functions using the Sinc-Galerkin method**

*Harwood, Adrian R G (1); Dupère, Iain D J (1)*  
(1) University of Manchester, UK

**ABSTRACT**

Green's functions represent the scattering behaviour of a particular geometry and are required to propagate acoustic

disturbances through complex geometries using integral methods. The versatility of existing integral methods of acoustic propagation may be greatly increased by using numerical Green's functions computed for more general geometries. We investigate the use of the Sinc-Galerkin method to compute Green's functions for the Helmholtz equation subject to homogeneous Dirichlet boundary conditions. We compare the results to a typical boundary element method implementation. The Sinc-Galerkin procedure demonstrates improved performance on a number of configurations tested in comparison to the BEM. In particular, accuracy comparable to BEM can be achieved in far less time while being less sensitive to both frequency and source position, although the BEM captures the tip of the singularity more completely. The characteristic exponential convergence, as expected, is slower than many Sinc-Galerkin applications due to the presence of the domain singularity typical of Green's functions.

**976 Comparison of the results of numerical and geometrical outdoor acoustic simulations in a real-life area**

*Hoshi, Kazuma (1); Oshima, Takuya (2); Hiraguri, Yasuhiro (3)*  
(1) Nihon University, Japan; (2) Niigata University, Japan; (3) Tokuyama College of Technology, Japan

**ABSTRACT**

Authors are developing a real-life outdoor finite-difference time-domain (FDTD) acoustic simulation using land cover acoustic characteristics. On Inter-noise 2012 and 2013, the identification method of land surface from airborne hyperspectral imagery was presented. Additionally, the identified surface characteristics are given to finite-difference time-domain outdoor acoustic simulations in a real-life area and the calculation results was reported. In present study, the calculation results of previous report are compared with that of using geometrical acoustic simulation.

**Wednesday 08:20-10:20 Room 213**  
**Q4b Vibration and vibro-acoustic experiments**  
**Chair: Stephen Conlon, Nourredine Atalla**

**456 Experimental study on sound transmission in condenser**

*Kong, Weitao (1); Xu, Wang (1); Ming, Pingjian (1); Liu, Gongmin (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

Even though there are lots of work studying acoustic resonance in tube bundles, the sound transmission rules barely got researchers attention. And most papers published assume that there is no interaction between the acoustic and structure modes. This paper tries to realize how sound source affects the acoustic transmission and whether the acoustic resonance could couple with the structure. A series of tests on model condensers were conducted. Results show that sound source at steam inlet contributes the most to the sound level of water outlet. And the acoustic resonance could couple with the structure. Besides, the transmission of sound is dominated by the structure.

**361 Vibration analysis based on time-frequency analysis with a digital filter: Application to nonlinear system identification**

*Itoh, Yoshiaki (1); Imazu, Taku (2); Nakamura, Hiroki (3); Yamazaki, Toru (3)*

(1) Kanagawa Industrial Technology Research Institute, Japan; (2) Graduate Student, Kanagawa University, Japan; (3) Department of Mechanical Engineering, Kanagawa University, Japan

**ABSTRACT**

The main purpose of this study is to model and identify the mechanical systems from their output signals of vibrations. The time-frequency analysis method based on infinite impulse response (IIR) digital filter technology is applied to identify nonlinear vibrations. In our previous research, the advantage of the time-frequency analysis procedure over FFT analysis was shown. Here, as a typical weakly nonlinear system, we discuss the time-frequency analysis of the Duffing equation. The time-frequency analysis results and the appropriate analytical solution are compared at steady state. Then, the numerical solutions of the Duffing equation for transient and non-stationary states, including passage through resonance phenomena, are examined with the use of the time-frequency analysis. Furthermore, the basic concept for an application to nonlinear system identification by the time-frequency analysis is discussed.

**60 The actuality of acousto-mechanical resonances for noise control**

*Vinokur, Roman*

ResMed Motor Technologies, USA

**ABSTRACT**

A clarifying analytical study was done for the 2-DOF acousto-mechanical system modeled as the Helmholtz resonator with elastic vibrating bottom. Generally, such a system has two resonances that can generate and radiate an annoying tonal noise. As shown, the two resonance frequencies may get very close with mutual amplification and even merge together into one powerful resonance (a close-form equation describing this transition was derived). Such an effect can happen because the mass of air in the neck and the rigid mass may differ in several orders of magnitude. This is less possible in 2-DOF mechanical systems where the masses of both vibrating rigid bodies are commonly within one order of magnitude. The results may be helpful in particular for noise identification and reduction in blowers and other air moving devices. Here, the role of a vibrating bottom is played by the impeller in combination with the rotor and suspension system, and the air inlet (or outlet) serves as the Helmholtz resonator neck. Low-frequency acousto-mechanical resonances can also occur in rooms with open windows or doors.

**312 A new high-frequency impedance tube for measuring sound absorption coefficient and sound transmission loss**

*Kimura, Masateru (1); Kunio, Jason (2); Schuhmacher, Andreas (3); Ryu, Yunseon (3)*

(1) Brüel & Kjær Japan, Japan; (2) Brüel & Kjær North America, USA; (3) Brüel & Kjær Sound & Vibration Measurement, Denmark

**ABSTRACT**

A high-frequency Impedance Tube (HF Tube) that can measure acoustic performance (sound absorption coefficient and sound transmission loss) up to 12.8 kHz was developed. This frequency range has become important due to trends in the automotive and cell phone industry. The trend toward more electric and hybrid vehicles has brought about new noise sources and challenges. One in particular is electrical inverter noise in the 10 kHz range, which is one of the dominant noise sources in these vehicles. In cell phone and smart phone applications, the trend is to improve telephone speech quality. High frequency audible noise has a major influence on perceived quality. Previously, conventional impedance tubes (for example the Brüel and Kjær Type 4206) could not evaluate acoustic performance in the frequency range of 8~10 kHz. The usable frequency range of the standard tube was limited to 6.4 kHz based on the microphone spacing and tube diameter. Therefore, based on ASTM E1050/ISO 10534-2 standard (for sound absorption coefficient) and ASTM E2611 standard (for sound transmission loss), a newly developed HF Tube allows for measurements of acoustic performance up to 12.8 kHz. The tube was designed with a 15 mm inner diameter and 11.9 mm microphone spacing. It was designed to use Brüel & Kjær's 1/4 inch microphones and pre-amplifiers, Type 4187/2670, from the conventional impedance tubes. In this paper, the HF Tube was verified by measurements on an air cavity (empty tube) and some acoustic absorber materials with the results compared with the conventional impedance tubes.

**337 Broadband dynamic parameters measurement by longitudinal vibration testing using pulse wave**

*Hou, Hong (1); Wei, Zhengyu (1); Dai, Yang (1); Yang, Jianhua (1)*

(1) Northwestern Polytechnical University, China

**ABSTRACT**

Paper presents a method to measure the dynamic parameters of viscoelastic material bar by the longitudinal vibration testing in a wide frequency range. In the measurement, one end of the bar is driven by a transducer using a pulse wave and the other end is allowed to move freely. The vibration velocity of the free end of the bar is measured by a laser Doppler vibrometer. The dynamic parameters are calculated from the vibration velocity ratio between the long bar and the short bar over a wide frequency range since the driven signal of the pulse wave is a broadband signal.



**824 Improving the sound insulation of construction boards with a high damping glue**

*Kinnari, Lasse*  
NMC, Finland

**ABSTRACT**

Lightweight building boards are being commonly used in various wall and floor structures because of their easy use and low costs. The sound insulation of a single board alone is not good enough so the constructions are mainly composed of multilayered structures. The thickness and weight of the structures are being minimized while the sound insulation properties should be optimized as well. With light weight building boards such as plaster boards, wood based boards and minerits, one constraining problem is the coincidence phenomenon. The dip in the sound insulation properties is quite deep, depending on the board properties, and it is located at the important frequency area concerning human perception. With visco-elastic high damping epoxy layer used in multilayered constructions, it's possible to get rid of the dip and increase the sound insulation above the critical frequency by several decibels. With the use of epoxy-based viscoelastic, high damping glue the sound insulation tests of plywood structures show that without any significant add of mass the total RW can be improved 2...4 dB and above critical frequency even 7...8 dB improvements are seen.

**Wednesday 08:40-10:40 Room 212**  
**Q5 Vibro-acoustics of lightweight composite panels**  
**Chair: Stephen Hambric, Steffen Marburg**

**462 Sound radiation from the waveguide double plate regarding air cavity between the upper and lower plates**

*Kim, H (1); Ryue, J (1)*  
(1) University of Ulsan, South Korea

**ABSTRACT**

In this study, the vibration and sound radiation from the double-layered strip plate with air cavity between the upper and lower plates are investigated by using the waveguide finite and boundary element method. The interaction between the structural and acoustic waves propagating along the double-layered strip plate is investigated by observing the dispersion relations of the waves. The vibration and sound radiation from the double-layered strip plate with and without the air cavity are compared. From this study, the interaction between the structural and acoustic waves appear in the dispersion curves due to the air cavity. The large variations of the vibration and radiated power between the unstiffened and stiffened double plates are observed due to the air cavity. As the stiffeners are added, however, its contribution becomes less.

**2 Quieting a rib-framed honeycomb core sandwich panel for a rotorcraft roof**

*Hambric, Stephen (1); Shepherd, Micah (1); Snider, Royce (2); May, Carl (2)*  
(1) Penn State University, USA; (2) Bell-Textron, USA

**ABSTRACT**

A rotorcraft roof sandwich panel has been redesigned to optimize sound power transmission loss (TL) for frequencies between 1 and 4 kHz. The roof section, framed by a grid of ribs, was originally constructed of a single honeycomb core/composite facesheet panel. The original panel, characterized in [1], has coincidence frequencies near 700 Hz, leading to poor TL across the frequency range of 1 to 4 kHz. To quiet the panel, the section was split into two thinner sandwich subpanels separated by an air gap. The air gap was sized to target the fundamental mass-spring-mass resonance of the panel system to less than 500 Hz. The panels were designed to withstand structural loading from normal rotorcraft operation, as well as 'man-on-the-roof' static loads experienced during maintenance operations. Thin layers of VHB 9469 viscoelastomer from 3M were included in the facesheet ply layups, increasing panel damping loss factors from about 0.01 to 0.05. The optimized panel is expected to provide more than 10 dB transmission loss improvement at critical rotorcraft transmission tonal frequencies.

**905 Patterned fibre constrained layer damping for composite materials**

*Verstappen, Andre P (1); Pearse, John R (1)*  
(1) University of Canterbury, New Zealand

**ABSTRACT**

Vibration damping is an important consideration in the design of fibre reinforced composite structures as these stiff, lightweight materials often have undesirable vibration transmission characteristics. If not properly addressed, high vibration levels can propagate throughout a composite structure, leading to significant noise levels and reductions in equipment longevity. It is possible to incorporate viscoelastic damping layers into a composite laminate's construction to achieve improved damping properties. Inclusion of embedded viscoelastic layers results in a constrained layer damping configuration, where the damping capacity is governed by the shear strain in the damping layer. A new composite damping arrangement is proposed where patterned fibre constraining layers are used to increase damping capacity of a viscoelastic mid-layer by inducing additional shear strains. This paper details the design of materials in such a configuration, and the methods used to fabricate and test the damping performance of these patterned fibre constrained layer damping treatments.

**875 Dynamic Laminate Model for Broadband Frequency Prediction**

*Borello, Gérard (1); Duval, Arnaud (2)*  
(1) InterAC, France; (2) Faurecia, France

**ABSTRACT**

Orthotropic multi-layered panels are well-spread in transport industry. Specific methods of prediction need to be addressed depending on construction. Laminate models based on zig-zag theory are useful for aircraft fuselage prediction and more

generally for composite panels. As soon as a very soft layer is inserted between stiff layers, breathing modes are occurring in mid and high frequencies and assumed zig-zag displacement field is no more representative of the actual behavior. It has to be replaced by 3D FEM modeling increasing cost of calculation. In Statistical Energy Analysis (SEA) models, because of the extended calculation range, the 'classical' laminate equations are limiting the class of simulated systems and zig-zag theory is most often pushed outside its natural limits. A new multi-scaled dynamic laminate model has thus been developed to take into account transverse decoupling of layers while converging correctly to equivalent static plate at low frequency. This laminate model accepts any kind of mechanical orthotropic layers as well as thin 2D acoustic layers. They may be ribbed or not to increase stiffness. Damping loss factor of the assembly is predicted from internal damping of the various layers. Basic equations will be presented as well as some early validation work.

**1007 Global sensitivity analysis of acoustic transmission models**

*Christen, Jean-Loup (1); Ichchou, Mohamed (1); Troclet, Bernard (2); Ouisse, Morvan (3)*  
(1) École Centrale de Lyon, France; (2) Airbus Defence and Space, France; (3) FEMTO-ST, France

**ABSTRACT**

Optimization of noise reduction inside cavities is a particularly important topic in the aeronautic and space industries, as the very high noise levels outside the vehicle can cause passenger or payload comfort issues, introducing the need for sound packages. With the increasing use of composite materials in aerospace structures, acoustic transmission models may become quite complex and depend on numerous material or geometric parameters, in a broadband frequency range. It is therefore interesting to identify the most influential of these parameters in order to reduce the computing cost associated with any optimization task on these models. Sensitivity analysis methods can be used for this purpose. As the parameters may vary in broad design ranges, interactions between them may arise, making the use of global methods such as analysis of variance relevant. An application of the Fourier amplitude sensitivity test (FAST) to acoustic transmission models through multilayered composite plates are presented in this paper. Outcomes are consistent with classical results such as mass law, and new interpretations are presented in the case of plane wave and diffuse field excitation.

**404 Numerical modelling and experimental determination of the dynamic behaviour of composite structures**

*Cohen, Brandon (1); Dylejko, Paul (2); Moore, Stephen (2); Phillips, Andrew (2)*  
(1) RMIT, Australia; (2) DSTO, Australia

**ABSTRACT**

Composite materials are finding increasing application in mechanical systems because of their desirable physical characteristics compared with metals; for example, high strength- and stiffness-to-weight ratios, and the potential for constructing complex shapes without joints or extensive machining. In addition, the dynamic behaviour of composite structures can be manipulated by judicious selection of their constituent materials and structural features. This study

investigates the dynamic behaviour of fibre-reinforced polymer hydrofoils using finite element analysis and experimental modal analysis. Four hydrofoils were made from different combinations of carbon, glass and aramid fibres to assess the influence of fibre type and fibre orientation on the hydrofoil's dynamic response. Numerical and experimental results showed good agreement for low-order modes. However, the results highlighted difficulties in determining higher-order modes accurately in both the numerical and experimental investigations. Fibre type and orientation were shown to appreciably affect the dynamic properties of the hydrofoil.

**Wednesday 08:20-10:20 Room 211**

**K1a Noise barriers**

**Chair: Jean Piere Clairbois, Crina Oltean-Dumbrava**

**943 Sustainability Criteria for standardisation of noise reducing devices**

*Oltean-Dumbrava, Crina (1); Clairbois, Jean-Pierre (2)*  
(1) University of Bradford, UK; (2) A-Tech / Acoustic Technologies, Belgium

**ABSTRACT**

This paper presents an overview of generic database of sustainability criteria values for a range of noise reducing devices (NRDs) for surface transport developed as part of the research carried out in the EU project "Quieting the Environment for a Sustainable Surface Transport" (QUIESST) (1) and how these criteria can be used for sustainability assessment of noise barriers standards. The NRD Industry has been involved in this research and NRD's manufacturers have always shown a great interest in sustainability assessment. This is coupled with the new Construction Product Regulation (305/2011/EU -CPR) (2) that came into force in July 2013 that promotes a new approach in products qualification based on the declaration of performance against seven essential requirements. Sustainability has been specifically addressed with the new 7th basic requirement, 'sustainable usage of natural resources'. The method developed within this research is used to define evaluation procedures to meet sustainability as the 7th basic requirement as part of new standards.

**716 The frequency and angular dependence of the absorption coefficient of common types of living plants**

*Prisutova, Jevgenija (1); Horoshenkov, Kirill (1); Groby, Jean-Philippe (2); Brouard, Bruno (2)*  
(1) University of Sheffield, UK; (2) l'Universit'e du Maine, France

**ABSTRACT**

The frequency and angular dependence of the absorption coefficient of specimens of several types of plants used in living walls and noise barriers is investigated. The reported data are obtained by placing the specimens in a large impedance tube which frequency range has been extended significantly beyond the frequency of the plane wave regime. The multi-modal sound pressure field in the tube is measured with a microphone array. A theoretical model is adopted to determine the reflection coefficients for the individual modes. This information is used to estimate the frequency and angular

dependent absorption coefficient for the plant specimens. The absorption coefficient data are compared against the predictions made with an equivalent fluid model which is based on the leaf area density and dominant angle of leaf orientation.

#### 482 Lightweight noise barrier

*Ho, Wilson (1); Wong, Wylog (1); Naveed, Yasir (1)*  
(1) Wilson Acoustics Limited, Hong Kong

##### ABSTRACT

Conventional noise barriers of 3m to 6m height either have a structural foundation or a heavy base in order to sustain occasional and short-lived heavy wind loading from gusts. The lightweight noise barrier, currently on trial for construction noise control in Hong Kong, employs an automatic mechanism to relieve such occasional excessive wind load. Therefore, the structural loading requirement is reduced to approximately 1/10 of conventional noise barriers and a lightweight structure with density less than 4kg/m<sup>2</sup> (including structure but excluding base) and height of up to 8m can be achieved. Noise insulation panels are designed to be installed upwards from ground level without the use of cranes. Components within 1.35m width and 2m height are designed in modular form for easy transportation and erection. The entire installation process of one 8m high barrier unit can be completed within 15 minutes by two people and it is quiet enough to be conducted at night. Noise barrier structure is mounted to a simple metal frame or a water barrier with 1m to 2m wide extended base. Insertion loss of 12 to 20dB(A) were tested.

#### 500 A study on sound insulation using rectangular plenum chamber arrays

*Lee, Seong-Hyun (1); Kim, Sang-Hoon (2)*  
(1) Korea Institute of Machinery & Materials, South Korea; (2) Mokpo National Maritime University, South Korea

##### ABSTRACT

For an energy-efficient and environmental-friendly building, natural ventilation has become an increasingly attractive method. Traditional windows and barriers are not suitable for a natural ventilation, because leaks decrease acoustic performance. Resonators in duct systems have been extensively used in many industrial fields to reduce noise and air can flow through them. If concepts of resonators applied to noise barriers, air can propagate through them and noise cannot. Resonators could be tuned with varying parameters because acoustic performance can be determined by dimensions. In this study, rectangular plenum chamber arrays were used as noise barriers. To improve sound insulation, parametric study and higher order modes wave propagation analysis were performed. For application examples, noise barriers using plenum chambers were made and the sound transmission loss was measured using mini-scaled reverberation chambers. The measured transmission loss showed good agreements with a theoretical prediction.

#### 91 Three dimensional quasi-periodic noise barriers

*M B Fard, Samaneh (1); Peters, Herwig (1); Kessissoglou, Nicole (1); Marburg, Steffen (2)*  
(1) UNSW, Australia; (2) Munich, Germany

##### ABSTRACT

Two dimensional noise barrier studies investigate the insertion loss in the shadow zone of an infinite noise barrier for a coherent line source. Such models are often preferred to avoid the high computational cost of three dimensional models. The major limitation of two dimensional barrier models is the constant cross section of the barrier in the third direction. This paper presents a new solution to evaluate the performance of 3D noise barriers that do not have a constant cross section. A quasi-periodic noise barrier model is developed to reduce the size of a 3D infinite boundary element model and thereby reduce the computational time. Different quasi-periodic noise barrier designs are developed and their acoustic performance at different frequencies and receiver positions are compared.

#### 1000 Transformation of sound by a phononic crystal

*Côté, Nicolas (1); Vasseur, Jérôme (2); Souron, Quentin (1); Hladky-Hennion, Anne-Christine (1)*  
(1) IEMN, UMR 8520 CNRS, ISEN Department, France; (2) IEMN, UMR 8520 CNRS, Cité Scientifique, France

##### ABSTRACT

Several noise barriers made of phononic crystals (i.e. manmade composite materials with a periodic structure) have been designed over the last decade. The periodic structure of phononic crystal avoids sound propagation in a defined frequency range called Bragg band gap (i.e. waves are evanescent). This study aims at quantifying the perceptual impact of a noise barrier based on a phononic crystal in terms of noise annoyance attenuation. First, a specific phononic crystal has been designed to study timbre modifications. Then, a combined acoustics/auditory analysis of noise barrier made of a phononic crystal is employed. The acoustic analysis consists in numerical simulations and measurements of acoustical scenes. In addition, several psychoacoustics parameters are estimated from the synthesized/recorded acoustic signals. In details, two specific timbre features are studied: the spectrum and temporal modifications of the sound source.

**Wednesday 08:40-10:20 Room 210**  
**N9a Impact noise in buildings**  
**Chair: Berndt Zeitler, Atsuo Hiramitsu**

**747 Subjective evaluation of floor impact sound of wood-frame construction dwellings in different living situation**

*Sato, Hiroshi (1); Hirota, Tomohito (2); Hiramitsu, Atsuo (3); Tanaka, Manabu (4)*

(1) National Institute of Advanced Industrial Science and Technology, Japan; (2) Hokkaido Research Organization, Japan; (3) National Institute for Land and Infrastructure Management, Japan; (4) General Building Research Corporation of Japan, Japan

**ABSTRACT**

This paper presents the subjective difference of floor impact sound of wood-frame floors with different floor-ceiling systems. All impact sounds of wood-frame floors were measured in reverberation chamber with standardized rubber ball. The impact sound of concrete floor was also measured. Sheffe's paired comparison method was used to obtain psychological scale values of each impact sound. The listening test confirmed that all wood-frame test floors are quieter than the RC floor, performance of larch plywood floor without resilient channel was lower than standard plywood floor but the performance of larch floor can be improved greatly with resilient channel. Furthermore, there are some cases those psychological scale value can differentiate conditions but the A-weighted maximum level cannot present differences between them.

**513 Uncertainties and validation procedures for the Compact Measurement Setup**

*Schmidt, Jan-Henning (1); Wittstock, Volker (1); Langer, Sabine C (2)*

(1) Physikalisch-Technische Bundesanstalt, Germany; (2) Technische Universität Braunschweig, Germany

**ABSTRACT**

By using a small floor mock-up, the impact sound reduction of floor coverings can be determined by measuring the difference of the acceleration levels instead of measuring a sound pressure level in a receiving room (ISO 10140). The setup is validated for locally reacting floor coverings and standardized within the ISO 16251-1. To decide whether the covering under test can be considered as locally reacting, a validation procedure was developed on the basis of the standard uncertainties of the differences for every measurement position. A further issue for the method is that the measurement equipment must be capable of handling the signals. To check this, the bare floor acceleration levels of existing compact setups are proposed to be used as a criterion. Both validation methods are compared to actual measurements. Furthermore, the uncertainties of a measurement at a compact setup are considered due to the method of the GUM. This estimate of the uncertainty is compared to uncertainties according to ISO 12999-1. Finally, standard deviations of measurement results obtained at different compact setups and results obtained with different tapping machines at the same compact setup are presented

which give an overview of the different uncertainty contributions.

**227 Field Floor Impact Noise South-East Queensland (Australia)**

*Huang, Eric Hsin-Cheng*

Palmer Acoustics Australia Pty Ltd, Australia

**ABSTRACT**

Floor impact noise is a significant inter-tenancy issue in high rise buildings. This paper, based upon over 10 years practical experience, provides an understanding of field floor impact insulation issues and discusses floor impact noise from hard flooring surfaces as it impacts into lower apartments, based on different floor finishes, type of underlay, thickness of concrete slab and ceiling construction. The standard test procedures and typical compliance limits are discussed with the analysis separated into two sections; the base building concrete slab (with and without ceiling) and different type of floor finishes with acoustic underlay. The ISO Standard methods used to assess floor impact insulation are discussed with a case study showing the performance of different floor systems (acoustic underlay samples) and different ceiling treatments. The paper concludes with a discussion of the implications of such noise for Body Corporate's and provides advice on ways in which they can mediate on floor impact noise matters.

**841 Floor impact sound insulation of timber three-story school building for final full-scale fire test**

*Hiramitsu, Atsuo (1); Hasemi, Yuji (2); Kaku, Teruhiko (3)*

(1) National Institute for Land and Infrastructure Management, Japan; (2) Waseda University, Japan; (3) Gendai Keikaku Kenkyujo Architects and Associates, Japan

**ABSTRACT**

There is a tendency that school buildings are constructed with timber construction, because the timber school buildings effectively improve the educational environment. However, the floor impact sound insulation of timber buildings often presents a problem. This paper reports the floor impact sound insulation of the timber three-story school building for final full-scale fire test. The results showed that the heavy-weight floor impact sound insulation using a car-tire source was Lr-65 or 66.2 dBA and the light-weight floor impact sound insulation was Lr-75 or 77.4 dBA. This three-story timber school building was of one-hour quasi-fire-resistive construction with "a reduced section design". Therefore, the building had large-sized girders and beams. Furthermore, the classrooms were arranged in "an open-plan type" with a large volume of sound-receiving room. From the results of the floor impact sound insulation, the effects of reduced section design and open-plan type are considered.

**755 Comparison of Resiliently Suspended Floating Slab Constructions**

*Downey, Paul (1); Byrick, Wilson (1); Bonnycastle, William (1)*

(1) CAA, Canada

**ABSTRACT**

Floating floor systems are commonly used in mechanical rooms, music practice rooms and other areas where rotating machinery and/or heavy impact sources create a need for

airborne and structure borne sound isolation. There are numerous technologies and construction methods used to create a decoupled or floating concrete slab condition. Through laboratory testing, a head-to-head analysis was completed to compare various systems including lift-slab, point isolation, and continuous compressible elastomeric technologies. All floor systems were tested on a 150mm (6") concrete slab, with a 100mm (4") topping slab. While the overall airborne (STC) and impact (IIC) ratings of the different isolation systems were similar, there are some significant variations at low and high frequencies. The effects of differing material properties between two generations of recycled rubber underlayment are also examined.

**Wednesday 08:40-10:20 Room 209**  
**D9a Mufflers and silencers**  
**Chair: Yatsze Choy, James McIntosh**

**989 Performance of multiple micro-perforated panels in a duct**

*Liu, Y (1); Choy, Yat Sze (1); Chiang, Yan Kei (1)*  
 (1) The Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

Generalized formulation is developed analytically to calculate the transmission loss performance of a silencer by using multiple micro-perforate panel (MPP) array silencers in ventilation duct system. The device, based on single MPP design, consists of different expansion chambers with the side-branch cavities covered by micro-perforate panels of different properties. The theoretical model can also be simplified to evaluate the performance for normal plate silencer. With a preliminary result of two normal plates, it shows that the plate silencer can offer a wide stop band of 3.5 from low to medium frequency range when the length ratio is 1 to 4. Compared with same total length of a single plate, the stop band is improved by 25%. For the MPP silencer under similar condition, the stop band is also increased by 16%. Apart from the considerable increment of stop band, the bending stiffness requirement is also released by 35% and 40% respectively.

**161 Improving muffler performance using simulation-based design**

*Cui, Fangsen (1); Wang, Ying (2); Cai, Richard Chao (3)*  
 (1) A\*STAR, Singapore; (2) Jinan DeJia Machine, China; (3) BWC, Singapore

**ABSTRACT**

It is well-known that the reactive type muffler gives effective noise attenuation at lower frequencies but fail to attenuate higher-frequency noise. On the contrary, dissipative type can absorb high-frequency noise but cannot reduce the low-frequency noise effectively. To combine the merits of each type, a hybrid muffler design was proposed and the performance could be improved in the frequency range of interest. To this end, computational acoustic models based on Boundary Element Method (BEM) were successfully developed for predicting Transmission Loss (TL) of exhaust mufflers which have perforated tubes backed with or without bulk sound absorbing materials (fibers). With these models, TLs of the muffler(s) proposed were simulated and evaluated. In addition,

simulation-based muffler analysis was carried out for parametrical studies of the muffler and efforts have been made to enhance TL in low frequency range.

**660 Acoustic performance of a plate with varying perforations**

*Wang, Xiaonan (1); Zhang, Weichen (1); Ying, Lechun (1)*  
 (1) Shanghai Academy of Environmental Sciences, China

**ABSTRACT**

A theoretical study of a plate with varying perforations is presented in this paper. The Bloch wave theory and the transfer matrix method are used to investigate the acoustic performance of the plate. It is found that different from the original attenuation characteristic of the plate with periodic perforations that brought about by structural periodicity, the varying perforations provides a unique structure performance. All of the results predicted by the theory fit well with a numerical simulation using a finite element method. As a result, the proposed structure may have a potential application in duct noise control under careful parameter design.

**184 Adaptive quarter wavelength tube tuned by varying air temperature**

*Doherty, Kieran (1); Larizza, Francesco (1); Tripodi, Matthew (1); Howard, Carl (1)*  
 (1) University of Adelaide, Australia

**ABSTRACT**

An Adaptive Quarter-Wavelength Tube (AQWT) that can be tuned by varying the air temperature was simulated with both a 90° notched and bell-mouth t-piece using Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA). The QWT was tested experimentally to determine the noise reduction that could be achieved at the fundamental firing frequency of an internal combustion engine (ICE). Electrical air heaters injected hot air into the QWT that varied the speed of sound of air and therefore varied the tuned length of the tube. Results showed that the fundamental firing frequency could be attenuated by approximately 5 dB over a 65-75 Hz range by varying the air temperature within the QWT.

**583 Potential of fibre-reinforced components for lightweight construction machines with low noise emission**

*Kolbe, Frank (1); Dannemann, Martin (1); John, Sebastian (1); Modler, Niels (1)*  
 (1) TU Dresden, Germany

**ABSTRACT**

The emission of sound and noise of machines especially for construction companies is increasingly considered as important. This is caused by the strict limitations of the overall noise emission on construction areas. Thus, machines with low noise emission are more and more required by the manufactures of construction equipment. Furthermore, construction machines have to be transported between different construction areas, wherefore they have to be light and easy to handle. Besides, a flexible and fast maintenance is required. A possibility to reach these targets is the use of modern fibre-reinforced composites with their adjustable property profile regarding stiffness, strength and sound emission [1]. Using the example of an upper side hood of a

cooling air outlet, the potential of glass fibre-reinforced composite was analysed. Besides the main focus of reducing the weight of the hood, the noise emission was considered in the design process. Starting with an analysis of the acoustical, thermal and mechanical behaviour of a reference hood made of steel, different fibre-reinforced concepts were developed. As a result, the usage of glass fibre-reinforced epoxy in combination with a material adapted design allows a reduction of the overall mass of the hood up to 85 %, achieving the requirements concerning stiffness, deformation, impact and sound. Based on the preliminary investigations, a prototype was built showing a significantly reduced weight. Subsequently, the prototype was installed at a construction machine and sound pressure measurements were done with both configurations. The resulting noise emission of the construction machine was kept constant and consequently additional noise absorbers got obsolete.

**Wednesday 08:40-10:00 Room 208**  
**F1a Noise events from transportation noise**  
**Chair: Lex Brown, Bert de Coensel**

**275 An overview of concepts and past findings on noise events and human response to surface transport noise**

*Brown, Alan Lex*  
 Griffith University, Australia

**ABSTRACT**

Noise events are well established in the measurement and management of aircraft noise. While there have been attempts to apply similar noise-event concepts to road and rail traffic noise signals for many decades, the idea has remained largely peripheral to the current paradigm of surface traffic noise measurement, assessment and management. The latter is based, almost exclusively, on metrics that utilize integrated energy of the traffic noise signal, or exceedance levels. This paper, as an introduction to a session that focuses on noise events from transportation noise, provides an overview of concepts and past findings on human responses of annoyance and interference with human activities, including sleep disturbance, that have been related to noise events and other pattern measures of the noise from surface traffic flows.

**31 The role of noise events in noise research, policy and practice (peaks, events or both...)**

*Van Kamp, Irene (1); Van Poll, Ric (1)*  
 (1) RIVM, The Netherlands

**ABSTRACT**

Commissioned by the Netherlands Ministry of Infrastructure and the Environment RIVM organized an expert meeting about reaction to sudden noise, and the way peak noise is dealt with in science, policy and practice. The aim was to exchange knowledge and ideas and formulate recommendations about situations with sudden high noise levels. Examples were presented from theory and practice, pertaining to road- and air traffic, high speed trains and impulse noise from pile driving and shooting. Acoustic aspects and moderating factors were discussed, such as unpredictability; trust in the government and expectations about future exposures. The main conclusion was that in most cases available noise-effect relations based on average weighted measures (Lden, Lnight) can be used.

Additional indicators are primarily needed to better communicate with the public on the impact of peak events; noise exposure levels, where possible and relevant, should be presented to the public in understandable measures such as events, duration and quality as well as the effects of interventions. When not communicated well, the number of complainants and percentage of highly annoyed will be high irrespective of the exact noise levels. This paper presents the highlights of the workshop, and more recent findings in relation to military air traffic and the role of peak levels on registry based health effects.

**101 Are noise events from surface transport predictable? Insights from a wide measurement campaign**

*Can, Arnaud (1); Guillaume, Gwenaël (1); Gauvreau, Benoit (1)*  
 (1) Ifsttar, France

**ABSTRACT**

The negative effect of road traffic noise events on annoyance is now established. However, the assessment and monitoring of road traffic noise remain mainly based on energetic indicators, which are easy to handle but mask noise dynamic structure. Recent developments in dynamic road traffic modelling, and in urban sensor networks, suggest that introducing noise events in urban noise management is possible. This however raises statistical questions: although their inherent random origin (very noisy cars, sirens, etc.) make them hardly predictable, noise events are probably site dependent. In this paper, we rely on a measurement campaign carried out in Toulouse (France), made of 20 1h-measurement periods covering both day and night time slots, to question some statistical matters relative to road traffic noise events. Firstly, some general reflections concerning candidate indicators for describing noise events are given, in line with road traffic noise dynamics. Then, a statistical method is proposed, which selects the frequency bands of interest, and then defines a set of indicators relevant to describe the urban soundscape of the site, in terms of noise events. Finally, some insights about the predictability of noise events are deduced from the spatial distributions of the selected set of indicators.

**208 A concept on predicting road network scale noise event probability by road function**

*Naish, Daniel A*  
 Independent Researcher, Australia

**ABSTRACT**

This paper presents a concept towards the development of a flexible method of predicting noise event probability across a road network using road function categories. The need for a flexible method is derived from the varying levels of data availability and data accuracy for different road authorities. A road authority should not be prevented in assessing noise events due to lack of highly detailed and accurate data. The benefits of a network scale method of predicting noise event probability include the ability to: (1) produce network scale noise event maps, (2) better conduct public health research, and (3) assess changes to the road traffic distribution across a network. These three listed benefits combined will allow application of localised transport-health research. The paper commences with a short review of literature and theoretical concepts, followed by an outline on the data and computational requirements for noise event probability

prediction. Analysis of sample road vehicle speed and classification data is conducted across varying road functions. The concepts behind a flexible prediction method are then presented along with a discussion on its potential application, limitations and benefits.

**Wednesday 08:20-10:40 Room 207**  
**R7 Numerical methods in underwater**  
**acoustics - Transmission**  
**Chair: Doug Cato**

**700 The influence of finely layered seabeds on acoustic propagation in shallow water**

*Duncan, Alec J (1); Gavrilov, Alexander N (1); Koessler, Matthew W (1)*

(1) Curtin University, Australia

**ABSTRACT**

Except in the deep ocean, the seabed has a major influence on low-frequency acoustic propagation. The formulation of an adequate geoacoustic model of the seabed is therefore one of the most important tasks facing anyone carrying out acoustic propagation modelling to predict underwater sound levels in coastal and continental shelf waters. It is often assumed that seabed layering on scales significantly smaller than the acoustic wavelength can be ignored when carrying out such modelling, and that these layers can instead be replaced by a simplified model involving a small number of layers in which the geoacoustic parameters vary smoothly with depth. This paper explores this assumption, with particular reference to the finely layered elastic seabeds typical of the Australian continental shelf. This investigation is based on a comparison of the plane-wave reflection coefficient vs grazing angle curves of these two representations of the seabed.

**387 Tidal effects on acoustic propagation off eastern Australia**

*Robertson, Robin (1); Hartlipp, Paul (1)*

(1) UNSW Canberra, Australia

**ABSTRACT**

Sound propagation in the waters off Eastern Australia is of keen interest to the Royal Australian Navy (RAN) as it affects sonar operation in one of their prime operating regions. Using temperature and salinity fields from an internal tidal model to determine horizontally and vertically dependent sound velocities, effects of internal tides on sound propagation were investigated along four latitude transects across the continental shelf into the deep basin off Eastern Australia. The sound velocity fields and individual acoustic ray paths varied during both the daily and spring-neap tidal cycles, although their basic characteristics were similar. The most noticeable tidal effects were for sound channel formation. More acoustic rays were present in the mid-water column sound channels over both the continental shelf and in the deep basin during spring tide than neap tide and there was a stronger latitude dependence on this number of rays. However, most of the metrics used to evaluate the acoustic rays did not show appreciable differences for either the spring-neap or the daily tidal cycles. There were strong dependencies of these metrics on latitude and source depth. Here, tidal effects on acoustic propagation appear

overpowered by effects from other features such as currents and eddies.

**390 Acoustic ray propagation in the waters off eastern Australia using ocean glider data**

*Clements, Jacqueline (1); Robertson, Robin (2)*

(1) UNSW Canberra, Australia, Royal Australian Navy, Australia;

(2) UNSW Canberra, Australia

**ABSTRACT**

The waters off Eastern Australia are very dynamic. The most prominent feature is the East Australian Current (EAC), a strong western boundary current, and eddies it spins off. Along with the EAC and its eddies, upwelling of cold waters, and wind and tide-induced mixing generate an active thermal environment in the coastal waters on the continental shelf. Additionally, internal waves, fronts, and continental shelf waves shifting water masses back and forth across the continental shelf/slope break add further complexity to the oceanographic conditions. Propagation of acoustic rays depends on the temperature field and is affected by these processes which influence the temperature structure. Using temperature and salinity data collected by ocean gliders transiting the waters off Eastern Australia, the dependence of acoustic ray propagation was investigated for several source depths. The formation of surface ducts, sound channels, and convergence were identified and correlated with oceanographic conditions and features. The acoustic rays' propagation depended both on these features and the sound source depth. Rays with high originating angles typically bounced back and forth between the surface and bottom; whereas rays from low originating angles were impacted more by the conditions. This is of key importance to navies for sonar operation.

**98 Further Considerations for Approximating a Physics-Based Model of Surface Reflection Loss**

*Jones, Adrian (1); Zinoviev, Alex (1); Bartel, David Wayne (1)*

(1) DSTO, Australia

**ABSTRACT**

Previously, the authors prepared a model of the coherent acoustic reflection loss at the ocean surface by combining an existing model of roughness loss with a description of surface grazing angle which accounted for the near-surface sound speed reductions due to an assumed distribution of wind-driven bubbles. More recently, the authors showed that the full derivation of surface incidence angle, which was based on an analysis by Brekhovskikh, could be approximated by a simple expression in terms of the physical parameters of the assumed model of bubble population, together with wind speed and frequency. In an extension to this work, the practical limits to the application of this approximated solution are examined, in terms of the wind speed-frequency combinations, and the range of grazing angles, for which it is adequate. The adequacy of the approximated model is tested by incorporating it within a Gaussian-beam acoustic propagation code and generating loss values for surface ducted transmission scenarios, to compare against data obtained by Monte Carlo runs of Parabolic Equation (PE) transmission calculations for which the sea surface is roughened and the near-surface sound speed reductions from the bubble distribution are included.

**294 The spatial structure of an acoustic wave propagating through a layer with high sound speed gradient**

*Zinoviev, Alex (1); Bartel, David Wayne (1)*  
(1) DSTO, Australia

**ABSTRACT**

A plane acoustic wave propagating through a high sound speed gradient layer in a liquid near a pressure-release surface is considered in detail. Analogously to the solution for the refraction of the incident plane wave obtained previously, equations describing the refraction of the reflected wave are derived. For the total acoustic field in the layer, dependencies of the pressure and the vertical particle velocity on the depth and frequency are calculated for several incident grazing angle values. It is shown that these dependencies have distinct features close to the acoustic duct cut-on frequencies. Near these cut-on frequencies, both pressure and vertical velocity have strong maxima along the frequency axis, whereas along the vertical spatial axis the two variables have alternate minima and maxima, the number of which increases with frequency. It is suggested that the maxima in the vertical velocity near the surface at the cut-on frequencies are responsible for the sharp maxima in the grazing angle at the surface in the incident wave. The latter maxima were demonstrated previously. The presence of the pressure maxima and minima within the layer is confirmed by calculations using the RAMSurf parabolic equation simulation code.

**156 A forecasting method for near-field scattering characteristics of underwater complex shells**

*Zhao, Anbang (1); Zhao, Zhishan (1); Zhou, Bin (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

In order to forecast near-field scattering characteristics of underwater complex shells with specific excitation quickly and efficiently, a simulation method using boundary element is proposed. Firstly, we compare the simulation results with theoretical results of rule models to verify the reliability of simulating rule models using software. Then the simulation results and tank experiment results of the complex shells are compared. It is proved that it is feasible to simulate the scattering characteristics of complex shells by using software. All the theoretical, simulation and experimental results indicate that this method could forecast the near-field scattering characteristics of underwater complex shells accurately, and it benefits further study of scattering field of complex shells.

**168 Results of the ray-tracing based solver BEAM for the approximate determination of acoustic backscattering from thin-walled objects**

*Burgschweiger, Ralf (1); Schäfer, Ingo (2); Ochmann, Martin (1); Nolte, Bodo (2)*  
(1) University of Applied Sciences, Berlin, Germany; (2) Federal Armed Forces Underwater Acoustics and Marine Geophysics Research Institute, Germany

**ABSTRACT**

The calculation of the acoustic backscattering from larger thin-walled underwater objects requires, especially in the middle and higher frequency range, computing resources that are usually not available in practice. Therefore, the use of

appropriate approximate methods appear useful for those cases. In this paper, a solution method is presented that is tracking "sound beams", generated by a plane wave and impinging on a submerged object. The method determines the complex reflection and transmission coefficients at the incident points, taking into account shell boundary conditions, and generates "child"-beams which are then followed up to a predefined level. Therefore, the material-dependent refraction and a possible multiple reflection can be considered within the structure. An appropriate post-processing calculation provides the backscattered sound pressure in the far field. Results for "inner" structures that include reflective areas and which are surrounded by thin "outer" shell structures are presented and compared with results of FEM-based applications (where applicable). Additionally, a method to determine the "hot spots" based on monostatic calculations is described.

**Wednesday 08:20-10:00 Room 206**  
**S5 Soundscapes and health related quality of life**  
**Chair: Peter Lercher, Daniel Shepherd**

**604 Health in the noise context: the relativity of absolute health**

*Shepherd, Daniel (1); Dirks, Kim N (2); McBride, David Iain (3); Welch, David (2)*  
(1) Auckland University of Technology, New Zealand; (2) University of Auckland, New Zealand; (3) University of Otago, New Zealand

**ABSTRACT**

Noise remains a potent degrader of health in many contexts, capable of inducing severe annoyance and sleep disturbance. However, quantifying the impact of noise on health involves methods that are neither standardized nor always agreed upon. One issue centers on the conceptualization of health, and whether the WHO's guidelines suggesting that noise impact is best measured using health-related quality of life indices is in fact valid. The WHO recommendation is largely based on the fact that, unlike diseases, disability, terminal illnesses or explicit physical insults, health impacts from noise are more insidious and covert, and difficult to disentangle from other processes impacting function. Arguably, however, the WHO's 1948 seminal definition of health represents the prerequisites of good health, and does not necessarily provide a definition of health itself. More holistic definitions can be entertained, for example, good health is the ability of an organism to remain viable and successfully engage goal-directed behaviors within a host environment. Acknowledging that how health is conceptualized determines how health is measured, this paper argues that health-related quality of life has been unfairly marginalized in noise research. Furthermore, rather than being an adjunct to biomedical measures, health-related quality of life measures should be central to noise research. Interestingly, the challenging nature of quantifying the impacts of noise upon health provides a context to examine the broader meaning of health and suggest amendments to those advanced by the WHO.



**754 Aviation-related noise-induced annoyance and health-related quality of life**

*Dirks, Kim N (1); Shepherd, Daniel (2); Welch, David (1); McBride, David (3)*  
(1) University of Auckland, New Zealand; (2) Auckland University of Technology, New Zealand; (3) University of Otago, New Zealand

**ABSTRACT**

Noise is an environmental nuisance that has the potential to degrade health and negatively impact the relationship between humans and their environment. The mode of transport effect stipulates that aviation noise is more annoying than either rail or road noise. While sleep disturbance and annoyance are the dominant health consequences of community noise exposure, cardiovascular disease and cognitive impairment in children also contribute. The WHO describe ideal health as "...a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity". While recent population-level studies demonstrate significant associations between aviation noise and risk of hospitalization for cardiovascular disease, few studies have engaged measures of wellbeing. This paper describes an epidemiological study undertaken to compare noise annoyance and health-related quality of life (HRQOL) of individuals residing close to a major international airport (n=87) with those in a demographically- matched area (n=91). Results indicate that domains of HRQOL may be degraded in those living in areas more likely to induce noise annoyance. Additionally, the addition of aviation noise to environments already encroached by road noise may induce further annoyance and degradations in HRQOL, indicating that unique sources of noise may not mask the impacts of other noises.

**362 Assessing the relationship between perceived disturbances from traffic, restorative qualities of the living environment, and health**

*Von Lindern, Eike (1); Hartig, Terry (1); Lercher, Peter (2)*  
(1) University Uppsala, Sweden; (2) Medical University Innsbruck, Austria

**ABSTRACT**

Home is for many a place to recover after a day at work and to find shelter from demands of the outside world. Being at home can thus be regarded as a resource for health and wellbeing. However, it is not always possible for people to ban traffic related disturbances from their home. Consequently, the restorative character of the home may become constrained, and this in turn may result in impaired health and wellbeing. We addressed this possibility in analyses of data from a door to door survey of residents in a valley near Innsbruck, Austria (N = 572). Participants reported on restorative qualities of their homes, their health, and perceived disturbances from transport-related noise, vibration, and air pollution. Results from a multiple mediation analysis suggest that transport-related disturbances negatively impact health, and that this apparent effect is indeed partially mediated via constrained restorative qualities of the respondent's home.

**88 Influence of soundscape and interior design on anxiety and perceived tranquillity of patients in a healthcare setting**

*Watts, Greg (1); Khan, Amir (1); Pheasant, Rob (1)*  
(1) University of Bradford, UK

**ABSTRACT**

Tranquillity characterised by a pleasant but calming environment is often to be found in natural environments where man-made noise is at a low level though natural sounds can be relatively high. Numerous studies have shown a link between such restorative environments and hospital recovery rates, stress reduction, longevity, pain relief and even how the brain processes auditory signals. In hospitals and primary care facilities there is a need to improve patient waiting rooms as current designs are largely based solely on medical need. There are often long waits in such spaces and patients are coping with the stress and anxiety caused by their medical condition. Attention should therefore be given to creating "restorative environment" as a component to their medical treatment. The study describes the effects of introducing natural sounds and large images of natural landscapes into a waiting room in a student health centre. Using self reported levels of anxiety and tranquillity it was possible to assess the impact of these targeted auditory and visual interventions had in affecting the quality of the patient experience.

**828 Sound Source Study in Shenzhen China**

*Liang, Hong (1); Yu, Lei (2); Zhao, Kang Sai (3); Zhang, Ming Di (3)*  
(1) Shenzhen Environmental Monitor Centre, China; (2) Shenzhen Graduate School HIT, China; (3) Shenzhen Environmental Monitoring Centre, China

**ABSTRACT**

Shenzhen is a rapid developing city in Chinese urbanization. With thirty-year development, the city is derived from a rural into the fourth metropolis in China. In such a dramatic transforming, the area's ecological environment has been changed tremendously, in which its sonic environment including sound level and sound sources has been changed too. No doubtfully, many man-made sounds have penetrated into the area and original natural sounds are dying away. In order to reveal how much sound source is having been and will be changed in the Shenzhen's urbanization, the Shenzhen Environmental Monitoring Centre (SEMC) started a project of recording and monitoring sound sources and their changes with the whole city context. In this paper, works of the SEMC in investigating sound sources and their distribution around the inner Shenzhen are demonstrated. It is expected to show an ecological diverse of sound in Shenzhen. The study is also supposed to express an ecological variation of acoustic environment in terms of sound sources. Moreover, the study result will be used to effectively monitor sound changes of the Shenzhen in order to provide useful guidelines to the city planners and designers in creating more sonic pleasure open spaces for the Shenzhen's further development.

**Wednesday 11:00-13:00 Room 220**  
**T6c Psycho-acoustics in noise evaluation**  
**Chair: Sonoko Kuwano, Peter Lercher**

**1013 Train noise - A psychoacoustic investigation for indoor aural comfort in high-rise urban environment in the tropics**

*Sheikh, Mahbub Alam (1); Lee, Siew Eang (1)*  
 (1) National University of Singapore, Singapore

**ABSTRACT**

Despite of many research on the assessment of negative impact (i.e. annoyance) of indoor aural environment, very limited research effort have been made on the positive assessment (i.e. aural comfort) of aural environment in residential settings subjected to environmental noise sources. Noise annoyance has often been related to different energy-based acoustical indicators such as LAeq, LDEN etc. which are unable to consider the temporal and spectral patterns of the complex noise environment. The indoor aural environment has rarely been examined for different psychoacoustic quantities, the influence of which are still unknown on indoor aural comfort subjected to environmental noise sources specially in high-rise urban built-up settings. This research investigates the indoor aural comfort in high-rise naturally ventilated residential dwellings in Singapore subjected to Train Noise. A psychoacoustic experiment was carried out to examine the indoor aural comfort and relating it with different psychoacoustic indices. Loudness, Sharpness and Roughness were found significantly correlated with the assessment of 'Noisiness' and 'Noise Disturbance' in indoor environment. Train noise with a maximum Loudness of 8 Sone, mean Sharpness of 1.25 Acum and maximum Roughness of 33 centi-Asper were found attributing to a 'quiet' indoor aural environment. This paper presents statistical models developed for subjective 'noisiness' and 'disturbances' and discusses their relationships with these psychoacoustic quantities.

**481 Progress in calculating tonality of technical sounds**

*Sottek, Roland*  
 HEAD acoustics GmbH, Germany

**ABSTRACT**

Noises with tonal components, howling sounds, and modulated signals are often the cause of customer complaints when emitted from technical products. The perception and evaluation of sound events containing such components has become increasingly important, e.g., in the field of vehicle acoustics for the assessment of tonality due to alternative drives. Furthermore, Information Technology (IT) devices and products such as hard disk drives may emit tonal sounds. Despite their very low sound pressure levels, such noises are unwanted and should preferably be avoided or masked. The psychoacoustic parameter tonality was introduced in order to quantify the perception of tonal content. However, existing methods for tonality calculation show problems when applied to technical sounds. Recently, a new approach to tonality calculation based on a hearing model was presented by Sottek, Kamp, and Fiebig. In accordance with recent research results, the calculation of tonality is therein performed upon the basis of the partial loudness of the tonal content. This paper presents model validations exploiting the results of new listening tests

using bandpass-filtered noise signals with varyingly steep filter slopes and model improvements, especially in order to adequately indicate the perceived tonality of technical sounds with low sound pressure levels

**550 Signal repetition rates and their relationship to the pleasantness of multi-tone sounds**

*Toepken, Stephan (1); Scheel, Henning (2); Weber, Reinhard (1)*  
 (1) University of Oldenburg, Germany; (2) Airbus, Germany

**ABSTRACT**

The sound character of multi-tone sounds offers a rich bunch of perceptual aspects that can be linked to spectral and temporal properties of the signals. The frequency spacing of the partials is one major underlying determinant. Already subtle changes of the partial spacing can have a big effect on the temporal structure in terms of the signals' repetition rate. For sounds consisting of a superposition of two harmonic complex tones and combination tones this leads to a rich mix of different sensations like beats, fluctuations, roughness, dissonance and tonality which are at least in part known for driving annoyance, unpleasantness or pleasantness. The pleasantness of such sounds has been investigated in listening tests. The ratio between the fundamental frequencies of the two complex tones has been varied systematically and an analysis of the time series of the stimuli shows clear differences in the periodicities and hence repetition rates. In comparison with the subjective judgments high correlation coefficients can be found between the pleasantness and the repetition rate of the signal. A combination of the repetition rate and the psychoacoustic sharpness are able to model the preference relevant sound characteristics of multi-tone sounds.

**831 Unsupervised feature learning on monaural DOA estimation using convolutional deep belief networks**

*Yan, Chen (1); Mengyao, Zhu (1); Nicolas, Epain (2); Craig, Jin (2)*  
 (1) Shanghai University, China; (2) CARLab, School of Electrical and Information Engineering, The University of Sydney, Sydney, Australia

**ABSTRACT**

In recent years, deep learning approaches have gained significant interest as a way of building hierarchical representations from unlabeled data. Additionally, in the field of sound direction-of-arrival (DOA) estimation, the binaural features like interaural time or phase difference and interaural level difference, or monaural cues like spectral peaks and notches are often used to estimate sound DOA. Although these binaural or monaural cues successfully explained human sound DOA ability, its accuracy and extent are all limited to the human knowledge on feature extracting methods. In this paper, we are interested in applying a deep learning approach to monaural sound localization based on monaural spectral cues. A convolutional deep belief network is applied to monaural auditory spectrograms processed by a computational auditory model to learning monaural features automatically. The learned features are then regressed using a support vector regression (SVR) model for sound DOA estimation tasks. Moreover, our feature representations learned from unlabeled monaural auditory spectrograms are then compared to the well-known binaural features. The results indicate that our

monaural model shows reasonable performance at the task of 3D DOA estimation.

**734 Effects of active noise control on subjective annoyance and cortical neural activities for car engine noise**

*Ito, Tomoki (1); Ishimitsu, Shunsuke (2); Nakagawa, Seiji (3)*  
(1) Hiroshima City University, Japan, National Institute of Advanced Industrial Science and Technology, Japan; (2) Hiroshima City University, Japan; (3) National Institute of Advanced Industrial Science and Technology, Japan

**ABSTRACT**

It is thought that active noise control (ANC) is able to control not only loudness but also auditory impression; however, few studies have focused on changes in the auditory impressions of noises through ANC. Some previous studies have reported significant correlations between subjective preference/annoyance of sounds and synchrony of the alpha activity, noises varied by ANC were investigated using psychoacoustic and neurophysiological measurements. Car engine noises were modeled as harmonic complex tones. 20 stimuli were obtained by applying ANCs with several reduction-levels. First, Scheffe's paired comparison tests were performed to evaluate subjective annoyance for each stimulus. Next, magnetoencephalographic responses for the reference noise, the intermediate-, and the least-annoyed stimuli for each participant were recorded, and then  $\alpha$  was estimated accordingly. Annoyance decreased as the cut-off frequency and the reduction-level increased. The results indicated that decrease of loudness is important for improvements in auditory impressions. However, no significant effects of ANC were observed in cause, the annoyance levels for each stimulus were not markedly different.

**133 Effect of Visual Stimulus on Subjective Impression of Indoor Sound Fields with Various Reverberation Times**

*Ishikawa, Ayumi (1); Terashima, Takane (1); Tokunaga, Yasunobu (2)*  
(1) Mie University, Japan; (2) Maizuru National College of Technology, Japan

**ABSTRACT**

In architectural and urban space, we are always exposed to multi-modal stimuli of visual information and sound fields in various scenes of everyday life. The purpose of this study is to clarify relationships between subjective impressions for vision (size, shape, colour, design etc.) and auditory (sound field as a structure of reflections) of indoor/outdoor space, and to acquire information which contributes to architectural design or acoustic design. In this study, laboratory experiments were carried out, in which subjective impression for indoor sound fields were measured when auditory stimuli with different reverberation times and visual stimuli of indoor VR pictures were presented simultaneously. In our previous papers [1~4], we compared measured values of single-modal presentation (auditory stimuli only) with those of multi-mode (visual and auditory stimuli), and could approximately understand the influence of visual stimuli on auditory impression. In this paper, it is mainly described that additional experiments were carried out under newly arranged conditions, so that the psychological influence of incongruity between visual and auditory stimulus on subjective impression for sound field could be clarified.

**Wednesday 11:00-13:00 Room 219**  
**V2c Sound visualization and manipulation**  
**Chair: Jung-Woo Choi, William Martens**

**596 Enhanced sound field reproduction within prioritized control region**

*Chen, Hanchi (1); Abhayapala, Thushara D (1); Zhang, Wen (1)*  
(1) ANU, Australia

**ABSTRACT**

Higher-order ambisonics has been identified as a robust technique for synthesizing a desired sound field. However, the synthesis algorithm requires a large number of secondary sources to derive the optimal results for large reproduction regions and over high operating frequencies. This paper proposes an enhanced method for synthesizing the sound field using a relatively small number of secondary sources which allows improved synthesizing accuracy for certain subregions of the interested zone. This method introduces the spherical harmonic translation into the mode matching algorithm to acquire a uniform modal-domain representation of the sound fields within different sub-regions. Then by changing the weighing of each region, the least mean squares solution can be easily controlled to cater for certain prioritized reproduction requirements. Simulations show that this technique can effectively improve the matching accuracy of a given sub-region, while only slightly increasing the global reproduction error. This method is shown to be especially effective in the situations where the number of secondary sources is limited.

☐ e. In this study, auditory impressions of car engine

☐ e. It is difficult to identify the

**342 Standardization of Korean head-related transfer function based on tensor-singular value decomposition**

*Son, Daehyuk (1); Park, Youngjin (1); Jang, Sei-jin (2)*  
(1) KAIST, South Korea; (2) NSSC, KETI, South Korea

**ABSTRACT**

Researches on three-dimensional multimedia has been performed actively in recent years. Virtual sound technology corresponding to virtual image should be provided to implement 3D multimedia with high quality. Head-related transfer function (HRTF) plays a key role in this research area. HRTFs measured in changing azimuth, elevation, and distance for each and every subject is necessary for ideal solution. However, it is practically impossible to measure all subjects' HRTFs, so various HRTF databases have been built by many researchers. Because HRTF displays quite different aspects from subject to subject, HRTF of dummy head has been used for generic usage. However, mannequin's HRTF showed much worse performance comparing with individual case so this solution should be improved. Therefore, this research deals with standardization of HRTF based on tensor-singular value decomposition method and verification with subjective listening test of four subjects. HRTF data used in this paper are extracted from Korean HRTF database which is built by author.

**125 Linear optimal source distribution mapping for binaural sound reproduction**

*Zheng, Jianwen (1); Lu, Jing (1); Qiu, Xiaojun (1)*  
(1) Nanjing University, China

**ABSTRACT**

Binaural playback over loudspeakers usually leads to crosstalk. The most effective strategy of general crosstalk cancellation systems is system inversion which, nevertheless, gives rise to several problems such as the loss of dynamic range and the lack of robustness. The optimal source distribution (OSD) method has been utilized to compromise the playback performance and the problems of the crosstalk cancellation; however, the method was based on the circular loudspeaker array and is hard to be implemented in some practical applications. The other problem associated with the method is that the frequency-span discretization only concentrates on the dynamic range loss. This paper proposes a novel mapping method by adjusting the circular loudspeaker array to the linear array, where the optimization of the discretization is discussed by taking full consideration of the crosstalk cancellation performance and the frequency response at the sweet spot. Both simulations and experiments demonstrate the efficacy of the proposed method. The proposed system has potential applications in both sound field manipulation and subjective noise evaluation.

**368 Discovering a physical parameter associated with a near-field sound control: comparing HRTFs of nine loudspeakers in a non-anechoic room**

*Kim, Sungyoung (1); Gosselin, Philip (2); Okumura, Hiraku (3)*  
(1) Rochester Institute of Technology, USA; (2) McGill University, USA; (3) Yamaha Corporation, USA

**ABSTRACT**

Previously, the authors proposed a novel method of near-field sound control using an electrostatic loudspeaker radiates planar wave from above the listening position. The method was based on a pseudo inside-head- localization (IHL) phenomenon similar to headphone listening experience, which generates a near-field sound image. To search for a physical parameter associated with this near-field image rendered through the electrostatic loudspeaker, the authors measured the head-related transfer function (HRTF) with eight conventional loudspeakers and compared them with the HRTF of the electrostatic loudspeaker. The HRTFs were measured at three distances (0.75, 1, and 2 m) in a non-anechoic listening room. The results were similar to the previous HRTF measurements at an anechoic room and numerical simulations, showing that the variances of group delays were associated with the distances. Moreover, the variance of electrostatic loudspeaker measured at 2 m was similar to the variance in conventional loudspeaker at 0.75 m, suggesting a reason for near-field sound images from the electrostatic loudspeaker in a reverberant room.

**805 Distance perception of a nearby virtual sound source reproduced by a linear loudspeaker array**

*Kang, Dong-Soo (1); Choi, Jung-Woo (1); Kim, Yang-Hann (1); Martens, William Leigh (2)*  
(1) KAIST, South Korea; (2) University of Sydney, Australia

**ABSTRACT**

When a virtual sound source is reproduced by a linear loudspeaker array, listeners can perceive not only the direction of the source, but also its distance. Control over perceived distance has often been implemented via the adjustment of various acoustic parameters, such as loudness, spectrum change, and the direct-to-reverberant energy ratio; however, there is a neglected yet powerful cue to the distance of a nearby virtual sound source that can be manipulated for sources that are positioned away from the listener's median plane. By extending the manipulation of interaural level difference (ILD) to lower frequencies than what is typical for such lateralized sources, a very strong means becomes available for controlling perceived distance of sources at close range, within the listener's peripersonal space (within arm's reach). Of course, the ILD of a virtual source reproduced by a line array will not be identical to that of a real monopole, due to many physical limitations such as finite aperture, spatial aliasing and stationary phase approximation. Using an ideal rigid sphere as a model of the variation in head-related transfer functions at close range, this paper identifies the effects of these artifacts on perception of the nearby virtual source.

**849 Manipulation of source width based on sound field reproduction**

*Lee, Jung-Min (1); Choi, Jung-Woo (1); Kim, Yang-Hann (1)*  
(1) Korea Advanced Institute of Science and Technology, South Korea

**ABSTRACT**

In this study, a method is proposed to generate an extended virtual source enabling the extension of the perceived source width. In various auditory scenes, a sound source delivers the sensations of its size and location. The perceived source width is a spatial auditory impression related to the source size. Among the source width attributes, individual source width (ISW) is defined as the perceived width of an individual sound source disregarding a room effect. Accordingly, in representing a virtual source containing the size attribute, it is required to manipulate ISW as well as localization. The perceived source width is inversely proportional to the similarity of the listener's ear signals. The dissimilar pressures at both ears can be generated by randomizing the spectral phase distributions. In this paper, it attempts to produce the randomized phase distributions in a large area based on the sound field reproduction. To achieve this goal, a target sound field is designed such that the radiation pattern is randomly changed with respect to frequency. A direct solution for reproducing the designed field is then derived in terms of integral approach. Simulation results show that the proposed method can manipulate the perceived source width over a large area.

**Wednesday 11:00-13:00 Room 218**  
**L4b Active vibration control and active**  
**structural acoustic control**  
**Chair: Li Cheng, Youngjin Park**

**364 Using a psychoacoustic criterion for the actuator placement in an active structural acoustic control system**

*Papantoni, Veatriki (1); Hesse, Christian (1); Rose, Michael (1); Monner, Hans Peter (1)*  
 (1) German Aerospace Center, Germany

**ABSTRACT**

Active structural acoustic control (ASAC) systems for flexible structures with enclosed cavities are normally designed with the goal of minimizing the acoustic potential energy in the cavity. This goal is also taken into account during the search for an optimal actuator placement for the ASAC system. This paper is concerned with the change in the acoustic response of a structurally excited cavity when a psychoacoustic criterion is used for the placement of the actuators of the ASAC system instead. The placement of actuators on a flexible structure enclosed by a cavity is optimized using a genetic algorithm. Two optimization criteria are used: the acoustic potential energy in the cavity and the psychoacoustic loudness in the cavity. Numerical results regarding the acoustic potential energy reduction and the loudness reduction in the cavity of the coupled system in the case of an optimal feedforward control are presented for the two different actuator placement criteria.

**386 A novel semi-active quasi-zero stiffness vibration isolation system using a constant-force magnetic spring and an electromagnetic linear motor**

*Leav, Orddom Y (1); Eriksson, Carolina (2); Cazzolato, Benjamin S (1); Robertson, William S (1); Ding, Boyin (1)*  
 (1) University of Adelaide, Australia; (2) Royal Institute of Technology, Sweden

**ABSTRACT**

The performance of conventional vibration isolation systems are limited by the stiffness of the mount required to support the weight of the payload. A potential method for addressing this limitation is to use the phenomenon of quasi-zero stiffness (QZS), which results in a high static stiffness to support the weight of payload and a low dynamic stiffness to achieve a wider vibration isolation range. Recently, QZS systems with various negative stiffness elements and mechanical configurations have been proposed and studied. This paper presents the design and analysis of a novel semi-active QZS vibration isolation system using a commercial constant-force magnetic spring and an electromagnetic linear motor. The proposed system combines the advantages of both passive QZS systems and active damping control, and therefore is cost-effective, energy-efficient, and has the potential of a large bandwidth of vibration isolation as well as a low resonance peak. The use of a commercial magnetic spring not only allows the system to support a large static payload over a wide range of travel but also simplifies the design. In this paper, the design, identification and control aspects of the proposed vibration isolation system are discussed and the system performance is investigated theoretically and experimentally.

**392 Source identification of a vibrating plate using phase conjugation and interior boundary element method**

*Liu, Song (1); Li, Sheng (1)*  
 (1) Dalian University of Technology, China

**ABSTRACT**

A method combining phase conjugation with interior boundary element method is developed for the identification of the pressure and normal velocity distribution of a vibrating plate. An interior problem is formed by enclosing the phase conjugation array plane and the plate surface. The pressures at the array elements are phase-conjugated as the specified pressure boundary condition. The impedance relationship between the surface pressure and the surface normal velocity of the plate is utilized as a specified impedance boundary condition. The interior boundary element method is applied to solve the interior problem. The identification of the surface pressure and normal velocity distribution is studied numerically. The numerical results show that with the array located in the near field the proposed method achieves subwavelength focusing to identify the surface pressure and normal velocity distribution and clearly shows the response shapes.

**796 Design of natural frequency adjustable electromagnetic actuator and active vibration control test**

*Liu, Xueguang (1); Han, Chao (1); Wang, Ye (1); Yang, Tiejun (1); Du, Jingtao (1); Zhu, Minggang (1)*  
 (1) Harbin Engineering University, China

**ABSTRACT**

An inertia electromagnetic actuator capable of adjusting natural frequency is designed in this paper. There are two procedures in the design of electromagnetic actuator: magnetic circuit design and stiffness conditioning design. ANSOFT software is used to simulate the magnetic circuit during the magnetic circuit design and optimize the design of the actuator. In order to adjust the natural frequency, the actuator spring is designed adjustable to meet the different need of the system stiffness. Using the X-LMS algorithm, a series of active vibration control test has been done on the test bench. Experiment results show that if fixing the adjustable spring, the actuator can be used as a normal actuator, and it can only get the best control effect at one natural frequency. But when using the adjustable spring, it can get the best control effect at four natural frequency. At different control frequency, that actuator can improve the control effect about 0.4~6.9dB.

**763 An experimental investigation on the acoustic performance of a flapping wing Micro-Air-Vehicle**

*Lu, Zhenbo (1); Marco, Debiasi (1); Nguyen, Quoc Viet (1); Chan, Woei-Leong (1)*  
 (1) National University of Singapore, Singapore

**ABSTRACT**

An experimental study was conducted to assess the acoustic performance of a two-winged Flapping-Wing Micro-Air-Vehicle (FW-MAV) with various wing materials and wing structure configurations for flapping flight applications. It was concluded that highly elastic materials could significantly reduce the flapping wing noise in a wide spectrum of audible frequencies. Furthermore, a dielectric elastomer (DE) which is a lightweight

and highly elastic smart material has been preliminarily investigated for its potential applications in the quiet FW-MAV under the passive control scheme.

**525 Development of a noise reduction system with piezoelectric material to transmitted noise (Structure for improvement of the noise reduction effect)**

*Yamamoto, Katsuya (1); Ishimori, Akiyoshi (1); Sato, Hiroyuki (1); Asahina, Mineyuki (1)*  
(1) Railway Technical Research Institute, Japan

**ABSTRACT**

We previously developed a noise reduction system consists of piezoelectric material attached on aluminum plate to reduce transmitted noise; the features and principles of this system were presented at the internoise2011. In that paper, each aluminum plate with a piezoelectric material (hereinafter "noise insulation panel: NIP") was assumed to have perfect flat plate and same size and therefore has the identical vibration characteristics. However, when panels were bonded to a frame to form a single structure, their vibration characteristics actually differed, and the noise reduction capability of the system became lower. To solve this problem, we have developed a method in which planar tension is applied to each NIP via a simple frame structure. We have verified that this method improves the noise reduction and allows the target frequency to be tuned. In this paper, we describe the features of this new structure, and present the results of our numerical analysis and experimental tests.

**Wednesday 10:40-11:40 Room 217**  
**G6 Measurement - Modeling and propagation**  
**Chair: Kristy Hansen, Renzo Tonin**

**199 Influence of non-standard atmospheric conditions on turbine noise levels near wind farms**

*Cooper, Jonathan (1); Evans, Tom (1); Alamshah, Vahid (1)*  
(1) Resonate Acoustics, Australia

**ABSTRACT**

This paper investigates the accuracy of wind turbine noise predictions under non-standard meteorological conditions. It reviews studies into the influence of meteorological variables on noise emission and propagation. In particular, it presents recent extended wind farm noise measurements undertaken by the authors to investigate the effects of periods of higher wind shear on noise propagation. Wind turbine noise levels were measured at a location 1150 m from a wind farm where wind shear was simultaneously monitored. It is found that wind shear tends to have a negligible influence on noise propagation for the range of operating conditions of the wind farm. The influence of wind direction on noise levels at the monitoring location was found to be much larger than that of wind shear.

**800 Assessing the Validity of Wind Farm Noise Monitoring Data for Periods of Partial Wind Farm Operation**

*Mitchell, Andrew*  
AECOM, Australia

**ABSTRACT**

Wind farm noise compliance assessments require measurement of the wind farm noise under full operating conditions. Normal wind farm operation typically includes periods where one or more wind turbines may be unable to operate, due to maintenance requirements, grid restrictions, or other factors. For a large wind farm with many wind turbines, or in situations where cumulative noise impacts from other wind farms need to be considered, there may be very few periods where all wind turbines at the wind farm, and any neighbouring wind farm, operate simultaneously. In such scenarios it is rarely practicable to simply take noise monitoring data from only the periods where all wind turbines were operating, as this may involve excluding a significant proportion of the noise monitoring data set, which would result in a considerable increase in the duration of noise monitoring that is necessary to obtain the required size of data set. To reduce the proportion of data that needs to be excluded, noise modelling can be used to determine whether the combination of wind turbines operating at any particular time would have resulted in a materially lower noise level than would have occurred with all wind turbines operating. Based on such modelling, non-representative noise measurement data can be excluded from the assessment. This paper discusses a data exclusion methodology that has previously been used for wind farm noise assessments in Australia, and investigates the effect that various modelling simplifications and exclusion criteria could have on the noise assessment outcome, based on a case study of noise monitoring data from 18 locations at two large Australian wind farms. For the case studies investigated it was found that the effect of excluding periods of noise data where there were non-operational wind turbines was minor, and the exclusion of such data could possibly be an unnecessary step in practical noise assessments for large wind farms, when using the assessment methodologies in use in Australia.

**829 Noise Propagation from a Vertical Axis Wind Turbine**

*Möllerström, Erik (1); Larsson, Sebastian (2); Ottermo, Fredric (2); Hylander, Jonny (2); Bååth, Lars (2)*  
(1) Halmstad University, Sweden, Uppsala University, Sweden;  
(2) Halmstad University, Sweden

**ABSTRACT**

Initial noise measurements were performed on a 200kW vertical axis wind turbine (VAWT) and results were compared to that of a Vestas V27, a similar size horizontal axis wind turbine (HAWT). Multiple recording units were placed in line downwind of the turbine to investigate noise propagation. The frequency distribution of the noise were analyzed indicating that the VAWT has lower relative levels for frequencies under 3000 Hz, especially within 600-1200 Hz. Furthermore, VAWT noise seems to occur more around the same frequencies as the natural background noise, increasing masking probability. Results from propagation measurements seemed to indicate that noise declines more rapidly with distance for the VAWT than for the reference HAWT, possibly explained by the lower levels at low frequencies. Further investigation is needed to establish these differences and the 200 kW VAWT creates an opportunity doing

so utilizing arguably the largest operational VAWT existing today.

**Wednesday 11:00-13:00 Room 216**  
**C7 Computational aeroacoustics**  
**Chair: Akhilesh Mimani , Paul Croaker**

**354 Boundary Condition for the Implementation of Arbitrary Acoustical Modes**

*Witthaus, Sina (1); Seume, Joerg R (1)*  
 (1) Leibniz Universität Hannover, Germany

**ABSTRACT**

With the increase of bypass ratios of current jet engines, the dominating sound emission sources of aircraft engine noise consist of the tonal components of the fan and the compressor. Hence, the rotor-stator interaction noise is a significant contributor to the overall sound radiation from aircraft engines. The sound field consists of a superposition of various acoustical modes, generated by two effects: Firstly, the interaction of rotor wakes with the stator in each compressor stage and secondly, the relative rotation of potential fields of the cascades. Based on the blade and vane count and on the blade-passing frequency (BPF), the compressor modes that propagate can be estimated. Since the excited modes determine the emitted sound field, the numerical analysis of these acoustic structures is of great importance in understanding jet engine noise emissions. For this purpose, the sponge-layer boundary condition of the CAA-solver PIANO (developed by the German Aerospace Centre, DLR) is extended to implement arbitrary superposed modes. The FORTRAN-based code computes the resulting sound field in a cylindrical geometry, for a given set of azimuthal and radial mode orders, wavenumber and amplitudes of the modes to be excited. The numerically generated sound pressure distribution is validated against an analytical solution.

**520 The nonlinear inhomogeneous Galbrun-Equation: Derivation and possible Ways to solve numerically**

*Guettler, Marcus (1); Marburg, Steffen (1)*  
 (1) Universität der Bundeswehr München, Germany

**ABSTRACT**

In recent years, the field of aeroacoustics has gained more attention in engineering developments like low noise ventilators, HVAC systems in electric vehicles, passenger cabins of commercial aircraft as well as novel engine designs of airplanes in general, to fulfill regulations of low level noise exposure. In order to close the gap between expensive prototypes with experimental testing and short development periods under high cost pressure, numerical simulations are state of the art for virtual prototyping. Numerous theories and acoustic analogies have been developed to investigate the effect of flow combined with acoustic radiation and propagation. Important contributions are known as the Linearized Euler Equations (LEE) or the Acoustic Perturbation Equations (APE). A different approach is pursued following the work of Galbrun. His displacement based linear formulation of aeroacoustics is extended to account for nonlinear effects as well as acoustic sources in turbulent flow. Difficulties arise when solving the Galbrun equation numerically. Therefore some already established numerical techniques that can be

used to cope with these problems such as the Finite-Element-Method and the Discontinuous-Galerkin-Method are proposed.

**628 Calculation of Duct Flow Noise Using CE/SE Method**

*Chan, Horus Y H (1); Lam, Garret C Y (1); Leung, Randolph Chi-kin (1)*  
 (1) Hong Kong Polytechnic University, Hong Kong

**ABSTRACT**

Noise generated in flow duct propagates extensively through the connected ductwork. Its propagation through the outlets would contribute to indoor acoustic discomfort and results in environmental problem. Silencers with acoustic lining are commonly adopted for noise mitigation in flow duct. Researchers have been devoting many numerical efforts in assessing the performance of a liner design. In general, numerical studies are performed by either time domain or frequency domain approach. This paper reports a development of calculation method solving Acoustic Perturbation Equations and Time-Domain Impedance Boundary on the Conservation Element and Solution Element (CE/SE) framework to calculate duct noise problem in time domain. In this paper, three benchmark cases are presented to verify the capability of the proposed method on calculating the flow induced acoustic generation, propagation, and the acoustic behavior at the impedance boundaries in the presence and absence of flow.

**788 A particle accelerated CFD-BEM technique applied to aeroacoustic scattering**

*Croaker, P (1); Kessissoglou, Nicole (1); Marburg, Steffen (2)*  
 (1) UNSW Australia, Australia; (2) LRT4 – Institute of Mechanics, Universität der Bundeswehr München, D-85579 Neubiberg, Germany

**ABSTRACT**

A particle accelerated computational fluid dynamics (CFD) - boundary element method (BEM) technique is proposed that allows the total sound pressure field produced by low Mach number flow past a rigid body to be predicted. An incompressible CFD solver is used to calculate the transient hydrodynamic flow field. The CFD/BEM coupling technique is then used to compute the acoustic pressure and pressure gradient incident on the body. The incident acoustic field is calculated based on a near-field solution of Lighthill's analogy. Numerical techniques are employed to accurately evaluate the strongly singular and hypersingular surface and volume integrals. A particle condensation technique is applied to accelerate the incident field computations and reduce the amount of data that must be stored during the CFD analysis. The incident field is then combined with a BEM model of the body to predict the scattered sound pressure field. The BEM model solves the Burton-Miller boundary integral equations to guarantee a unique solution at all frequencies. Results from the particle accelerated CFD-BEM technique are presented for flow past a circular cylinder with Reynolds number,  $Re_D=100$  and Mach number,  $M=0.02$ . The directivity of the sound pressure field at the vortex shedding frequency and its harmonics predicted using the condensation technique are compared with non-condensed results as well as results obtained using Curle's analogy.

**996 Numerical investigation of the refraction effects by jet flows in anechoic wind tunnels**

*Redonnet, Stéphane (1); Bulte, Jean (1)*  
(1) ONERA French Aerospace Centre, France

**ABSTRACT**

In regard to the problem of aircraft noise mitigation, the present study focuses on the refraction effects to be possibly induced by anechoic facility jet flows on the measured acoustic signatures, during typical airframe noise experiments. To this end, Computational AeroAcoustics (CAA) calculations based on the solving of the Perturbed Euler Equations (PEE) are conducted, enabling the estimation of the refraction effects characterizing a typical open-jet, anechoic wind tunnel, namely the NASA Langley's Quiet Flow Facility (QFF). Coming along with their validation against analytical results obtained through a Ray Tracing (RT) technique, the analysis of these CAA/PEE calculations highlights the refraction effects by the facility jet flow, delivering preliminary insights about what are the key parameters (jet height, jet curvature, jet spreading angle, shear layer thickness, etc.) to play a major role in these refraction phenomena.

**787 Self-noise prediction of a flat plate using a hybrid RANS-BEM technique**

*Croaker, Paul (1); Kessissoglou, Nicole (1); Karimi, Mahmoud (1); Doolan, Con J (2); Chen, Li (3)*  
(1) UNSW Australia, Australia; (2) University of Adelaide, Australia; (3) DSTO, Australia

**ABSTRACT**

The self-noise generated by a flat plate immersed in low Mach number flow is predicted using a hybrid RANS-BEM technique. A Reynolds Averaged Navier-Stokes (RANS) simulation is performed of the turbulent flow over the flat plate. The predicted flow field data, such as mean velocity, turbulent kinetic energy and turbulent dissipation rate, is then processed using a statistical noise model and combined with a boundary element method (BEM) model of the flat plate to predict the far-field sound. The results from the hybrid RANS-BEM technique are presented for turbulent flow past a flat plate, with Reynolds number based on chord  $Re_c = 2.0 \times 10^5$  and Mach number  $M = 0.044$ . The computed aerodynamic and acoustic results are compared with numerical and experimental results from the literature.

**Wednesday 11:00-12:20 Room 215**

**U3 Personal hearing protectors and headsets**

**Chair: Pam Gunn, Ben Elsey**

**28 Earmuff Comfort Evaluation**

*Gerges, Rafael (1); Gerges, Samir N Y (2)*  
(1) Federal University of Santa Catarina, Brazil; (2) Federal University of Santa Catarina, Brazil, Institute Federal de Santa Catarina IFSC/Mecatronica, Brazil

**ABSTRACT**

The use of hearing protectors in high noise environments is indispensable, protecting the workers from suffering permanent hearing loss. In this regard, hearing protector comfort is of crucial importance. Consequently, the selection of

the hearing protector used should be based on comfort rather than noise attenuation. In a previous paper (1), published by one of the authors of this article, a novel method was presented to evaluate the comfort of earmuffs by measuring the distribution of the contact pressure between the earmuff cushion and the human head surface. Also, in this previous paper a detailed literature review on earmuff comfort was presented. This literature review shows that a large number of papers published on hearing protector comfort cannot explain some results for subjective evaluations where a high degree of comfort is associated with earmuffs with high headband force rather than low headband force. Our previous paper explains these results which are due to the distribution of the contact pressure between the earmuff cushion and the human head. This paper is a continuation of that research, with two new contributions. Firstly, a new measurement system is used which is more robust and has permanent sensors fixed on a dummy head and a flat surface at the same time. Secondly, the comfort index is calculated employing a second equation for comparison.

**323 Comparison of speech intelligibility between normal headsets and bone conduction hearing devices at call center**

*Maeda, Setsuo (1); Kobayashi, Koji (2); Nakatani, Hidenori (3); Nakatani, Akiko (3)*  
(1) Kinki University, Japan; (2) Toyota Tsushyo Corporation, Japan; (3) Goldendance, Japan

**ABSTRACT**

The purpose of this paper is to clarify the difference of speech intelligibility between the normal headsets and the bone conduction hearing devices. From the research results of the assessment of noise exposure of call center operators with wearing the headsets, the risk of hearing damage in call centers has been found out. Also, it has been found that the bone conduction hearing devices is better equipment than normal headsets for prevention of hearing loss of call-center operators. But, the difference of speech intelligibility between normal headsets and bone conduction hearing devices does not clear exactly yet. In this paper, the comparison experiment of speech intelligibility between normal headsets and bone conduction hearing devices at call-center was carried out at the laboratory. It was clear that the speech intelligibility had almost the same between normal headsets and bone conduction hearing devices. It was also clear the bone conduction hearing devices are able to use instead of the normal headsets without hearing loss damages at the call center.

**121 Anthropometry of External Auditory Canal by Non-contactable Measurement**

*Tu, Tsung-Hsien (1); Yu, Jen-Fang (2); Wang, Ren-Hung (2); Chen, Yen-Sheng (2)*  
(1) Industrial Technology Research Institute, Taiwan; (2) Chang Gung University, Taiwan

**ABSTRACT**

Human ear canals cannot be measured directly with existing general measurement tools. Furthermore, general non-contact optical methods can only conduct simple peripheral measurements of the auricle and cannot obtain the internal ear canal shape-related measurement data. Therefore, this study uses the non-invasive method, computed tomography (CT)



technology, to measure the geometric shape of the ear canal to complete the anthropometry of external auditory canal. The results of the study show that the average height and width of ear canal openings, and the depth of the first bend for male are generally longer, wider and deeper than those for female. In addition, the difference between the height and width of the ear canal opening is about 40% ( $p < 0.05$ ). Hence, currently the circular cross-section shape of the earplugs should be replaced by an elliptical cross-section shape during manufacturing for better fitting.

#### 1005 Construction Apprentices, Work and Noise

*Kosny, Agnieszka (1); Benke, Geza (1); Allen, Amy (1); Dimitriadis, Christina (1); Ewan, MacFarlane (1); Sim, Malcolm (1)*  
(1) Monash University, Australia

##### ABSTRACT

Noise-induced hearing loss (NIHL) continues to be a major problem for those employed in the construction industry. Work-related NIHL is among the most common occupational diseases. Besides hearing loss, exposure to loud, persistent noise has been linked to the development of Tinnitus, a persistent buzzing in the ear that can be debilitating and lead to sleep loss, depression and suicide. Noise at work is also associated with a range of mental health issues and lowered job satisfaction. In this study we examined the experiences and perceptions of a group of carpentry apprentices in Melbourne, Australia who were in the early stages of their career and training. The study focussed specifically on the issue of noise at work, apprentices' perceptions of noise as a hazard and their views toward noise control and hearing protection at work.

**Wednesday 11:00-12:40 Room 213**  
**Q4c Vibration and vibro-acoustic experiments**  
**Chair: Steve Conlon**

#### 441 Low frequency sound transmission of stiffened panels

*Kim, Hyun-Sil (1); Kim, Jae-Seung (1); Lee, Seong-Hyun (1); Seo, Yun-Ho (1)*  
(1) KIMM, South Korea

##### ABSTRACT

In this paper low frequency sound transmission of stiffened panels is studied. The panels are rectangular plates with lattice stiffeners, and boundary of the plates is clamped. The sound transmission of the panels is measured using a mini reverberation chamber. The specimen is MDF board of 3 mm thickness, and size is 1.2 m x 1.0 m. Two different lattice size is tested: 205 x 255 mm for 4 x 4 cells and 280 x 280 mm for 3 x 3 cells, where stiffener is made of wooden rod whose cross section is 30 x 30 mm or 35 x 50 mm. Insertion loss is measured when impact is applied to the base panel with and without stiffened panel, where microphone position is fixed in the receiving room. It is found that insertion loss shows a dip around 220 Hz, while insertion loss becomes larger as frequency decreases. It is important that Young's modulus of the stiffener must be sufficiently larger than that of the plate so that unit cell may show modes of clamped plate.

#### 695 Vibrational Energy Flow in Carbon Composite Structures

*Jaber, Mariam (1); Schneeweiss, Helmut (1); Bös, Joachim (2); Melz, Tobias (2)*  
(1) BMW Group, Germany; (2) Technical University of Darmstadt, Germany

##### ABSTRACT

Structures made from carbon composite materials are rapidly replacing metallic ones in the automotive industry because of their high strength-to-mass ratio. The goal of this study is to enhance acoustic comfort of cars made from carbon composites by comparing various carbon composites in order to find the most suitable composite in terms of mechanical and dynamic properties. To achieve this goal, the structural intensity method is implemented. This method can give information concerning the paths of energy propagated through structures and the localization of vibration sources and sinks. The significance of the present research is that it takes into account the effect of the material damping on the dissipation of the energy in a structure. The damping of the composite is presented as a function of its macro mechanical properties, frequency, geometry, and boundary conditions. The damping values are calculated from a 2D analytical model based on the laminate theory and the modal strain energy method. The benefit of this research for acoustics is that it demonstrates the effect of material properties on the passive control of vibrations in a structure. Consequently, vibrational energy propagated in carbon composite structures is reduced, and less noise is radiated.

#### 317 Measurement of Structural Intensity Using an Angular Rate Sensor

*Omata, Nobuaki (1); Nakamura, Hiroki (1); Waki, Yoshiyuki (2); Kitahara, Atsushi (2); Yamazaki, Toru (1)*  
(1) Kanagawa University, Japan; (2) Bridgestone, Japan

##### ABSTRACT

Measuring or calculating structural intensity allows us to understand the propagation paths of vibration and the amount of transmitted power. In this paper, a new structural intensity measurement method is proposed, in which an angular rate sensor and an accelerometer are used. The results obtained by the new method are compared numerically and experimentally with those from the 2-point method, which is commonly used measurement method using two accelerometers. However the finite difference calculation of displacements at two points for angular displacement cause an error in the process of the 2-point method. On the other hand, the new method using the angular rate sensor directly measure the angular rate, so it does not cause such errors. Effectiveness of the new method is shown through numerical simulation that the new method can measure the structural intensity in a beam structure at least as accurately as the 2-point method. Also, sensitivity against sensor noise is examined; the simulation results show that the new method and the 2-point method are both robust enough against regular sensor noise. Furthermore, structural intensity measurements on a simple supported acrylic beam were performed experimentally. The results show that new methods could measure structural intensity with similar accuracy as 2-point method.

**263 Influence of background noise on non-contact vibration measurements using particle velocity sensors**

*Fernandez Comesaña, Daniel (1); Yang, Fan (2); Tijs, Emiel (1)*  
(1) Microflown Technologies, The Netherlands; (2) Microflown Technologies, The Netherlands, University of Stuttgart, Germany

**ABSTRACT**

Structural vibrations are usually measured using accelerometers or laser Doppler vibrometers. However, the weight of the accelerometers can influence vibration patterns and lasers can have problems with non-reflective or fibrous materials. Alternatively, vibration can also be measured acoustically using particle velocity sensors positioned near the structure. Although the capabilities of this approach have been demonstrated in several studies, the influence of background noise on the results has been considered insufficiently thus far. This paper explores how non-contact vibration measurements using particle velocity sensors are affected by external sound sources; results from both simulations and measurements are presented and analysed.

**511 Experimental and numerical tools for the characterization of ultrasonic propagation for nuclear reactor application**

*Van De Wyer, Nicolas (1); Schram, Christophe (1); Van Dyck, Dries (2); Dierckx, Marc (2)*  
(1) von Karman Institute for Fluid Dynamics, Belgium; (2) Belgian Nuclear Research Center, Belgium

**ABSTRACT**

Due to being cooled by liquid metal, the next generation of nuclear reactors requires an ultrasonic visualization system for internal inspection and object detection. In such environment, acoustic propagation is submitted to peculiar conditions in terms of temperature and velocity gradients. In the core of the nuclear reactor, temperature gradients are 5K over 0.1 m and the velocity gradients reach 1 m/s over 0.2 m. The effects of these conditions on the ultrasonic propagation are investigated in a specific water facility, reproducing conditions similar to the nuclear application. The design and the characteristics of this new facility are presented in this paper. This includes a shadowgraph system for the visualization of the propagation of the acoustic wave in various conditions. The acoustic similitude between water and liquid metal is discussed for ensuring the validity of the water test for nuclear application. The propagation of ultrasonic waves in the full scale application is modeled by using a ray tracing algorithm. The validation of this algorithm has been performed by comparing the results with data from literature and numerical acoustic calculation. Preliminary results obtained with this algorithm are shown in the paper.

**Wednesday 11:00-13:00 Room 212**  
**P2 Vibrations in bridges, foot bridges and similar structures**  
**Chair: Len Koss, Vincent Rouillard**

**68 Mini-trampoline vibration exciter- Force measurements**

*Koss, Leonard Louis (1); Rouillard, Vincent (2)*  
(1) Monash University, Australia; (2) Victoria University, Australia

**ABSTRACT**

of a foot- bridge. The jumper on the mini-trampoline is "bobbing", just not lifting off the membrane to provide dynamic force to excite a foot- bridge into vibration in order to determine the stiffness and natural frequency of the bridge. The stiffness and natural frequency were identified as being 10.4 MN/m and 10.6 Hz respectively. Results of bobbing tests are presented to determine the accuracy of using a jumper's inertial force, mass of person multiplied by the body acceleration at the hip position, as being the transmitted force to the structure on which the mini- trampoline is stationed. The tests consisted of using two people with body masses of 55 kg and 100 kg and only employing three supporting legs that were instrumented to measure force transmitted to the ground. The three measured force signals were summed and analyzed using Matlab® software. A fourth channel was used to measure hip body acceleration for the case of the accelerometer strapped to the hip using a kidney belt. Analyzed data from the tests demonstrate that the first two inertial force harmonic amplitudes, fundamental and first overtone, compare well with the measured transmitted force amplitudes through the three legs for the 50 kg jumper. Comparisons for the 100 kg person were poor. Also, normalized force- frequency spectra will be presented to estimate what hip body acceleration is required for the jumper to just lift off from the trampoline membrane.

**105 A review of impact dampers to control cross wind vibration of structures due to vortex shedding**

*Koss, Leonard Louis (1); Melbourne, William H (1)*  
(1) Monash University, Australia

**ABSTRACT**

This paper reviews the application of chain, ball and beam impact dampers to control cross wind induced vibration of structures. These structures can vibrate with large amplitudes in the cross wind direction when the Scruton number has an insufficient value to prevent high amplitude vibrations and when the Strouhal number achieves a critical value. Thus, added damping is required to reduce the amplitude of motion to prevent possible fatigue failure of the structure in question. Impact dampers are relatively inexpensive and, in general, do not require exact tuning as for the case of tuned mass dampers. These two factors make impact dampers attractive as add on damping for slender structures. Important variables considered in the design of the impact dampers will be discussed and emphasis will be made on the need for testing of the largest possible experimental model of the structure, if possible, due to some of the unknowns, as for example, the coefficient of restitution of the impacting bodies required to provide damping.

**328 Research activities on INCE/J RTV (Road Traffic Vibration)-Model Part: 1 Prediction of road traffic vibration for elevated roads**

*Shimura, Masayuki (1); Kamiakito, Noboru (1); Fukada, Saiji (2); Sabo, Yasuyuki (3); Matsumoto, Yasunao (4); Osafune, Toshikazu (5); Iwabuki, Hiroshi (5); Yabe, Akito (6); Hama, Hirokazu (7)*

(1) Civil Engineering and Eco-Technology Consultants Co. Ltd., Japan; (2) Kanazawa University, Japan;; (3) Aichi Institute of Technology, Japan; (4) Saitama University, Japan;; (5) Nippon Expressway Research Institute, Japan;; (6) KKE Inc., Japan;; (7) Fujiengineering Co., Japan

**ABSTRACT**

There have been an increasing number of complaints from residents living along sides of highways about noise and vibration. Especially, ground vibration and low-frequency sound generated from bridges which are related to various factors such as bridge structures, ground conditions and traffic load. Therefore, the problems originated from this complex phenomenon are hardly solved. Concerning about vibration problem, this may be a problem only happened in Japan because of uniquely light-weight house lined close to the road. The committee of Japan Noise Control Engineering Society has published a version of road traffic vibration prediction formula named "INCE/J RTV-Model 2003". At present, this version is highly applicable for flat roads, but not for cutting-structure roads, banking-structure roads, and elevated roads. The objective of this report was to introduce research results of the working group (WG) related to elevated roads. In addition, results of performing the numerical simulation and extensive experiment on operated highways were shown.

**602 Research activities on INCE/J RTV (Road Traffic Vibration)-Model - Part: 2 Prediction of ground-borne vibration induced by traffic from cutting- and banking-structure roads -**

*Kunimatsu, Sunao (1); Kitamura, Yasutoshi (2); Yokota, Akinori (3); Uchida, Hidenobu (4); Shimura, Masayuki (5); Sano, Yasuyuki (6); Osafune, Toshikazu (7); Iwabuki, Hiroshi (7); Ishida, Riei (8); Hirao, Yoshihiro (9)*

(1) National Institute of Advanced Industrial Science and Technology, Japan; (2) Construction Engineering Research Institute Foundation, Japan; (3) Rion Co., Retired, Japan; (4) Tobishima Corporation, Japan; (5) Civil Engineering and Eco-Technology Consultants Co., Japan; (6) Aichi Institute of Technology, Japan; (7) Nippon Expressway Research Institute Co., Japan; (8) Freelance, Japan; (9) Kobayasi Institute of Physical Research, Japan

**ABSTRACT**

In INCE/J, the prediction method of the first version of INCE/J RTV-Model named INCE/J RTV-Model 2003 for environmental impact assessment on ground-borne vibration induced by the road traffic was published for flat roads in 2003. LV10 (10 percentile-exceeded frequency weighted acceleration level) is used in the vibration evaluation for an environmental assessment in Japan. For this reason, the prediction in the model was based on a method to calculate the summation in decibel considering traffic volume within the defined time from the unit pattern which is the time history of vibration acceleration level at the prediction point when one vehicle runs on the road. The unit pattern could be calculated by using a

simply empirical equation for the distance attenuation by Bornitz. In order to extend the previous model to a new applicable model for both cutting- and banking-structure roads, numerical simulations were performed. These results were summarized in this paper.

**798 Modal floor parameters and their correlation with footfall vibration**

*Duschlbauer, Dominik (1); Miller, Aaron (1)*

(1) SLR Consulting Australia Pty Ltd, Australia

**ABSTRACT**

Excessive floor vibration in buildings can make occupants uneasy and many prediction methods of varying degree of sophistication have been developed over the years to assist engineers in the prediction of footfall vibration. This paper presents a statistical analysis of footfall vibration measurements on a series of relatively stiff floors which exhibit impulse response behaviour. The correlation of dynamic floor properties (such as dynamic and static stiffness, fundamental frequencies, damping and functional combinations) with measured footfall vibration is discussed. The discussion considers correlation with time\_domain measurement data and one\_third octave data. More than thirty result sets are presented and subjected to statistical analyses.

**973 Vibration insulation of footbridges so as to reduce human discomfort**

*Sjöström, Anders (1); Clausén, Christin (1); Ingemansson, Victor (1); Austrel, Per-Erik (1); Persson, Kent (1); Sandberg, Göran (1); Bard, Delphine (1); Novak, Colin (2); Ule, Helen (3)*

(1) Lund University, Sweden; (2) University of Windsor, Canada; (3) Akoustik Engineering Limited, Canada

**ABSTRACT**

Low frequency vibrations in footbridges is a cause of annoyance for pedestrians crossing the bridge. Bagers bro, a footbridge built in Malmö (Sweden) had several constraints in the physical design that caused the first eigenmode of the bridge to be at 1.8Hz which is a severe problem for pedestrians. Therefore the bridge was fitted with tuned mass dampers to mitigate the vibration problem. To evaluate the performance of the dampers and the accuracy in the predictions of the Finite Element (FE) Models of the bridge, an investigation through modeling and measurements with respect to the performance of the tuned dampers fitted to the bridge has been done. The measurements were performed both with and without the mass dampers engaged. The results from the operational modal analysis of the bridge were compared with finite element simulations. The mass dampers were found to greatly improve the vibratory performance of the bridge in as much as making an otherwise almost unusable bridge acceptable.

**Wednesday 10:40-12:00 Room 211**  
**K1b Noise barriers**  
**Chair: Jean Piere Clairbois, Crina**  
**Oltean-Dumbrava**

**570 The effectiveness of particle damping for use on vertical surfaces**

*Ott, Mark (1); Weisbeck, Jeffrey (1); Gerges, Samir N Y (2); Bustamante, Marcelo (2)*  
 (1) ITT Control Technologies, USA; (2) Federal University of Santa Catarina, Brazil

**ABSTRACT**

Particle damping has been shown to effectively reduce vibrations on complex structures and systems. Particle damping relies on intimate contact with the vibrating surface to be effective. Previous studies have focused on applying particle damping to horizontal structures where gravity ensures contact with the surface. However, many applications would make use of this damping technology on vertical surfaces. This paper investigates the added challenge and methodology of packaging particle damping for vertical applications and studies the variables that impact performance. The outcome will establish the key system parameters which drive performance and allow the capability to optimize particle damping effectiveness for these types of systems.

**705 On enhanced sound absorption by non-uniform liners**

*Campos, L M B C (1); Oliveira, J M G S (1)*  
 (1) Técnico, U.Lisboa, Portugal

**ABSTRACT**

The use of acoustic liners is a common means of noise reduction in jet engine exhausts. The quest for more effective sound absorption mechanisms in cylindrical ducts has led to the consideration of non-uniform liners, with impedance varying circumferentially, axially, or in both directions. The present paper is based on the theory of mode coupling in a non-uniformly lined cylindrical duct and considers the complementary problem of generation of sound or excitation of coupled modes by a source distribution. The sound field due to an arbitrary source distribution is obtained as a superposition of eigenfunctions corresponding to complex eigenvalues for the radial wavenumbers and natural frequencies taking into account that the radial, axial and azimuthal modes are coupled by the non-uniform wall impedance, and including resonant and non-resonant cases. The waveforms are illustrated for point monopole, dipole and quadrupole sources and a continuous monopole distribution. It is shown that a non-uniform liner provides a greater attenuation than a uniform liner with the same average impedance if it is 'well-matched' to the sound field, that is, if it has higher impedance at the peaks and lower at the nodes of the standing modes.

**706 On the effect of shear and bias flow on the performance of acoustic liners**

*Campos, L M B C (1); Legendre, C (2); Sambuc, C (2)*  
 (1) Técnico, U.Lisboa, Portugal; (2) Free Field Technologies S. A., Mont-Saint-Guibert, Belgium

**ABSTRACT**

The acoustic-vortical wave equation is derived describing the propagation of sound in (i) a uni-directional shear flow with a linear velocity profile upon which is superimposed (ii) a uniform cross flow; together with an impedance wall boundary condition representing the effect of a locally reacting acoustic liner in the presence of bias and shear flow. This leads to a third-order differential equation in the presence of cross flow, and in its absence simplifies to the Pridmore-brown equation (second-order); also the singularity of the Pridmore-brown equation for zero Doppler-shifted frequency is removed by the cross flow. Because the third-order wave equation has no singularities (except at the sonic condition), its general solution is a linear combination of three linearly independent MacLaurin series in powers of the distance from the wall. The acoustic field in the boundary layers is matched through the pressure and horizontal and vertical velocity components to the acoustic field in a uniform free stream consisting of incident and reflected waves. The scattering coefficients are plotted for several values of the five parameters of the problem, namely the angle of incidence, free stream and cross-flow Mach numbers, specific wall impedance and Helmholtz number using the boundary layer thickness.

**193 An experimental investigation of cavity noise control using mistuned Helmholtz resonators**

*Chintapalli, V Surya Narayana Reddi (1); Padmanabhan, Chandramouli (1)*  
 (1) IIT Madras, India

**ABSTRACT**

The major objective of this paper is to demonstrate higher noise reduction when an acoustic cavity is coupled to a combination of Helmholtz resonators (HRs) tuned to slightly different frequencies. An acoustic cavity, whose first two modes are close to each other, is selected for carrying out experiments. These are carried out to understand the behaviour of the coupled Helmholtz resonator-cavity system; the cavity is excited using two speakers and sound pressure is measured using two microphones on a rotating boom. When a resonator is coupled to a cavity, the acoustic natural frequency to which it is tuned, splits into two modes, one below and one above the original frequency. When multiple resonators are used, it is demonstrated that higher noise reduction can be achieved by mistuning them to the new split frequencies rather than tuning all of them exactly to the first cavity mode. Similarly, higher noise reduction is seen when resonators are placed near edges/corners of the cavity walls than at the centres of the boundary walls. In all these cases anti-nodal locations are selected for superior noise reduction. A detailed study has been carried out and guidelines for tuning resonators for superior noise control is proposed.

**Wednesday 10:40-13:00 Room 210**  
**N9b Impact noise in buildings**  
**Chair: Berndt Zeitler, Atsuo Hiramitsu**

**471 Design and Acoustic Performance of a Spring Isolated Outdoor Rooftop Basketball Court**

*Campbell, Alex (1); Cosstick, Lloyd (2); Murray, Timothy (2); Yates, David (1)*  
 (1) WSP, Australia; (2) Embelton, Australia

**ABSTRACT**

The proposal of a rooftop basketball court created an issue of significant impact/footfall noise and structural vibration ingress to the sensitive environment beneath. As part of a new building in a dense urban environment, a unique solution had to be designed due to the maximum weight capacity of the underlying rooftop structural slab and FFL design controls. Further challenges were faced in the form of fluctuations of up to 30 mm in the level of the underlying structural slab and subsequent excessive deflection caused by a relatively high live load. The final design incorporated the use of over 300 cast in 'jack-up' style mounts complete with 25 mm deflection springs within a 100 mm secondary concrete slab covering an area of approximately 630 m<sup>2</sup>. Installation of the court encountered few problems and upon completion small deflections of the slab could be felt underfoot however there were no unfavourable 'trampolining' effects generated by live loads. Completion testing showed a significant reduction in impact noise levels between the isolated court and an exposed portion of the structural slab.

**884 Direct impact sound insulation of cross laminate timber floors with and without toppings**

*Zeitler, Berndt (1); Schoenwald, Stefan (2); Sabourin, Ivan (1)*  
 (1) National Research Council, Canada; (2) Empa Swiss Federal Laboratories for Materials Science and Technology, Switzerland

**ABSTRACT**

Cross Laminated Timber (CLT), which is well suited for construction of tall buildings, is becoming a more popular construction material in North America. However, to ensure comfortable living conditions, sound insulation measures are necessary. The study presented here compares results of direct impact sound insulation of 5- and 7-ply CLT floors covered with different concrete toppings on various interlayers. Improvements of up to 21 dB in Weighted Normalized Impact Sound Pressure Level ( $L_{n,w}$ ) were observed using a newly proposed reference floor for CLTs. Furthermore, the improvements of floor coverings on CLT floors are compared to those achieved on other types of construction, such as the reference concrete floor. The improvements of  $L_{n,w}$  tend to be higher on the concrete floors than on the CLT floors tested. These and other findings will be presented.

**908 Flanking transmission in three different lightweight wooden building types**

*Sjöström, Anders (1); Negreira, Juan (1); Bard, Delphine (1); Sandberg, Göran (1); Novak, Colin (2); Ule, Helen (3)*  
 (1) Lund University, Sweden; (2) University of Windsor, Canada; (3) Akoustik Engineering Limited, Canada

**ABSTRACT**

Three different Swedish lightweight multistory buildings have been investigated with respect to the flanking transmission over an inner wall. Among the buildings analysed, one of them had been used by residents for three years and the two other were only just erected and being built respectively. A tapping machine and a Japanese ball were used as excitation sources so as to produce vibrations in the structures over the junctions in the respective buildings. Despite of the different vibratory performances depending on the construction type, all three buildings were found to perform well in the low frequency range

**786 Comparing low frequency impact noise using a tapping machine and heavy/hard impact source on various fitness floor assemblies**

*Gartenburg, Paul*  
 Pliteq Inc., Canada

**ABSTRACT**

Energy introduced into a concrete slab by a tapping machine is not sufficient to simulate much larger impact levels as seen in fitness areas. Excitation of the slab is not seen at the lower frequencies, due to the low energy transmission of the tapping machine hammers. When a 7 kg spherical weight is dropped from a height of 1 m and the results are measured using 5 velocity sensors placed radially from the underside concrete slab center, drastically different results are observed in the calculated velocity level values, when compared to tapping machine results. These results are seen in the tested performance of different fitness floor assemblies. The added benefit of using slab-mounted velocity sensors allows for readings to be taken at lower than the 100 Hz one-third octave band. Additionally, placing the sensors radially from the underside concrete slab center allowed for the analysis of energy decay rate as a function of distance from the impact source.

**724 Measuring  $L_n$  without using a tapping machine?**

*Dodd, George (1); Yen, Benjamin (1)*  
 (1) University of Auckland, New Zealand

**ABSTRACT**

We propose an alternative method for measuring  $L_n$  which we suggest will make field testing of buildings easier and more attractive to do. Although field testing is essential for quality control during construction, and to demonstrate conformity with building code requirements, it has challenges which make it unpopular. In particular the tapping machine's fixed power-output and hence  $L_n$ 's lack of immunity to interference from background noise rules out its use during construction. In addition the formal measurement procedure can be time consuming, it involves the cost of a tapping machine and it requires a specialist acoustical engineer. In our method  $L_n$  is inferred from a measurement of the airborne sound insulation

(R) by using a relationship between R and Ln. R can be measured by either using a high power source, or by coherent averaging of a deterministic signal, hence background noise interference is obviated. An impact on the floor is still necessary to determine the effect of its actual impedance. However our method uses a single hand-held hammer and infers the effect of impacting with the tapping machine by measuring the reaction force on the hammer.

**493 Accuracy of prediction methods for impact sound pressure levels**

*Griffin, Daniel*

Marshall Day Acoustics, Australia

**ABSTRACT**

There are various methods available for predicting impact sound pressure levels of floors. the accuracy of these prediction methods can be an important aspect of designing or refining a proposed flooring system. This paper provides a brief outline of some available prediction methods for massive (typically concrete) floors and light weight floor constructions. Consideration is given to what tolerances are suitable for evaluating prediction accuracy, with reference made to variation in laboratory measurements of impact sound pressure level (measurement reproducibility). Prediction results are presented for a number of different constructions to demonstrate the extent of agreement between prediction methods and laboratory results. Both massive and light weight flooring systems are considered, with various arrangements of floor covers and ceilings.

**484 Effect of modulation on perceived annoyance of floor impact noise**

*Lee, Sinyeob (1); Hwang, Dukyoung (1); Park, Junhong (1)*

(1) Hanyang University, South Korea

**ABSTRACT**

Floor impact noise generation depends on the configuration of multistory building structures. In this study the sound radiation mechanisms between the two different structural configuration are compared through experimentation using laboratory setup of the scaled model. The transfer of vibration energy from external impact source is calculated and compared with the measured results. Parameters affecting the radiated sound energy are determined and evaluated. The in and out-of phase vibrations of the building floors resulted in tonal sound radiation at two-closely located frequencies which resulted in modulated floor impact sound. This modulation increased the perceived annoyance of residents. Eventually, a design method to efficiently reduce the floor impact sound is proposed.

**Wednesday 10:40-12:00 Room 209**

**D9b Mufflers and silencers**

**Chair: Yatsze Choy, James McIntosh**

**102 Sound attenuation using duct silencers with micro-perforated panel absorbers**

*Yu, Xiang (1); Cheng, Li (1); Tong, Yuhui (2); Pan, Jie (2)*

(1) Hong Kong Polytechnic University, Hong Kong; (2) University of Western Australia, Australia

**ABSTRACT**

Micro-perforated panel (MPP) can be used as non-fibrous acoustic absorber which can provide broadband sound absorption performance. In this study, a sub-structuring methodology based on the Patch Transfer Function (PTF) approach to deal with duct silencers with MPP absorbers and internal partitions is proposed, and the sound attenuation performance of such silencers is investigated. Reactive silencers with only internal partitions are shown to exhibit strong resonant pattern, with each sub-divided chamber acting as acoustic resonators for strong sound reflection. On the other hand, hybrid silencers which combine the reactive effect of partitions and dissipative effect of MPP absorbers are studied. Simulation results show that MPP parameters such as hole diameters have strong influence on the silencing performance. Although the hole diameter of MPP is typically very small (less than 1mm), the reactive effect of MPP silencer is still obvious. The calculation accuracy of the proposed formulation is validated against finite element method (FEM) analysis.

**470 Performance analysis of a suction muffler in a hermetic reciprocating compressor using CAA techniques based on Lattice Boltzmann Method**

*Lee, Songjune (1); Cheong, Cheolung (1); Lee, Hyo Jae (2); Kim, Haeseung (2)*

(1) Pusan National University, South Korea; (2) LG Electronics, South Korea

**ABSTRACT**

A suction muffler in a hermetic reciprocating compressor is used for reducing noise induced by pressure pulsation inside the compression chamber. Since complex flow passages inside the suction muffler inevitably lead to the adverse effects on the efficiency of the compressor, high-performance mufflers in terms of both flow and acoustics are favored. However, the acoustic and flow performances of the muffler are still separately assessed in terms of the insertion loss and pressure drop in the related industry. In fact, flow and acoustic waves inside the muffler interacts strongly so that the separate prediction cannot provide the reliable assessment for each performance. In this paper, acoustic and flow performances of a suction muffler used in a reciprocating compressor is numerically investigated using the computational aeroacoustic (CAA) techniques based on the Lattice Boltzmann Method, which solves flow and acoustics simultaneously. To improve the accuracy of numerical simulation results, the measured static pressure at the inlet of the compression chamber is used at the outlet boundary condition. The energy conversion between the acoustic and vorticity waves are identified, which manifests that the interactions between the flow and acoustic quantities play important roles in determining the acoustic and flow performances of a muffler. The identified physical phenomena

can be used to provide new design concepts to maximize the flow rate while keeping the noise level at a minimum.

**579 Acoustic two-port simulation model for the particle oxidation catalyst (POC®)**

*Hynninen, Antti (1); Åbom, Mats (2)*  
(1) VTT Technical Research Centre of Finland, Finland; (2) KTH Royal Institute of Technology, Sweden

**ABSTRACT**

The reduction of the exhaust noise from internal combustion engine (IC-engine) is mainly managed by proper silencer design, while less attention is paid to the acoustic performance of the after treatment devices (ATD). It is known from the earlier studies, that the transmission loss of a typical ATD unit can be quite significant. An ATD unit for diesel engines is classically assembled from several specific parts such as selective catalytic reducers (SCR), diesel oxidation catalysts (DOC) and diesel particulate filters (DPF). One new alternative to the conventional DPF is the particle oxidation catalyst (POC®). The substrate used in the POC-X type filter consists of fine, corrugated metallic wire mesh screens piled askew and rolled into a cylindrical shape. In this paper an acoustic two-port simulation model for POC-X is sought starting from the classical Kirchhoff solution for prediction of the acoustic wave attenuation in narrow channels. According to experimental studies, correction factors to the narrow channel two-port model are proposed.

**940 Hybrid coupling method to nonlinear acoustic source and linear duct system in compressor**

*Oh, Seungjae (1); Wang, Semyung (1)*  
(1) GIST, South Korea

**ABSTRACT**

In recent years, when consumers buy home appliances and cars, energy efficiency has been considered to be significant. Therefore, studies on how to increase the energy efficiency are being accelerated. A representative study is to raise the energy efficiency of the compressor which is a core part of the refrigerator using acoustic theory in suction part. However, the acoustic source characteristics in suction part of the compressor are the nonlinear and time-varying. While the acoustic propagation characteristics of suction muffler are the linear and time-invariant. Thus, couplings between the source represented in the time domain and wave propagation represented in the frequency domain are not easy. In this study, we showed how to effectively coupling. That is, in the frequency domain, the input impedance of muffler was measured. Then, the impedance changes to state space form using modal method. And a state space model is coupled to the acoustic source model in the time domain. This approach was verified through the experiment with speaker model

**Wednesday 10:40-12:20 Room 208**  
**F1b Noise events from transportation noise**  
**Chair: Lex Brown, Bert de Coensel**

**507 Smart sound monitoring for sound event detection and characterization**

*De Coensel, Bert (1); Botteldooren, Dick (1)*  
(1) Ghent University, Belgium

**ABSTRACT**

As there is little doubt that the perception of one's acoustic environment is mainly driven by noticed sound events, an environmental sound policy approach with a focus on the local urban neighborhood scale should address all noticeable sound events. These sound events have in common that they are not easily predictable, and that they show a very strong spatial variability. Dense urban sound monitoring networks are therefore well suited to assess such sound events, and could support a micro noise policy based on targeted action plans. This paper reports on the Smart Sound Monitoring project that was carried out on the Katendrecht peninsula, located within the Rotterdam harbor zone. A distributed measurement campaign using 12 intelligent sound measurement devices, active during several months, was carried out in combination with an online, continuous survey. Through the latter, inhabitants of the case study area were encouraged to signalize, instantly and triggered by perception, salient sound events that occurred around their dwelling, and to report their general sleep quality on a daily basis. The presented approach can be used to relate the occurrence and acoustical characteristics of sound events to reported events and sleep quality.

**206 Influence of loudness of noise events on perceived sound quality in urban context**

*Delaitre, Pauline (1); Lavandier, Catherine (1); Ribeiro, Carlos (2); Quoy, Mathias (3); D'Hondt, Ellie (4); Gonzalez Boix, Elisa (4); Kambona, Kennedy (4)*  
(1) MRTE, France; (2) Bruitparif, France; (3) ETIS, France; (4) VUB, Belgique

**ABSTRACT**

One of the aims of Cart\_ASUR project is to propose an indicator of urban sound quality based on perceptive and acoustic data. The originality of this project consists in using mobile phone technology to collect data. 60 persons had to assess about 20 locations in Paris at four or five homogenous periods (days, evening, night, summer, winter) with a specific questionnaire through mobiles. In the questionnaire, the first questions are related to global sound environment characterization with semantic scales. The next questions concern the perceived loudness assessment of some emergent sources (light vehicles, trucks, bus and mopeds). Finally, the last questions deals with the presence time ratio assessment of sources that do not emerge from the background (birds, voices, steps, etc). Before each assessment, sound pressure level is recorded each second from the mobile phone's microphone during a 10-minute period. In this paper, the link between global sound quality and loudness assessment of emergent sources is developed. A particular attention is devoted to the situation classification. Depending on the type of location, some identified sources have an influence on the sound quality of the environment.

## 82 Sound Exposure Levels from Trains and Sleep Disturbance

*Jabben, Jan (1); Potma, Charlos (1)*  
(1) RIVM, The Netherlands

### ABSTRACT

Train passages during the night can seriously affect the sleep quality in nearby dwellings. Ongoing research aims to improve our understanding of how environmental noise, in connection with human physiology, causes sleep disturbance. A widely used approach to estimate noise effects on sleep quality is to make use of dose-response relations with Lnight as a predictor for the percentage of disturbed people. The underlying mechanisms that govern sleep disturbance by noise events are still not fully understood and predictions can deviate considerably from surveys. An alternative approach is to assess the probability of sleep disturbance of each individual event and deduce the overall sleep quality from all individual events during the night. In this paper, both methods are compared for railway noise, using RIVM monitoring results of sound exposure levels from trains over 2013. The paper discusses how a better understanding of sleep disturbance by individual noise events, may help to improve or refine dose-response relations that are based on long time average noise levels.

## 642 Mobility and life quality relationships – Measurement and perception of noise in urban context

*Misdariis, Nicolas (1); Marchiano, Regis (2); Susini, Patrick (1); Ollivier, Francois (2); Leiba, Raphael (2); Marchal, Jacques (2)*  
(1) CNRS-UPMC, France; (2) UPMC, France

### ABSTRACT

Noise in urban context is one of the main concern in terms of societal impact. In fact, sound environment is addressing issues at various levels: transmission of information, social relations, perception of comfort, and in the worst cases, health effects on city-dwellers. The paper will present the first steps of an academic research concerning measurement and perception of noise in urban context – otherwise integrated into the broader framework of a Chair of Research dealing with relationships between mobility and quality of life in urban environments, in terms of air/sound pollution and healthcare. The following content will be developed : i/ elements of a state-of-the-art in the joined fields of measurement/simulation and perceptual evaluation of urban soundscapes; ii/ first planned axes of research focusing on interactions between elementary sources mainly coming from urban mobility – assuming that transportation is one of the main source of noise in the city – with their context either in physical and perceptual points of view; iii/ according to the work progress, first results concerning preliminary experiments conducted on dedicated urban environments.

## 577 Towards new less noisy mobility patterns in cities

*Wolfert, Henk*  
DCMR EPA, The Netherlands

### ABSTRACT

Traffic noise, especially road traffic noise, is capturing most of our urban areas. Around 50 % of the people living in European cities is exposed to noise levels above 55 dB LDEN. If measures remain noise will increase due to the increase of car use and

mileage that might be expected. The percentage mentioned is derived from the noise observatory that comprises data from the first and the second round noise mapping according to the Environmental Noise Directive EU. EUROITIES working group noise, concerned about these figures and developments, decided to draft a paper on urban transport noise. This paper considers the mobility in urban areas from numerous perspectives and comes to the conclusion that noise, especially extreme noise situations in cities could be mitigated and even solved. This by following a holistic approach, combining conventional technical measures, smart or innovative solutions, traffic management solutions, Intelligent Transport Systems (ITS) and ICT solutions but also educational and solutions based on insights and instruments derived from social sciences. Efforts are needed on legislative, policy, technical and societal level to achieve this. A brief summary of the paper on urban transport.

**Wednesday 11:00-13:00 Room 207**  
**R3 Numerical methods - Interaction with**  
**submerged structures**  
**Chair: Adrian Jones**

## 108 Moving boundary similarity method and its application on ship structural borne noise prediction

*Pang, Fu-zhen (1); Miao, Xu-hong (1); Tang, Dong (2); Song, Hong-bao (2)*  
(1) Naval Academy of Armament, China; (2) Harbin Engineering University, China

### ABSTRACT

Based on the principle of structural dynamics, the unitary of exciting force and moving boundary condition is proved by vibration analyzing of an equipment-base system. By constructing "virtual force" to keep the consistency of moving boundaries of structure with dynamic parameters locally unknown, moving boundary similarity method (MBSM) is proposed to get structural dynamic response of given moving boundary conditions with structural dynamic parameters locally unknown. The effectiveness of MBSM is also verified. On that basis, MBSM is applied to the study of ship's underwater vibration and noise radiation. The underwater noise radiation characteristic of a ship is analyzed. Result shows that the underwater vibration and sound radiation of a ship is highly related with location and frequency of excitations. On one hand, ship structural borne noise radiation is mainly concentrated in the vicinity of excitation of the middle and aft region of ship, followed by aft and bow. On the other hand, the underwater noise radiation is more uniformly distributed along the ship length in low frequency band, while the inhomogeneity and directivity gradually increases as excitation frequency increases.



**135 An Analytical Substructure Method for the Analysis of Vibration Characteristics on Conical-Cylindrical-Spherical Combined Shells in Vacuum**

*Chen, Meixia (1); Xie, Kun (2); Wei, Jianhui (2); Deng, Naiqi (2)*  
(1) Huazhong University of Science and Technology, China & The University of Western Australia, Australia, The University of Western Australia, Australia; (2) Huazhong University of Science and Technology, China

**ABSTRACT**

In this paper a new semi-analytic numerical method i.e. Analytical Substructure Method (ASM) is established to study the vibration characteristics of conical-cylindrical-spherical combined shell with arbitrary boundary conditions in vacuum. First, according to the structure types, the whole structure is divided into substructures: conical shell, annular circular plates, bulkheads, cylindrical shells, open spherical shell. Second, by using power series method, annular circular plate theory, and wave propagation method and by introducing auxiliary functions, the dynamic equations of the substructures are formed respectively. Then using the boundary conditions and the displacement and force continuity conditions between the substructures, the dynamic equation of the whole structure is established. Finally, the vibration characteristics of the structure are obtained. By comparison with computational results obtained from a finite element method, the accuracy and the efficiency of ASM are verified. Three common boundary conditions of the structure are discussed in numerical analysis. The paper demonstrates that ASM is applicable for complex structures with all tested boundary conditions, providing a new approach and idea to study the vibration characteristics of complex combined shells.

**80 Wave based method for vibration and acoustic characteristics analysis of underwater cylindrical shell with bulkheads**

*Xie, Kun (1); Chen, Meixia (1); Deng, Naiqi (1); Xu, Kun (1)*  
(1) Huazhong University of Science and Technology, China

**ABSTRACT**

Wave based method (WBM) is presented to analyze the vibration and acoustic responses of underwater cylindrical shell with bulkheads under a radial harmonic excitation. The hull is divided into several substructures and the dynamic field variables in each substructure are expressed as wave function expansions. The stiffeners and bulkheads are treated as discrete members and the equations of motion of annular plate are adopted to describe the motion of them. Boundary and continuity conditions between adjacent substructures are used to form the final matrix to be solved. The far-field radiated sound pressure is then calculated by means of the Element Radiation Superposition Method (ERSM). By comparison with computational results obtained from a fully coupled finite element/boundary element model, the present method is verified. Furthermore, effects of bulkheads and location of exciting force on vibro-acoustic characteristics of cylindrical shell have been discussed. The results show that bulkhead thickness has negligible influence on the response, but the number of bulkheads, the location of bulkheads and the exciting force have significant effects.

**146 The study on sound radiation of semi-submerged cylindrical with antisymmetric velocity distribution**

*Zhang, Junjie*  
China Ship Development and Design Center, China

**ABSTRACT**

The vibro-acoustic characteristics of cylindrical shell are widely studied because of its strong engineering application background, especially when the shell is immersed in infinite fluid field or partially immersed. In the present paper, the method for analyzing sound radiation of semi-submerged finite cylindrical shell with antisymmetric velocity distribution is first proposed. The orthogonality of trigonometric function and sound field distribution characteristic of dipole are utilized to establish the formulas. Sound radiation diagram of representative velocity distribution is depicted. Numerical calculations show that BEM Sysnoise is an effective tool to deal with the sound radiation of semi-submerged cylindrical shell.

**606 Sound radiation from nested cylindrical shells**

*Wu, Hongjian (1); Peters, Herwig (1); Kessissoglou, Nicole (1)*  
(1) UNSW Australia, Australia

**ABSTRACT**

Fluid-loaded nested cylindrical shells are modelled using a doubled-walled cylindrical shell structure closed at each end by circular end plates and excited by a transverse force at one end. The effects of various influencing factors on the radiated sound power are examined corresponding to non-concentricity of the cylindrical shells, entrained fluid and rib connections in the annular space between the inner and outer shells. The doubled-walled cylindrical shell is modelled using two different approaches to consider low and high frequencies. In the first approach, a fully coupled finite element/boundary element model of the fluid-loaded nested cylindrical shells is developed, whereby the finite element method is used to model the structure and the boundary element method is used to model the entire fluid domain. The second approach uses an energy based method to consider the high frequency range. A hybrid finite element/statistical energy analysis technique is developed whereby the rigid components corresponding to the annular ribs and end plates are modelled using finite elements, while the fluid and flexible shell structures are modelled using statistical energy analysis. Results obtained using the deterministic and statistical numerical methods are compared.

**128 Lattice-Boltzmann simulation of circular column coupled with square column in cross flow**

*Shi, Dongyan (1); Li, Hongqun (1); Wang, Zhikai (1); Jiao, Han (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

Based on the single relaxation time lattice Boltzmann method, a numerical simulation model of fluid flow over two side-by-side columns is developed. One is a resting square column and the other is a circular cylinder which can rotate with a constant velocity. The calculation is carried out at a pitch ratios ( $S/D = 0.5$ , where  $S$  is the gap distance while  $D$  is the circular column diameter) at Reynolds number of 150. The effects of the curved boundary offset lattice links and the solid boundaries velocity is introduced into the model. Comparing

the benchmark problem of fluid flow over a single column, the drag and lift forces ( $C_d$ ,  $C_l$ ) and the wake flow characteristics are studied to verify the model and investigate the interaction of the two columns. The results indicate that the interaction of the two columns has significant influence on dynamic characteristics of fluid flow over columns. The regular vortex shedding comes into irregular. The  $C_d$  and  $C_l$  increase under the effect of the interaction. Furthermore, with the rotating velocity is increased, the fluctuation of  $C_d$  and  $C_l$  becomes more serious.

**Wednesday 10:20-11:20 Room 206**  
**K3 Noise control within offshore facilities and maritime vessels**  
**Chair: Greg Stewart**

**48 Verification of a Duct Resonator Array for Larger Pipe Diameters**

*Newman, Michael James (1); Garrido, Maria (2); Liu, Zheji (3); Ryliskis, Andre-Pierre (4); Colette, Julien (4); Eugui, Inigo (5); Haaheim, Ole Georg (6)*  
 (1) Lifetec AS, Norway; (2) Lifetec, Norway; (3) Dresser-Rand, USA; (4) Dresser-Rand, France; (5) Aibel, Norway; (6) Statoil, Norway

**ABSTRACT**

A reactive silencer for gas compressors and associated pipework has been investigated for use in pipes of larger diameter. This complements the investigation carried out previously on a silencer for smaller diameter pipes. The acoustic performance of the two sizes of Duct Resonator Arrays are compared. The silencer is applied to the inlet and discharge pipes as spool pieces. The evaluation was carried out as sound insertion loss measurements. The arrays can be custom tuned to deliver maximum attenuation at the predominant tonal noise component (commonly at the blade passing frequency) of the corresponding compressor or be tuned to a frequency range with broadband high levels of noise. Workshop verification measurements demonstrated that the duct resonator array reduces narrow band noise by 14dB or more for the designed bandwidth (2-3 kHz) and broadband noise by up to 8dB (1-2kHz). This technology provides a flexible solution for the implementation of noise control measures to compressor piping systems.

**1014 A method for demonstration of ALARP for noise control**

*Keswick, Paul (1); McLoughlin, James (1); Stewart, Greg (1)*  
 (1) SVT Engineering Consultants, Australia

**ABSTRACT**

The regulatory environment for offshore facilities is moving away from hard limits to "As Low as Reasonably Practicable". As noise control experts, if we want to see our designs and recommendations implemented, acousticians must move beyond the realm of what is possible, and noise control design in isolation, into the realm of operations and practicality of implementation on a broader scale. Getting buy-in to noise controls in the design phase has historically been difficult as we must first overcome entrenched attitudes to noise risk and the value of noise control. SVT Engineering Consultants has developed a quantitative method for undertaking this analysis

and determining an ALARP position, which has been used on a number of projects and seen the successful implementation of noise control. A particular feature of the process is its resistance to inherent bias in attitudes to noise control by all parties. This paper presents an overview of the process.

**473 Isolator Internal Resonance and Radiated Noise from Ships**

*Dylejko, Paul (1); MacGillivray, Ian (1); Skvortsov, Alex (1)*  
 (1) DSTO, Australia

**ABSTRACT**

Reducing the radiated noise from ships is becoming increasingly important as ship-builders aim to reduce the disturbance to marine life, passengers and crew. A major contributor is on-board machinery which typically radiates noise to the water column from both structure-borne and air-borne transmission paths. Problematic machinery is often decoupled from the hull by supporting it on resilient isolation mounts. This paper predicts the effect of isolator internal resonance on the underwater radiated noise by considering a typical marine diesel characterised by source levels estimated from empirical relationships. The structure-borne and air-borne transmission paths are resolved individually using approximate analytical methods. It is subsequently demonstrated that the reduction of isolator internal resonances could provide a significant reduction in the underwater radiated noise from ships.

**Wednesday 11:40-13:00 Room 206**  
**Q2g Numerical methods in vibro-acoustics**  
**Chair: Weikang Jiang, James Forrest**

**181 Research on vibration and acoustic radiation of planetary gearbox housing**

*Zhang, Tianmu (1); Shi, Dongyan (1); Zhuang, Zhong (1)*  
 (1) Harbin Engineering University, China

**ABSTRACT**

In this paper, an analysis model of planetary gearbox housing is constructed based on finite element method/boundary element method (FEM/BEM). Its vibration and acoustic radiation characteristics are investigated. Firstly, the finite element model is established using ABAQUS. The main factors affecting its dynamic characteristics are observed through modal analysis. Then impact of main structural parameters on transmission characteristics is investigated. Secondly, the acoustic radiation analysis model is established using VA-One on the basis of vibration characteristics analysis. Acoustic pressure nephogram, noise spectrum, noise radiation and modal contribution of housing surface are obtained through the numerical analysis. The effects of main structure parameters on noise radiation characteristics are observed. It is shown that the rigidity of the front and back plate is weaker than the circumferential rigidity of the housing. However, reinforcing the local thickness of the front and back plate cannot improve the dynamic characteristics due to the effect of shafting in the gearbox housing. Finally, acoustic protection of the housing is carried out. It can be observed that changing the loss factor can effectively reduce the noise of the housing structure. This investigation can provide technical support on the scheme design of the planetary gearbox housing.

**187 Analysis of acoustic radiation of a ring-stiffened cylindrical shell in underwater based on precise integration transfer matrix method**

*Pang, Fu-zhen (1); Wu, Chuang (2); Wang, Qingshan (3); Song, Hong-bao (2)*

(1) Harbin Engineering University, China, Naval Academy of Armament, Beijing, 100161, P. R. China; (2) Harbin Engineering University, China; (3) College of Mechanical and Electrical Engineering, Harbin Engineering University

**ABSTRACT**

Based on transfer matrix theory and inhomogeneous precise integration method, precise integration transfer matrix method (PITMM) is developed to study the dynamic response of stiffened cylindrical shell. Firstly, field transfer matrix and point transfer matrix for stiffened cylindrical shell are obtained based on Flügge theory, transfer matrix theory and Helmholtz equation. The effect of generalized acoustic pressure excitation is handled with the inhomogeneous precise integration method and increment-dimensional storage methods. According to the boundary conditions for both ends of cylindrical shell and motion continuity condition on the fluid-solid interaction, the coefficient of acoustic pressure is calculated. Thus, acoustic radiation of the stiffened cylindrical shell is determined. The accuracy of the proposed approach has been demonstrated by comparing the current results with those in the literature and with some experimental results. On this basis, the effects of boundary conditions, loss factors of structures and fluid medium on the acoustic radiation of stiffened cylindrical shell are discussed. It is shown that, the acoustic radiation pressure of structure is largest for free boundary condition, and becomes smaller in that order for simply supported and clamped boundary condition. With an increase of loss factors of structures, the acoustic radiation pressure monotonically decreases. However, the radiation pressure increases with an increase of fluid medium impedance.

**200 Free vibration analysis of orthotropic rectangular Mindlin plates with general elastic boundary conditions**

*Shi, Dongyan (1); Zhuang, Zhong (1); Zhang, Tianmu (1)*  
(1) Harbin Engineering University, China

**ABSTRACT**

In this investigation, a modified Fourier solution based on the Mindlin plate theory is developed for the free vibration problems of orthotropic rectangular Mindlin plates subjected to general boundary supports. In this solution approach, regardless of the boundary conditions, the plate transverse deflection and rotation due to bending are invariantly expressed as a new form of trigonometric series expansions with a drastically improved convergence as compared with the conventional Fourier series. All the unknown coefficients are treated as the generalized coordinates and determined using the Raleigh-Ritz method. The change of the boundary conditions can be easily achieved by only varying the stiffness of the three sets of the boundary springs at the all boundaries of the orthotropic rectangular Mindlin plates without the need of making any change to the solutions. The excellent accuracy of the current result is validated by comparison with those obtained from other analytical approach as well as the Finite Element Method (FEM). Numerical results are presented to illustrate the current method is not only applied to the classical homogeneous boundary conditions but also other interesting

and practically important boundary restraints on free vibrations of the orthotropic rectangular Mindlin plates with varying stiffness of boundary springs.

**1032 Withdrawn5**

*Withdrawn5,*

**ABSTRACT**

Withdrawn5

**Wednesday 14:00-15:00 Room Plenary  
Plenary 2  
Chair: Norman Broner**

**912 Soundscape planning as a complement to environmental noise management**

*Brown, Alan Lex*  
Griffith University, Australia

**ABSTRACT**

The role and application of the concepts of soundscape planning, vis-à-vis those of environmental noise management, need elaboration. In noise control, sound is a waste product managed to reduce the immersion of sounds that cause human discomfort. The soundscape approach, by contrast, considers the acoustic environment as a resource, focussing on sounds people want, or prefer. Quiet is not a core condition for acoustic preference in the outdoor acoustic environment, but congruence of soundscape and landscape is. So too is that sounds that are wanted are heard above, not masked by, sounds that are unwanted in that particular place and context. Advancement of the soundscape approach will be facilitated by distinguishing it, both conceptually and in practice, from the management of environmental noise. Dimensions of complementarity and difference between the two approaches include: different sound sources of interest in any acoustic environment; human responses to these sounds and outcomes that arise from these responses; measurement techniques and mapping; and appropriate objectives for management, planning and design. Soundscape planning and management augments environmental noise management, expanding the scope for application of the tools of acoustic specialists.

**Monday 09:20-Tuesday 18:00 Foyer  
Posters**

**304 Management Policy on Community Noise to Improve the Quality of Life – Focused on Apartment Noise**

*Park, Young Min (1); Kim, Kyoung Min (1)*  
(1) Korea Environment Institute, South Korea

**ABSTRACT**

Community noise (also called environmental noise, residential noise or domestic noise) is defined as noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighborhood. Typical neighborhood noise comes from premises and installations

related to the catering trade (restaurant, cafeterias, discotheques, etc.); from live or recorded music; sport events including motor sports; playgrounds; car parks; and domestic animals such as barking dogs. Recently, in South Korea, disputes over the neighborhood noise (especially, apartment noise) lead to murder cases as the number of residents who live in the apartment complex is on the rise. The problem has emerged as one of the major social issues and making efforts for solution is needed. This study suggests methods for prevention and post management systems to improve the quality of life and it is expected to handle the apartment noise more active.

**510 The Influence of the Load Condition upon the Radial Distribution of Electromagnetic Vibration and Noise in a Three-Phase Squirrel-Cage Induction Motor**

*Sato, Yuta (1); Hirotaka, Isao (1); Nakamura, Masanori (1); Iguchi, Akihiko (1); Hayashi, Daisuke (1); Takahashi, Yousuke (2)*  
(1) Chubu University, Japan; (2) Toshiba Industrial Products and Systems Corporation, Japan

**ABSTRACT**

The reduction of electromagnetic vibration and noise in three-phase squirrel-cage induction motors (IMs) has become very important from an environmental standpoint. However, the relationship between the radial distribution of the electromagnetic vibration and noise and the force wave that causes them has yet to be analyzed in sufficient detail. In this paper, we present the results of several experimental trials and show the analysis of an IM under various load conditions to study the causes of the vibration and noise components by examining of their radial distributions.

**137 A Noisy Vehicle Surveillance Camera (NoivelCam) System**

*Agha, Apoorv (1); Gan, Woon Seng (1); Chong, Yong-Kim (1); Ang, Boon-Wee (2)*  
(1) Nanyang Technological University, Singapore; (2) National Environment Agency, Singapore

**ABSTRACT**

Traffic noise is one of the main contributors to noise pollution near urban settlements. To keep a check on the vehicle noise emissions in Singapore, a pilot project has been carried out to identify offending vehicles that exceed the stipulated noise limit set by the environmental agency in Singapore. In particular, noise due to tail pipe emission and engine are the main concerns. The current law enforcement practice includes holding roadblocks, and measuring noise of stationary vehicle at different revolution per minute. However, this approach is highly manpower-intensive, costly and does not determine the actual driving pattern of drivers on highway. To provide an efficient and automated alternative to noisy vehicle monitoring, a standalone integrated vehicle noise tracking system, known as the "NoivelCam," is designed and built for a single lane monitoring in expressways. This system will be scaled up to multiple-lane monitoring in the next stage of the project. In this paper, we present the design and technical functioning blocks of the NoivelCam system and how it is currently being deployed in overhead bridge spanning highways to estimate the tail pipe level noise generated from individual vehicle passing through the overhead bridge. Vehicles that exceed the stipulated noise level threshold will be tracked and captured through the

cameras. The collected evidences, which include audio and video clips of the captured footage, snapshots of the vehicle number plate, and data log files of sound pressure level with time stamp, serve as a mean to identify offending vehicles in an in-situ operation. In addition, we will also highlight some situations of false alarm or error detection, and how multimodal information can assist in filtering out these false detections.

**452 A Study of Pavement Noise for Asphalt Pavements with Different Service Life in National Highway**

*An, Deok-Soon (1); Lee, Jae-Jun (2); Ohm, Byungsik (1); Son, Hyeon-Jang (1); Kwon, Soohahn (1)*  
(1) Korea Institute of Construction, South Korea; (2) Chonbuk National University, Republic of Korea

**ABSTRACT**

Currently, asphalt pavement is covered about 90% of the national highway. The average service life of national highway is 8~9 years. In this study, the characteristic of sound pressure level(SPL) and frequency from traffic noise of asphalt concrete pavement(ACP) is evaluated according to service period. In order to find relationship between ACP's service life and traffic noise, the traffic noise from asphalt concrete pavement was collected and analyzed. The traffic noise was measured by the statistical pass-by method(SPB) that consisted of placing microphone at a defined distance from vehicle path at the side of the roadway was adopted. The analysis was evaluated the traffic noise by comparing 1/3-octave band frequency characteristics of traffic noise from asphalt concrete pavement that was three different service life: new pavement(0 year), 6 years and 10 years. Based on both SPL and 1/3 octave band frequency analysis, the SPL of 6 years asphalt pavement was shown the highest number, 78dB(A). Also, The SPL of the vehicle type, the SUV than passenger car was the highest with the average 78.8dB(A). The total Frequency range of the pavement life type and the vehicle type was a range of 400Hz~2500Hz.. According to noise characteristics results of the ACP life, in the existing literature and our result has produced different results. Later, after additional field noise test, Evaluation using the statistics technique is required.

**480 A Study of Traffic Noise Characteristic of Pavement Types Using NCPX Method**

*Son, Hyeon-Jang (1); An, Deok-Soon (1); Lee, Jae-Jun (2); Kim, Yong-Joo (1)*  
(1) Korea Institute of Civil Engineering and Building Technology, Republic of Korea; (2) Chonbuk National University, Republic of Korea

**ABSTRACT**

To analyze the traffic noise as changed pavement types, a research team measured traffic noise in test road located in Yeosu, Korea. The test road was composed of four different pavement types as followed; Dense grade asphalt concrete pavement (ACP), Joint concrete pavement (JCP), Continuous reinforced concrete pavement (CRCP), Transverse grooving on jointed concrete pavement (GJCP). In order to measure traffic noise as function of vehicle speed at interface between pavement and vehicle tire, NCPX (Noble Close ProXimity) method was adopted in the study. Based on analysis of test results, transverse grooving on JCP was shown the highest SPL 110.5 dB(A), However, Dense grade asphalt concrete pavement

was shown the lowest value, 101.5 dB(A). Therefore, the transverse grooving on JCP is average 9 dB(A) higher than that of asphalt concrete pavement. Also, the sound pressure level (SPL) was analyzed between front and rear axle in vehicle. The front SPL was average 4.4 dB(A) higher than that of rear SPL. In this case study, asphalt concrete pavement shows the highest differences in SPL with 7.4 dB(A). However, CRCP was lowest differences in SPL with 3 dB(A). It implies that there is different interaction between tire and road as changed vehicle axle.

**205 Vehicle suspension and steering nonlinear integrated system coordinated control based on human-vehicle function allocation**

*Wang, Hongbo (1); Yang, Liuqing (2); Hu, Yanping (1)*  
(1) Hefei University of Technology, China; (2) Anhui Communications Vocational & Technical College, China

**ABSTRACT**

The coupled dynamics between the vehicle chassis suspension system and electrical power steering system (EPS) is analyzed, to establish the full-vehicle nonlinear model, EPS model, tire model and road input model. The tire's complex nonlinear model is approximated by utilizing the least square method, so as to obtain the integrated system model with the 22th-order. To simplify the nonlinear controller design, the nonlinear dynamics model is separated into two parts of nonlinear part and linear part. The state feedback optimal controller is designed for the linear part model, and the linear compensator based on the deviation separation is for the nonlinear part model, which can ensure the closed-loop control system is exponential asymptotic stability at the equilibrium point. The human-vehicle function allocation is adopted to adjust the two subsystems' output weights based on the fuzzy rules, to restrain the suspension roll motion and adaptively compensating driver's steering torque. The considerable simulations are carried out, and the results demonstrate that the suspension and EPS coordinated control system by applying bilinear control can obtain better performance than another nonlinear control method; the human-vehicle function allocation can further improve the vehicle whole-region control performance.

**336 Integrated test system for tyre/road noise – ISO/DIS 11819-2 and AASHTO TP76-12 methods**

*Li, Xun (1); Lim, Vincent (1)*  
(1) Vipac Engineers & Scientists, Australia

**ABSTRACT**

A CPX trailer for tyre/road noise measurements was constructed and certified in accordance with ISO/DIS 11819-2. The trailer is a two-wheel trailer (one for test tyre and another for support tyre) with an acoustic enclosure made of sheet metal. To measure the tyre/road noise according to AASHTO TP76-12 method (sound intensity method), a pair of sound intensity probes, constructed using the high precision B&K type 4958 microphones, were also mounted on the trailer. An integrated test system consisting of the acoustic sensing and a position sensing system are presented in this paper.

**711 RONDA - CPX Trailer Initial Test Results**

*Tonin, Renzo (1); Szabo, Attila (1)*  
(1) Renzo Tonin & Associates, Australia

**ABSTRACT**

RONDA (Road Noise Data Acquirer) is a CPX trailer conforming to Draft ISO 11819-2 intended for measuring road surface noise. The trailer is of the open frame type without an enclosure. A description of the design of the trailer is provided and the results of initial testing on NSW roads is to be presented at the conference venue.

**779 Environmental impact assessment of road noise with noise map in Korea**

*Sun, Hyosung*  
Korea Environment Institute, South Korea

**ABSTRACT**

The environmental impact assessment of road noise is performed to evaluate the noise influence from the development project including a road in Korea. Recently, the noise impact assessment with a noise map is increased in order to describe the real noise environment according to a development project. In spite of this trend, the detailed guideline for the application of a noise map in the environmental impact assessment of a development project is deficient in Korea. Therefore, this paper suggests the application guideline of a noise map with a noise prediction program in order to perform the real noise impact assessment of a development project.

**255 Basic study on inset position of stack in the system with branch tubes for applying thermoacoustic silencer to multi cylinder engine muffler**

*Sakamoto, Shinichi (1); Kawamoto, Satoshi (1); Orino, Yuichiro (1); Ota, Yoshitaka (1); Inui, Yoshitaka (1); Watanabe, Yoshiaki (2)*  
(1) University of Shiga Prefecture, Japan; (2) Doshisha University, Japan

**ABSTRACT**

We have proposed an automobile muffler that uses the thermoacoustic effect. Application of the thermoacoustic effect to a silencer was investigated experimentally in previous studies. Results confirmed that the sound pressure after passing through the stack with a temperature gradient was less than that without a temperature gradient. From these experiment results, a silencer based on the thermoacoustic effect was developed. This study specifically examined the stack installation position. The muffler of a multi-cylinder engine has branch tubes. We investigated the influence of the stack installation position of the branch tube. A branch tube has a confluence. A stack was installed on the front and back of the confluence. When the stack was installed on the front and back of the confluence, a silencing effect was confirmed. When the stack was installed on the back of the confluence, the silencing effect was effective.

**772 A study on the prediction of the noise reduction performance according to applying the rail web-damper in curved track section**

*Kim, Jinho*

Korea Railroad Research Institute, South Korea

**ABSTRACT**

This research plans to consider noise reduction performance of the rail web-damper in curved track section. For this purpose, we predicted vibration and noise and analyzed noise reducing elements. Firstly, the predictive value of vibration and noise was calculated by the BEM based program and numerical analysis toward the curved track section in the tunnel. Also, the actual noise value was compared with the predictive noise value from track component vibration, such as sleeper and the rail before & after applying rail web-damper.

**1011 Railway noise impact assessment: An overview of the Railway Noise and Vibration Research project in South Korea**

*Hong, Jiyoung (1); Koh, Hyo-In (1); Jang, Seunho (1); Lee, Soogab (2)*

(1) Korea Railroad Research Institute, Republic of Korea; (2) Seoul National University, Republic of Korea

**ABSTRACT**

Technology development for sustainable low noise railways, a consortium project funded by the Ministry of Land, Infrastructure and Transport of South Korea, has aimed to develop new technology for reducing railway noise and vibrations. One of the goals of this project is to establish guidelines for impact assessments on railway noise. Changes in people's perception of noise have elicited changes in approaches to the development of technology to reduce railway noise. Prior to formulating guidelines, research on procedures to measure railway noise, an impact assessment on people exposed to railway noise, and the selection of measures to evaluate railway noise impact must be conducted. This paper presents an overview of part of the project and the preliminary results of establishing guidelines for railway noise impact assessment. The results of this research are expected to contribute to the development of the effective methods and technology for reducing railway noise.

**465 Wind turbine noise: practical immission measurements**

*Fauville, Benoît (1); Moiny, Francis (1)*

(1) University of Mons, Belgium

**ABSTRACT**

For 15 years the number of wind turbines installed in Europe has increased rapidly. In this framework many objections are expressed towards the sound emitted during the Wind Turbine (WT) working and its perception as a noise in the direct neighbourhood. The noise is due to aerodynamic interactions with the blades of WTs. After its propagation over several hundred meters, the noise is more or less stationary but can feature an amplitude modulation that can be very annoying for the human hearing. To understand the physical causes of this potential annoyance, some noise measurements were carried out. A lot of care is necessary to have relevant recordings of the WT noise. The measurement precautions are explained as well as the data processing to avoid the periods with a dominant

background noise. Finally some results of measurement campaigns are exposed.

**350 Experimental approach on transmission of low-frequency sound into a building**

*Doi, Tetsuya (1); Iwanaga, Keiichiro (1); Naka, Yusuke (2)*

(1) Kobayasi Institute of Physical Research, Japan; (2) Japan Aerospace Exploration Agency, Japan

**ABSTRACT**

Field experiments were conducted to investigate transmission of low-frequency sound into a test building by using a transportable device that could generate low frequency sounds down to 2 Hz. Results show no significant inside-outside SPL differences at 4 Hz or lower. Theoretical analysis indicated that this tendency is affected by the air-tightness of the test building. For higher frequency regions around 12.5 Hz, it was inferred that the vibration of the windows play an important role on the SPL difference between outdoors and indoors. In addition, SPL increase due to the presence of a building with glass panes was investigated. Below 10 Hz, the SPL difference in front of the building was less than 2 dB. However, above 20 Hz, the SPL in front of the building increased up to 6 dB when the building existed.

**435 Application of fractal dimension to the evaluation of environmental sound**

*Makabe, Yoshiaki (1); Muto, Kenji (1)*

(1) Shibaura Institute of Technology, Japan

**ABSTRACT**

We propose an evaluation method that uses fractal dimension for the analysis of environmental sound. In previous studies, it was shown that the sense of hearing is able to identify fractal dimensions. Fractal dimension is therefore considered to be a useful parameter for the evaluation of acoustic environments. However, there are still many issues left to study, partly because fractal dimensions are not widely known about, and partly because they are affected by non-stationary sounds. In this report, we use the concept of entropy (which is widely used to evaluate quantities of information in the field of information theory) to demonstrate the effects of fractal dimensions on non-stationary sounds, and we investigate the validity of applying this knowledge to the analysis of acoustic environments.

**502 Using the interpolation in the DIN EN ISO 17201-1**

*Trimpop, Mattias*

lfl GmbH, Germany

**ABSTRACT**

Since 2005 the Standard ISO 17201-1 is used for the prediction of shooting noise. In this time the standard has been applied to many measurements. While it is working well for most of the measurements, some measurements led to unreasonable results by adopting the interpolation method of the standard. This is documented by some artificial directivity pattern. Some solutions are discussed like changing the criteria for the validation of a measured directivity pattern and using other interpolation schemes.

**897 Numerical Analysis of Sound Wave Propagation Using CIP-MOC Method with Non-Uniform Grid**

*Matsumura, Yuta (1); Okubo, Kan (1); Tagawa, Norio (1); Tsuchiya, Takao (2); Ishizuka, Takashi (3)*  
(1) Tokyo Metropolitan University, Japan; (2) Doshisha University, Japan; (3) Shimizu Corporation, Japan

**ABSTRACT**

In recent years, time-domain numerical analysis for sound wave propagation has been investigated widely as a result of advances in computer technology. For sound field imaging and/or prediction, the development of accurate numerical schemes is an important issue. A method of characteristics (MOC) is used as a time domain numerical analysis method, examples of which are the constrained interpolation profile (CIP) method, the LAX method, and the QUICKEST method. We used the MOCs for numerical analyses of sound wave propagation in an earlier study. However, new grid systems are required for the CIP large-scale simulations of wave propagation. Additionally, for multidimensional analysis, the high-efficiency outer absorbing boundary is also required. To overcome these problems, we introduce the non-uniform grid system with perfectly matched layer (PML) technique. The purpose of this study is to evaluate these techniques for two-dimensional (2D) sound field numerical analysis using the MOCs. The present results indicate that these techniques for MOCs have advantages of small memory requirements and less calculation time.

**415 An evaluation on comfortable sound design of unpleasant sounds based on chord-forming with bandlimited sound**

*Ohshio, Yoshitaka (1); Ikefuji, Daisuke (1); Nakayama, Masato (1); Nishiura, Takanobu (1)*  
(1) Ritsumeikan University, Japan

**ABSTRACT**

The unpleasant noise is one of the important social problems because our quality of life is degraded by it. We have previously proposed the unpleasantness reduction method based on auditory masking to reduce the discomfort feeling of the noise with peak frequency components in a higher frequency. The former proposed method can reduce the discomfort feeling by emitting a control signal to a listener. However, it has the discomfort feeling caused by that the control signal increases the sound energy. To solve this problem, we focus on the reformation of peak frequency components in addition to auditory masking. Here, chords are generally known as typical comfortable sounds in music theory. Chords are felt as comfortable sound, if some peak frequency components are in the specific rules. In this paper, therefore, we propose the comfortable sound design method based on chord-forming with music theory. The proposed method can design the comfortable sound by reforming the spectral structure of the noise to that of comfortable sounds. As a result of evaluation experiments, we confirmed the effectiveness of the proposed method.

**421 A Design of Comfortable Dental Treatment Sound Based on Auditory Masking**

*Ikefuji, Daisuke (1); Suhara, Yuko (1); Nakayama, Masato (1); Nishiura, Takanobu (1); Yamashita, Yoichi (1)*  
(1) Ritsumeikan University, Japan

**ABSTRACT**

In a dental treatment, patients and doctors often feel strong discomfort feeling by hearing the dental treatment sound. It is caused by peak frequency components on a high frequency-band. For reducing discomfort feeling of a single peak frequency component, we have previously proposed the discomfort reduction method that can mask a single peak frequency component based on auditory masking. Auditory masking is a phenomenon to increase an audible level by a composite sound. Here, we focus on discomfort feeling of the dental treatment sound. The previous method has difficulty applying it to the discomfort reduction of the dental treatment sound because it has multiple-peak-frequency components. In this paper, we therefore propose a new method for designing the masking sound that can mask them. The proposed method employs the comfortable nature sound including a running water sound as the sound source of the masking sound to achieve a comfortable masking sound design. As a result of subjective experiments, we confirmed that the proposed method can make the dental treatment sound more comfortable.

**178 One-dimensional unidirectional acoustic boundary through active control method**

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**ABSTRACT**

The unidirectional acoustic boundary has a broad application prospect. Besides the acoustic metamaterial or the strongly nonlinear acoustic medium, which were applied in the realization of the unidirectional acoustic boundary, the present paper proposes another approach through the active control method, where the control source has the property of single directivity. In order to validate its effectiveness in one-dimensional duct, experiment is implemented in two steps: 1. constructing the control source with single directivity by two monopoles; 2. constructing the unidirectional acoustic boundary through the control source in step 1. Results show that the approach to the unidirectional acoustic boundary in one-dimensional duct is feasible and effective, and this work has the potential to be achieved in broadband sound field, in three-dimensional case, and by the adaptive system.

**890 Robust time-domain acoustic contrast control design under uncertainties in the frequency response of the loudspeakers**

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**ABSTRACT**

Time-domain acoustic contrast control method using loudspeaker array has been studied for generating bright and dark zones in personal audio system. Acoustic contrast which is defined as the acoustic energy ratio between bright and dark

zones can be inevitably influenced by the uncertainties in the frequency response of loudspeakers. In this paper, a robust extension of broadband acoustic contrast control with response variation is proposed through exploiting knowledge of the statistical model of the uncertainties. Its performance is evaluated by Monte Carlo simulation method and compared with other acoustic contrast control methods. Simulation results show that better contrast over the continuous frequency range can be achieved using this proposed method.

**542 Narrow area control for individual sound image generation by combining NBSFC and liner loudspeaker array**

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(1) Shizuoka University, Japan

**ABSTRACT**

In this paper, we propose a method for reproducing different sound for multiple users by forming a narrow area, where the users can listen only the desired sounds. We have proposed a sound field control method for narrow area by combining Null-space Based Sound Field Control (NBSFC) and liner loudspeaker array. NBSFC filtering can suppress the sound pressure on the each control point and maintain the sound pressure around the user's ear. However, consideration of the effective arrangement of control points was insufficient. Therefore, we aim to improve the reproduce performance of individual sound image generation by optimizing the arrangement of control points. The numerical simulation showed that the averaged power difference between desired and undesired area is by about 2 dB by the proposed method.

**38 A study of the position of the reference microphone of active noise control of feedforward type for MRI noise**

*Muto, Kenji (1); Nakayama, Shohei (1); Osada, Ryosuke (1); Yagi, Kazuo (2); Chen, Guoyue (3)*  
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**ABSTRACT**

Magnetic resonance imaging (MRI) devices generate loud acoustical noise during operation. The sound pressure level of the MRI noise depends on the imaging sequence, but it is generally 100 dB or more. Our current study is aimed at the improvement of the acoustical environment for the MRI patient by means of an active noise control system. We propose using a feedforward system because acoustical MRI noise typically comprises unsteady pulse waves. It is important for a feedforward system that the reference microphone is located near the sound source. Here, we discuss the measurement of the sound source of MRI acoustical noise to position a reference microphone and show the effect of reference microphone position in an active noise control system by computer simulation. The apparent source of MRI acoustical noise was estimated from the delay time of the cross correlation between the signals of two microphones on the table in the MRI gantry. The result indicates that the apparent source lies between the center and edge of the gantry. Computer simulation shows that the proposed system produces substantial noise reduction when the reference microphone is attached in the vicinity of the apparent origin of the sound, such as in the wall of the scanner.

**552 Active reduction of sound transmission in aircraft cabins: a smarter use of vibration exciters**

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**ABSTRACT**

This paper addresses an active structural acoustic control (ASAC) approach to reduce sound transmission through an aircraft trim panel. The focus is on the practical implementation of the virtual mechanical impedance approach through self-sensing actuation instead of using sensor-actuator pairs. The experimental setup includes two sensor-actuators designed from an electrodynamic inertial exciter and distributed over an aircraft trim panel, which is subject to a time-harmonic diffuse sound field. A methodology based on the experimental identification of key parameters of the actuator is proposed, wherein the vibration of the structure is estimated from the electrical signals picked up at the input terminals of the transducer. Measured data are compared to results obtained with conventional sensor-actuator pairs consisting of an accelerometer and an inertial exciter, particularly as regards sound power reduction. The decrease of sound power radiated is comparable in both cases and equals 3 dB when the panel is controlled at the excitation frequency of 363 Hz, as expected by optimal calculation for two control units.

**893 Application of disturbance-observer-type velocity estimator to electroacoustic absorber for noise absorbing**

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**ABSTRACT**

Direct impedance control (DIC) technique used for an electroacoustic absorber in this paper requires a pair of pressure and velocity sensor. However, it can be quite costly to develop array system of this electrostatic absorber for acoustically large space. To overcome this problem, in this paper instead of using velocity sensor, disturbance-observer-type velocity estimator is applied to DIC technique for the electroacoustic absorber. In order to verify the practicality of this technique, a robust velocity estimation performance of disturbance-observer-type velocity estimator to acoustic load change of the loudspeaker diaphragm is demonstrated experimentally. Next, its velocity estimation performance is verified after diaphragm velocity is induced both by external pressure and applied DIC voltage. Finally, the possibility of applying disturbance-observer-type velocity estimator to electroacoustic absorber is verified through the measurement of sound absorption coefficients. In this paper, the possibility for the real space acoustic control using array system of electroacoustic absorber using DIC technique is presented.



**212 Numerical and experimental analysis of the effectiveness of material composition of piezoelectric elements with chosen shapes on plate vibration reduction**

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**ABSTRACT**

This paper presents numerical analyses of efficiency of different shapes and with a step change of material properties of piezoelectric actuators used for vibration and structural noise reduction. Analytical models representing a plate clamped on all sides with two attached piezoelectric elements were created. For each model, one element had the same shape and composition and was used for plate excitation, and the other one, used for vibration reduction, had different shape (circular, square, triangular) and location of the inner part of a two-part piezoactuator. Analyses of results were performed with ANSYS software. Finally, results of numerical simulations concerning effectiveness in vibration reduction of piezoactuators constructed this way are presented and are compared with experimental results.

**962 Measurement of Temperature Dependence in the Piezoelectric Active Element of a Knock Sensor**

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**ABSTRACT**

The article describes experimental research on PZT ceramics used in knock sensors. The aim of the paper is to investigate the temperature effects related to the parameters of piezoelectric materials and to characterize the influence and changes exerted by these parameters on the properties of knock sensors. The material properties of such elements based on PZT ceramics are significantly affected by temperature changes; we therefore examined the temperature effect during the heating phase and analysed the subsequent permanent changes to the piezoelectric coefficients. In the experiment, emphasis was placed on investigating the piezoelectric coefficient changes up to the limit value (i.e., the Curie temperature): we determined the Curie temperature of the piezoelectric material used in the knock sensor, measured the impedance and phase characteristics at the given thermal value, and cooled the material down to the ambient temperature. Subsequently, the piezoelectric constants were calculated from these characteristics, and the related influence was evaluated. The experiments demonstrated that temperature can affect the piezoelectric coefficients and thereby also to accuracy of a knock sensor or piezoelectric sensors generally.

**256 Characteristics of polymeric interlayer films and its impact on acoustical performance of laminated glass**

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(1) Korea Railroad Research Institute, South Korea

**ABSTRACT**

The advantages of noise attenuation, easy fabrication, and compatibility with glass have promoted the application of PVB (polyvinyl butyral) interlayer films for laminated glass. Though PVB laminated film shows moderate performance in sound absorption/insulation, much of the noise is still transmitted through a glass in high-speed train, HEMU-430X. To improve sound attenuation via a laminated glass, it is beneficial to find a relationship between characteristics of interlayer films and sound absorption/insulation performance. The chemical and physical properties of representative polymer films (PMMA, PC, EVA as well as PVB) were analyzed based on differential scanning calorimetry, dynamic mechanical analysis, and thermomechanical analysis. Further, acoustical performance, i.e. absorption coefficient and transmission loss, was measured using impedance tube and reverberation method.

**301 Study of Enhanced Sound-absorbing performance for Polyurethane Foam which Carbon Nano-tube is applied**

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**ABSTRACT**

The semi-rigid polyurethane foam was studied to improve the sound-absorbing performance for automotive noise reduction. The existing materials as 'Glass wool' and 'Resin felt' generally had the low fuel-efficiency due to the high product weight and environmental problems caused by the adhesive binder has occurred. If the semi-rigid polyurethane foam was substituted for above materials, the semi-rigid polyurethane can be expected the improvements of the fuel-efficiency due to the low weight and the increased sound-absorbing performance. Our study proceeded with the goal to enhance the conventional sound-absorbing performance of the semi-rigid polyurethane foam in high frequency range. In this study, Carbon Nano-tube materials were added to foaming reaction by Polyol, Isocyanate and some additive to control the property, and examined for the relation between the effect of the sound-absorbing performance and the Carbon Nano-tube contents or structure. The effects of Carbon Nano-tube were analyzed by the change of air-permeability using Flow-resistance measurement and the morphological change for the polyurethane foam using SEM measurement. Through this study, the optimal contents and structure of Carbon Nano-tube were clarified to improve the sound-absorbing performance. Therefore the sound-absorbing performance over the entire frequency range was significantly enhanced by increasing the viscous and frictional loss over the noise and air-permeability resulting from the morphological changes.

**547 Privacy protection method for speech using small speakers placed around a head**

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**ABSTRACT**

One method of protecting speech privacy in public places, such as the waiting room of a pharmacy, hospital, or clinic, is to introduce a masking noise to the area. However, this method raises the overall noise level, which is undesirable. We propose a new method for protecting speech privacy without raising the overall noise level. In the proposed method, a masking noise is played from small speakers placed around the heads of listeners, and this protects privacy without raising the overall noise level in the room. In this experiment, various positions for the small speakers were considered on the basis of practicality and efficacy. The degree of masking provided by using small speakers was measured by a word intelligibility test. In addition, the noise level in the room was measured by a sound level meter. These experiments were carried out in a room arranged to simulate a pharmacy waiting room. The results indicated that the proposed method is suitable for protecting privacy without raising the noise level in the room and therefore offers a new method of protecting speech privacy.

**848 Improvement of PC Hearing Support System: The Use of One-USB-OS**

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**ABSTRACT**

Sign language interpretation and PC captioning are commonly used as a means of assisting hearing impaired people to get information. A noise in the classroom is bigger than is expected, so it became a problem for those with hearing impairments, who had extra difficulty in listening in the classroom. Our earlier paper reported that we developed a supporting system of nursing care for the hearing disabled people, using a tablet PC and school LAN. This system also utilizes speech transmission on wireless LAN. Then, they can use their own smartphones and mobile games devices. The data showed its usefulness as a result of our monosyllabic intelligibility test. In the current project, we developed our earlier system into a new software-based system; the "one-usb-os" system. This new system enables users to run a USB start if they have a PC and to operate our proposed PC hearing support system. This paper reports the results of our measurement and describes acoustic characteristics observed in the actual noisy classroom environment.

**188 Priority of subjective attribute in discrimination between sound fields of architectural spaces**

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**ABSTRACT**

We can realize and discriminate the difference between sound fields of different spaces by some clue. It seems that

discrimination between sound fields is due to the difference in some subjective attributes. We hypothesize that the subjective attribute, which is the ground of judgment in discrimination of sound field, is determined according to subjective weight/priority, and are discussing about modeling of mechanism in discrimination. The purpose of this study is to model the discrimination process between sound fields in architectural spaces, and that of this paper is to clarify the weight/priority of subjective attributes in discrimination judgment. Subjective experiments were carried out by using stimuli of impulse responses from existing concert halls and music data, which is made from convolution of impulse responses and dry sources. In these experiments, subjects are asked to evaluate the impression of each stimulus, and to judge the difference among stimuli in paired comparison. The results of these experiments were analyzed and the weight of each subjective attribute was estimated. It seems that for pulsing signal of sound source, the attribute related to Reverberance is dominant in discrimination, but for continuous signal, Clarity is dominant, in the case of monaural presentation of stimuli.

**414 A design of reflective audio spot with parabolic reflector for sound pressure improvement on separating emission of carrier and sideband waves**

*Konabe, Ryosuke (1); Matsui, Tadashi (1); Ikefuji, Daisuke (1); Nakayama, Masato (1); Nishiura, Takano (1)*  
(1) Ritsumeikan University, Japan

**ABSTRACT**

A parametric loudspeaker can represent the audible sound to a narrow spatial area because of its sharper directivity. However, even in the parametric loudspeaker, acoustic reflections and intercepts become noise. To solve this problem, we have already proposed the audio spot design method based on separating emission of the carrier and sideband waves using multiple parametric loudspeakers. However, the former method has had the problem that the audio spot has a low sound energy. In this paper, we therefore propose a new audio spot design method based on separating emission of the carrier and sideband waves using the parabolic reflectors to achieve a large sound energy on the audio spot. The proposed method achieves the audio spot design with the large sound energy by re-collecting the carrier and sideband waves passed through the audio spot using the parabolic reflectors. It is important for the proposed method to utilize the parabolic reflectors corresponding to the carrier and sideband waves. Thus, we investigate the suitable curvature of the parabolic reflectors. We carried out the evaluation experiment for measuring the spatial distribution of the demodulated audible sound energy. As a result of the evaluation experiment, we confirmed the effectiveness of the proposed method.

**418 A study on 3-D Sound Field Localization System Using Parametric Loudspeaker and Indirect Loudspeakers for Reverberation Reproduction**

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**ABSTRACT**

3-D sound field reproduction technology can provide listener with a sense of presence. In this study, we have proposed the 3-D sound field localization system called "Acoustic

Planetarium". This system can represent sound images easily in everywhere by using parametric loudspeaker that has high directivity. However, it is difficult to reproduce reverberant environments such as concert hall because the parametric loudspeaker has difficulty representing omni-directional reflections. To solve this problem, we have previously proposed a method that steers the reverberation time by using indirect dynamic loudspeakers. The previous method had difficulty representing reverberant environments with a high accuracy because it steered the reverberation time without acoustic characteristics including D value. In this paper, therefore, we propose the 3-D sound field localization system with reverberation reproduction based on D value using parametric loudspeakers and indirect dynamic loudspeakers. Specifically, in reverberation reproduction, we design inverse filters between listening points and indirect dynamic loudspeakers. In addition, we design impulse responses (reverberation filters) based on D value. Finally, indirect dynamic loudspeakers emit acoustic signals filtered with inverse and reverberation filters. As a result of subjective experiments on sound image localization and reverberation, we confirmed the effectiveness of the proposed method.

**420 Multiple Audio Spots Design Based on Separating Emission of Carrier and Sideband Waves**

*Matsui, Tadashi (1); Ikefuji, Daisuke (1); Nakayama, Masato (1); Nishiura, Takanobu (1)*  
(1) Ritsumeikan University, Japan

**ABSTRACT**

The parametric loudspeaker has sharper directivity and it can achieve audio spot which can represent the audible sound to a narrow spatial area. However, the parametric loudspeaker has problems caused by reflections and intercepts because they become noise to other listeners except a target listener. Here, we focus on that principle of the parametric loudspeaker. It can be formulated as non-linear interaction of carrier and sideband waves in emitted ultrasonic sounds on the air. This suggests that we can design audio spot by individually emitting the carrier and sideband waves. Thus, we have proposed the design method of audio spot with separating emission of the carrier and sideband waves. The former proposed method has designed a single audio spot using multiple parametric loudspeakers. In the present paper, we propose the design method of multiple audio spots based on separating emission of the carrier and sideband waves using multiple parametric loudspeakers. More specifically, the audible sound is demodulated at multiple audible areas where the single carrier and sideband waves individually emitted from each parametric loudspeaker are overlapped. As a result of evaluation experiments with the sound energy distribution, we confirmed the effectiveness of the proposed method.

**423 Evaluation on flexible beamformers with curved-type parametric loudspeaker for spatial audible area design**

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**ABSTRACT**

In the fields such as evacuation guidance and entertainment, it is important for each listener to provide different sound information by using some loudspeakers in a same room.

However, listeners have difficulty obtaining target sound information because various sound signals are mixed by using a general loudspeaker which has a wide directivity. To solve this problem, a parametric loudspeaker which has a high directivity by utilizing an ultrasound wave is ideal candidate. The parametric loudspeaker can provide each listener the target sound information because it can form the spatial audible area to the narrow space. However, the conventional parametric loudspeaker system requires a large system using too many parametric loudspeakers corresponding to each listener. In this paper, we therefore propose flexible beamformers with curved-type parametric loudspeaker for spatial audible area design using a small system. The proposed method utilizes the curved surface arrangement of ultrasound transducers and can design various spatial audible areas by changing its curvature. Finally, we evaluated the relationship between its curvature and spatial audible area in the proposed method. As a result of the evaluation experiment, we confirmed the effectiveness of the proposed method.

**748 Objective comparison between Ambisonics basic decoding and a SIRR-based parametric decoding in the context of concert hall auralization**

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**ABSTRACT**

The room acoustics group at Pierre and Marie Curie University has a database of directional room impulses responses (DRIR) measured in unoccupied concert halls and theatres in Paris. The DRIRs were measured in 2009 with a SoundField ST250 microphone in B-Format (first order Ambisonics) for auralization purposes. Listening tests conducted in 2012, using a basic Ambisonics reproduction over twelve loudspeakers, showed a lack of spaciousness that could be linked to a high interaural coherence and a non-optimal sound incidence reproduction. Decoding improvement is made by means of the estimation of the energy and the intensity vector of the sound field, based on Spatial Impulse Response Rendering (SIRR) method. The constant Q transform (CQT) is used for time and frequency domain analysis. The non-diffuse components are routed using VBAP rendering and diffuse field is synthesized using MLS signals. The intensity vector associated to the direct sound, the reverberation and the interaural correlation profile are compared between this decoder and a basic Ambisonics decoder. Finally, a comparison of some conventional acoustic descriptors is performed between the real and reproduction contexts.

**892 Development of GPGPU-Based Interactive Simulation for Numerical Analysis of Sound Wave Propagation**

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**ABSTRACT**

To date, numerical analysis for sound wave propagation in time domain has been investigated widely as a result of computer development. For time domain acoustic simulation, the

reduction of the calculation time and the development of the visualization method are important technical issues. Recently, GPU (Graphics Processing Unit) is used as an acceleration tool for the calculation in various study fields. This new movement has been called GPGPU (General Purpose computing on GPUs). GPGPU gives us the high-performance computing environment at a lower cost; therefore, the approach by GPU-based computing efficiently achieves a significant reduction of the calculation time. Moreover importantly, the use of GPUs has an advantage of visualization of calculated fields; GPU-based computing makes it possible to directly write drawing information to the VRAM on the video card without the transfer through the PCIe bus, because the calculated data is stored in the VRAM itself. In this study, we focus on numerical analysis of sound wave propagation using GPU-based computing with CUDA-OpenGL high speed visualization. We examine a feasibility of an interactive simulation using GPGPU-based parallel computing.

#### 118 Bootstrap masker generation method for speech masking systems

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##### ABSTRACT

Currently, speech masking systems make use of pre-recorded speech signals to generate maskers, which we call offline generated maskers. The offline masker includes no feedback from the speech environment, and only the overall averaged masking effect of the speech is gained, not the environment. In our prior study, a speaker-dependent masker that is generated by mixing pre-recorded speech of the speaker to be masked has been found to be the most effective, and can mask at low sound levels. Accordingly, the real time acquisition of the masked speaker speech signal is required to create the masker, which we shall call online generated maskers. In the online masker generation, there is a problem that sufficient amount of sound material may not be available from the cached memory in real time. Therefore, we have applied the bootstrap method used in machine learning techniques, and generated a masker as if many speech samples from a small amount of speech is available. We tested the proposed masker using two subjective indexes, i.e., annoyance and listening difficulty. We used sentence speech signals recorded with a dummy head. We compared the bootstrap type online masker (BS), the ring buffer addition type online masker (RA), and 3 types of offline maskers. These maskers were played at three signal noise ratio (5, 0, -5 dB). As a result, the annoyance scores of the online maskers were about the same as the offline maskers. However, the listening difficulty scores improved, and the BS type online masker was the most effective masker when the SNR is higher, at 5 and 0 dB. In addition, the masking effect of the speaker dependent condition (masker created from the target speaker speech) using the BS-Human Speech-Like Noise (HSLN) was found to be significantly higher than others, especially at the Target to Masker Ratio (TMR) of 5 dB.

#### 428 Basic study on improvement of stage acoustics by active method

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##### ABSTRACT

The purpose of this study is to optimize sound field for players on stage of concert hall by active method. Optimization of sound field for players is difficult because there is unevenness in sound field even on narrow stage and also difference of preference among players by musical instrument or personality. This study is to investigate fundamentally into a means to solve this problem by controlling sound field of the player neighborhood locally by superimposing sound fields actively. In this report, the effect of superimposition was discussed by comparing STEarly of original sound field and feedback sound field that was convoluted with specific sound field data (impulse response).

#### 419 High accuracy calculating model for sound field simulation with DFT-based FDTD on polar-quaternion-based axis towards craft restoration

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##### ABSTRACT

In this paper, an approach is proposed to improve the numerical precision at the sound field simulation by the finite-difference time-domain (FDTD) method. The FDTD method is a numerical solution for the wave equation, proposed by R. Courant. Although it has achieved to simulate wave propagation by numerical solution for the wave equation, it causes numerical dispersions due to their approximated approach. Thus, we also studied to improve the precision of the FDTD method and have proposed a calculation model based on spatial spectrum. The improved method allows the FDTD to detach the approximations by DFT-based computation, and it has achieved to reduce numerical dispersion. However, the discrete Fourier transform(DFT)-based computation has caused wrong results, which are the wave spatially-wrapped propagation, due to the periodic extension of the DFT. Therefore, we have proposed a new approach to avoid the problems by employing polar-quaternion for the wave equation. In the approach, the wave-equation is represented in polar-coordinate with quaternion, and the DFT-based partial differential operator is applied on space-time angle (argument) spectrum. The argument domain is originally periodic, and the problems of periodic extension can be avoided by using the proposed approach. The conducted numerical experiments indicated that the approach successfully prevented the FDTD method from causing problems of DFT-based spatial extensions.

**925 Design sensitivity analysis of the acoustic dispersion relations**

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**ABSTRACT**

In general, the design approach using the frequency response (e.g., S-parameters) is widely used, in order to design the acoustic metamaterial (AMM). On the other hand, this approach is very sensitive to the frequency response. Also, the acoustic energy loss due to resonance characteristic of the sonic crystal always exists. Thus, we propose the acoustic dispersion relation-based design approach in order to complement the limitations of this conventional approach. As the first step towards this goal, this paper proposes the design sensitivity analysis methodology for the acoustic dispersion relation. The representative dynamic characteristics of acoustic dispersion relation are "a natural frequency" and "a group velocity". Any type of the acoustic dispersion relation can be described by these two dynamic characteristics. In other words, this means that the AMM satisfying the specified acoustic dispersion relation can be designed by adjusting these dynamic characteristics. The proposed design sensitivity analysis methodology is verified through the design of the sonic crystal tracking the target natural frequency and group velocity at a single wavevector. This proposed method will be used for design optimization of the acoustic zero-index metamaterial (AZIM) in the future.

**315 An impedance tube measurement technique for controlling elastic behavior of test samples**

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**ABSTRACT**

For this paper, a modified sample mounting technique in which a sample is loosely-supported in an impedance tube testing was studied. This alternate mounting technique was compared to the traditional method of holding the test samples inside of the tube. This loosely-supported technique is defined by having a sample intentionally loosely fixed to the inner wall of impedance tube to control elastic behaviour of the test sample itself. In general the influence of the elastic behaviours, due to the shearing resonance, results in unwanted flexural vibrations of the test sample in the tube. This adversely affects the calculated results from the tube measurements. The significance of the impact will depend on the physical properties and/or supporting condition of the test samples. In addition, this influence will decrease the accuracy of not only measured acoustic properties but also the predicted acoustic parameter (e.g. Biot's parameters such as porosity and tortuosity) estimated from the absorption coefficients curve versus frequency using an inverse characterization method. Another candidate for controlling the flexural vibration is the well-known nailing technique, which directly prevents the vibration of test sample. However, nailing may change or damage the internal structure of the sample materials. In this report, advantages of the loosely-supported technique is presented. This technique does not change the internal structure of a sample and is minimally influenced by the cutting accuracy of the test samples. Validation of this method will be

shown using multiple glass wool and recycled fiber samples with varying bulk densities.

**699 Experiment and study of tactile characteristics resulting from vibration of a touch panel**

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**ABSTRACT**

The recent popularity of touch interfaces equipped in smart phones, tablet PCs, and the like has dramatically increased the opportunities for performing finger operations directly on a touchscreen. In this study, the authors report on experiments in which an actuator is used to perform an operation on a touchscreen surface to express surface unevenness and roughness in order to determine the range of differences in stimuli, reproduced on the surface of a touchscreen, that can be distinguished by a test subject. Three types of waveforms (triangle wave, square wave, and sine wave) for presenting surface roughness were achieved, and the perceptions resulting from those waveforms were investigated at that time. The results showed that differences existed according to the waveform shape, even when the magnitude of the sensation is the same. This magnitude was found to be perceived as successively larger when using waveform shapes in the order of triangle wave < square wave < sine wave.

**244 Beat period control of bell sound using an operational modal analysis**

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**ABSTRACT**

Beats in the sound of a ringing bell are periodic variations in volume that are generated by a slight asymmetry of the bell structure. However, beat periods are often too long or short due to uncontrollable elements in the bell-casting process. To optimize the beat period, beat tuning is performed after bell casting using the mode data of the bell. In the case of a large oriental bell, which is sounded by striking it with a heavy wooden hammer, mode data should be extracted only using the response data such as acceleration or sound pressure. In this study, we introduce a beat-tuning method using the operational deflection shape (ODS) for a large Oriental bell. Using the ODS, we extract the frequency and mode pair, which cause the beating sound, and we tune the beat period of the sound through a structural modification technology.

**190 Underwater acoustic passive localization base on multipath arrival structure**

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**ABSTRACT**

An acoustic passive localization method for underwater targets in shallow water waveguide using homomorphic signal processing is presented in this paper. The multipath arrival structure is extracted from source radiated noise by cepstrum analysis. Instead of using the single reflection path, the source

range and depth are estimated by the time-delay differences between direct path and twice reflection paths, such as surface-bottom reflection path and bottom-surface reflection path. The estimation performance is analyzed with computer simulation in an ideal waveguide. BELLHOP model is used to examine the effect of ray warping on the localization method in Pekeris waveguide and real ocean waveguide.

### 310 Effectiveness of background music for noises in hospital wards

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#### ABSTRACT

This study explored the effectiveness of background music for improving the sound environment in hospital wards. Participants were 21 female and 9 male Japanese college students. They were presented both noises in hospital wards and 10 kinds of music simultaneously and asked to evaluate the degree of annoyance and the degree of uncomfortableness of the sounds. Participants were also asked to rate both the degree of annoyance and the degree of uncomfortableness of noises when presented alone, and to rate them for each kind of music when presented without noises. It was found that participants were not particularly annoyed by the noises, but the noises made them feel uncomfortable. With respect to the music (for example, healing music and music with affective characteristics, such as elation, lightness, or affinity) presented with the noises, participants were not particularly annoyed by them and felt less uncomfortable than when the noises were presented alone. These results suggest that background music could be useful for improving the sound environment in hospital wards.

### 830 A research on the validity of expression method of sonic environment by using Japanese onomatopoeias

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#### ABSTRACT

The method that expresses a person's surroundings by onomatopoeias on a graphics like comics enables us to realize the sonic, visual, or thermal environment not by physical value but by easy words. Such onomatopoeias may be useful for people who are not specialists of physics to report the problems of their surroundings properly. In the present research, three experiments are carried out. First, an experiment verifying that Japanese onomatopoeias that are provided from dictionary can evoke the common feelings to environment among people. The results show that sonic, visual, and thermal environment can be expressed commonly by onomatopoeias. In the second experiment, subjects are instructed to write down the real environment by onomatopoeias on the picture of the place, and evaluate the impression. In the third experiment, other subjects are instructed to evaluate the impression of the place presented by a picture with onomatopoeias in the experimental room. Comparison of the results of two experiments reveals that the proper impression of sonic environment can be evoked by onomatopoeias even in the experimental room. It is suggested

that a picture with sonic onomatopoeias can transfer the visual and sonic impression properly to the person who is not there.

### 384 Investigation on high-frequency noise in public space.

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#### ABSTRACT

In recent years, rodent repelling devices are increasing in urban public spaces, especially in front of food storages or restaurants. These devices emit high-frequency noise, whose spectral peak is around 20 kHz, with extremely high sound pressure. To make good use of these high-frequency sounds adequately and effectively, security of the people exposed to these sounds must be ensured. Especially young children are supposed to be sensitive to high-frequency sounds. Hence, the consideration to the security of them is a matter requiring immediate attention. As a first step to solve this matter, the measurement of noise from a rodent repelling device was carried out in a commercial facility. In parallel with that, questionnaire survey was conducted to the workers and young users in the facility. The measurement results showed that the maximum sound pressure level was about 120 dB directly under the device, and more than 90 dB at the point of 15 m away from the device. Concerning the result of the questionnaire survey, the younger workers and users recognized the high-frequency sound from the rodent repelling device more clearly when compared with the elderly workers. Furthermore, most of the answerers who recognized the high-frequency sound reported negative evaluation, such as "unpleasant", "noisy", "having a headache or an earache" and so on. Taking these serious results, remedial measures were discussed while considering economical efficiency, immediacy and facility. The specific method and the result of remedial measures will be described in this paper.

### 424 A study of degraded-speech identification based on spectral centroid

*Furoh, Takayuki (1); Fukumori, Takahiro (1); Nakayama, Masato (1); Nishiura, Takanobu (1)*  
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#### ABSTRACT

Hands-free speech interfaces are developed with the progress of speech recognition techniques. In the conventional automatic speech recognition (ASR) system, normal speech can be recognized with high accuracy. However, the ASR performance is degraded because the human speech is distorted by noise and speaking styles in noisy environments and crisis situations. This problem can be solved by applying suitable acoustic model corresponding to degraded speech. Therefore, we had previously proposed the identification for degraded-speech based on the fundamental frequency (F0), 2nd-order mel-frequency cepstral coefficient (MFCC) and rahmonic. The conventional method can identify normal speech, Lombard speech and shout speech, but it has an insufficient identification performance. This is because the conventional method utilizes acoustic features which are similar in Lombard speech and shout speech. In this paper, we therefore propose degraded-speech identification method based on the spectral centroid, F0, 2nd-order MFCC and

rahmonic. The spectral centroid can represent the formant shift to the high-frequency spectrum. In the proposed method, the spectral centroid is utilized for identifying Lombard speech and shout speech. As a result of objective evaluation experiments, we confirmed the effectiveness of the proposed method towards the identification for degraded-speech.

#### 569 Survey on vehicle horn use in urban areas of Korea

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(1) Kyushu University, Japan; (2) Surugadai University, Japan

##### ABSTRACT

In previous studies, we carried out questionnaire surveys to investigate the current circumstances of vehicle horn use and the effects of horn use on drivers and pedestrians in Japan. Several cities in other countries face noise problems relating to the use of car and motorbike horns. Our survey design might help obtain information on the circumstances of vehicle horn use in such areas, which can subsequently be used to design countermeasures to reduce adverse effects. Therefore, we conducted a similar survey on horn use in South Korea. Measurement of noise at a crossroad with heavy traffic revealed more than 100 uses of the horn per hour. The questionnaire survey included questions on the latest or last-remembered case of horn use in various situations in which the respondent was a driver or pedestrian. It was found that many pedestrians had experiences of being honked at with a single honk, two short honks and a long honk. Such honking mostly aroused negative psychological reactions such as the respondent finding the horn use startling, noisy, or irritating. There were no significant relationships between questionnaire items of the driver's own horn use, suggesting there is no particular manner of the driver's own horn use.

#### 524 The effects of the aircraft noise and multiple echoes on speech intelligibility of outdoor public address system

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##### ABSTRACT

This study investigates how multiple echoes reflected from adjacent buildings influence the speech intelligibility of outdoor public address systems when aircraft noise is added. To accomplish this, the sound of an aircraft flying over industrial areas was recorded from the vicinity of an airport in Tokyo and then added to speech sounds at a signal-to-noise ratio (SNR) of -5 dB. Then, the speech signals, with or without artificial multiple echoes, were presented to 18 young adults at sound pressure levels (SPLs) of 60, 70, and 80 dB. The results of the listening test showed that aircraft noise and multiple echoes separately decreased speech intelligibility, but that speech with the multiple echoes present had significantly lower word identification scores than speech without multiple echoes. The results also showed that speech intelligibility increased when the SPLs was increased from 60 to 70 dB, but no further increase was observed when the SPLs rose from 70 to 80 dB, with or without multiple echoes. Taken together, the results indicate that both aircraft noise and multiple echoes decrease the speech intelligibility of outdoor public address systems, and to ensure sufficient information is transmitted when multiple echoes and aircraft noise are present, SPLs should not be lower than 70 dB.

#### 530 Influence of Visual Information on Subjective Evaluation of Road Traffic Noise

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##### ABSTRACT

It is well known that human auditory and visual senses interact with each other, and that visual information has an influence on human subjective impression of sound. The purpose of this study is to clarify an influence of visual information on a subjective evaluation of sound as to road traffic noise. We carried out a subjective evaluation experiment using video of a driving motor vehicle as a visual stimulus taken with a video camera in the vicinity of a road, and sound data of the driving motor vehicle as an auditory stimulus. Subjects performed subjective evaluations for a case with the auditory stimulus only and a case with both the auditory and visual stimuli. After an analysis of variance, the result showed that presence or absence of the visual stimulus has a statistically significant influence on a subjective evaluation value of the noise.

#### 899 High directivity masking sound system for achieving speech privacy

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##### ABSTRACT

In recent years, importance has been attached to achieving speech privacy in open spaces. Generally, although measures such as the use of sound partition are instituted in many cases, measures that use other sounds to mask speech by emitting sound other than speech have also been considered. The masking noise emitted to the area where high level of speech privacy is not required, may cause an increased psychological impression of annoyance, leading to a decline in performance. In this study, we constructed a masking sound system with highly directional sound from modulated ultrasound as a masking noise for achieving speech privacy in the narrow area. Psychological experiments were conducted in which the masking sound was transmitted to participants from frontal or above directions with a high directivity masking sound system. Using the experimental data, the relationships between the degree of speech privacy and frequency characteristics and directivity of a high directivity sound through the masking sound system were investigated.

#### 440 On frequency characteristics of bone conduction actuators by measuring loudness, acceleration and otoacoustic emission

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(1) Kumamoto University, Japan

##### ABSTRACT

Bone conduction is being utilized widely for music reproduction and hearing aids. However, due to unclear transmitting process of bone conduction, some detailed characteristics are still in discussion. Previous researchers has made achievements on frequency characteristics of bone conduction actuators by comparing the relationship between loudness as a subjective measurement and acceleration as an objective measurement.

In this paper, besides discussion on the possibility of estimating loudness characteristics on bone conduction actuators by means of acceleration, another method that uses otoacoustic emissions(OAEs) to estimate frequency characteristics of bone conduction is also presented. OAEs, which are acoustical signals considered to be from cochlea, are measurable of most humans with normal hearing. By giving a single stimulus to cochlea, otoacoustic emission will be transmitted into ear canal. According to the results, the emitted signal arose in response to the stimulus which was from a bone conduction actuator. It was found that similar emissions were responded to stimulus of bone conduction at the same frequency. It suggests possibility of using otoacoustic emission as a method for measuring frequency characteristics of bone conduction actuators.

**417 Efficiency evaluation of subspace-based spectral subtraction based on iterative eigenvalue analysis in real environments**

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**ABSTRACT**

In real environments, the recorded speech signal is much affected by unwanted noise. Therefore, it is necessary to reduce the unwanted noise from the recorded noisy signal. The spectral subtraction (SS) and the flooring processing-improved SS (F-SS) have been proposed to achieve that. The F-SS iteratively estimates the clean speech signal by utilizing the SS. However, the F-SS generates the distortion in the noise-reduced signal although it can reduce the unwanted noise. In this paper, we propose the subspace-based spectral subtraction (S-SS) to reduce the distortion from the noise-reduced signal. The proposed S-SS performs the eigenvalue analysis with multiple noise-reduced signals by the SS. The proposed S-SS acquires multiple noise-reduced signals by the SS under the various conditions of noise estimation. The subspace of speech component is calculated from multiple noise-reduced signals by the eigenvalue analysis. The proposed S-SS then acquires the noise-reduced signal which is reduced the distortion by using the subspace of the speech component. The proposed S-SS can simultaneously reduce the unwanted noise and the distortion of the observed signal by iteratively performing these processes. As a result of objective experiments with signal-to-distortion ratio (SDR), we confirmed that the proposed S-SS can reduce the distortion of the noise-reduced signal.

**422 Evaluation of clipping-noise suppression of stationary-noisy speech based on spectral compensation**

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**ABSTRACT**

Development of communication systems allows people to easily record and distribute their speech. The clipping-noise, however, degrades the sound quality in the speech recording when gain level of input signals is excessive in the maximum range of an amplitude. In this case, it is necessary to suppress the clipping- noise in the observed speech for improving its sound quality. Although a linear prediction method has been

conventionally proposed for suppressing the clipping-noise, it has a problem with degradation of the restoration performance by cumulating error when the speech includes a large amount of the clipping-noise. This paper describes a method for the clipping-noise suppression for the stationary-noisy speech based on the spectral compensation in a noisy environment. In this method, to suppress the clipping-noise, the Gaussian mixture models are utilized for modeling the power spectral envelope of the speech on each frame in the lower frequency band. The clean speech signals in a database are also utilized for restoring the clipping speech in the higher frequency band. We carried out evaluation experiments with a speech quality, and confirmed the effectiveness of the proposed method for the speech which includes a large amount of the clipping-noise.

**593 Influences of whole-body vibration on roughness sensation**

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**ABSTRACT**

"Texture" is one of the elements that contribute to the appearance of industrial products. It is an important element in improving a surface's added value. In this study, we quantified the surface of various irregular shapes using areal surface texture parameters compliant with ISO25178-2:2012. Then, we investigated the relations of roughness sensations and areal surface texture parameters. Moreover, we investigated the effects on a car passenger's sense of roughness when exposed to whole-body vibration. By investigating the areal surface texture parameters of textured surfaces, parameters that were effective for characterizing irregularities in different surfaces were described. In conclusion, design guidelines for surfaces that include tactile factors were suggested.

**11 The empirical assessment of human vibration propagated in building and HVAC systems**

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**ABSTRACT**

Researchers in vibration have shown that disorders of a heart-cardiovascular circle appeared by vibration exposure. In the first step of doing work, the vibration accelerometer put on the base of a fan where the vibrations send toward the duct wall. Vibration assessment of building is done in the other steps to compare with guidelines. The vibration rates in these areas should not be more than recommended values of ASHRAE for buildings. The methods tried including the isolator and balancing duct. By placing the isolator on the duct wall, the accelerometer locates on the body of duct wall and the value of vibration measured in a millimeter per seconds. A Peak reduction of vibration velocity in building has been appeared at frequency of 68.5Hz by a value of 33mm/s after applying isolation.

For other parts of the vibration rate of the frequency's band, the taken results prove a proper cut of vibration paces. There were exceptions in the cut of vibration rate for frequencies, including 627.2 and 636Hz, but the increased amounts are excusable. Thus, applying the methods of control may be



acceptable, but it could not cover few parts of vibration frequency band spreading in building.

**625 On a Binaural Model with Front-back Discriminator using Artificial Neural Network trained by multiple HRTF catalogs**

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(1) Kumamoto University, Japan

**ABSTRACT**

Various binaural models have been proposed for the application of hearing assistance system as well as humanoid robot, and a frequency domain binaural model(FDBM) is the one. Like other binaural models, the original FDBM can separate and segregate a signal from the specific direction based on interaural information, but it works only in the frontal semisphere due to front-back confusion. In order to reduce this confusion, a front-back discriminator was proposed for FDBM using artificial neural network (ANN) trained by a head related transfer function (HRTF) catalog. This discriminator has strong dependency on the trained HRTF catalog thus it is not robust against various fluctuation including individual differences and reverberation. This paper discusses an extension of the discriminator using multiple HRTF catalogs for ANN training. The simulation results for the new discriminator show the possibility to reduce the front-back confusion under various conditions including ones obtained in a reverberant room.

**259 A triple microphone array for surround sound recording**

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(1) Chinese Academy of Sciences, China

**ABSTRACT**

B-format signal can be directly by the gradient microphones. In this paper, a small size triple microphone for surround sound recording is proposed, where every two components of triple microphone array compose a differential microphone array. Some direct and indirect methods for B-format signal are discussed. With the virtual microphones method, the loudspeakers feeding signal will be obtained.

**411 Localization of multiple environmental sound sources by MUSIC method with weighted histogram**

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(1) Shizuoka University, Japan

**ABSTRACT**

This paper presents an estimation method of environmental sound sources localization based on MUSIC method by small-sized microphone array. MUSIC spectrum depends on array manifold vector calculated from microphone array configuration and eigenvectors provided an observed signal. By considering the relation between a microphone array and MUSIC spectrum, we examine the arrangement of microphones for high accurate localization with fewer number of elements. And to estimate the environmental sound sources, which have various frequency properties, we propose a weighted histogram method for direction of arrival (DOA) estimation considering frequency properties of the observed signal. We introduce histogram obtained by detected peaks by MUSIC spectrum at each frequency bin. In addition, the sound source

positions are estimated on intersection of the estimated directions which are obtained by a pair of microphone arrays. In the numerical simulation, the localization accuracy can be improved with reduced aliasing using a microphone array of irregular interspace. And, the proposed method can be improved the estimation accuracy for the electronic sound, which has sparse frequency property.

**572 The study on the woofer speaker characteristics due to design parameters**

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**ABSTRACT**

In the vehicle speaker, because the sound characteristics are changed by the space of vehicle which mount the speaker, the speaker elements should be determined according to sound field. In this study, the nonlinear characteristics, the frequency response and the sound pressure for the same size speakers which is adapted to domestic vehicle model are investigated. The vehicle model is classified to semi-midsized, midsized, full size vehicle in order to change the vehicle space. As a result, we can investigate the differences of the force factor and the stiffness of suspension system for speaker. According to the change of the speaker characteristics, the sound pressure is changed, also. In the future, these data will be used to investigate the correlation between the sound quality and measurement data.

**348 Virtual sensing in the reverberant field based on the harmonic signal from the emitting source.**

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**ABSTRACT**

To perform active noise control it is necessary to establish sensors locations, knowing that the error sensors should be placed near to areas that we want to reduce the noise. It's quite inconvenient the need of positioning the error sensor in the center of a room, or in walking areas, or near of the observer's ears, so, It has been investigated a new method, that does a virtual detection from the physical sensors. In this paper we investigate the remote responses obtained in a reverberant room, from a generated harmonic signal. The acoustic emission is characterized from one vibrational sensor and it is used artificial neural networks to estimate a virtual detection response. Was compared and investigated: the neural network architecture, the usage of reference signals, influences due to environment changes, operating condition changes and noises from other sources. Frequency responses in magnitude and phase were also evaluated and compared. It has been investigated ways to accomplish the system identification, and the evaluation of the answers accuracy when there are changes in the dynamics of propagation.

## 262 Impedance matrix of rubber-cord fluid-filled hose

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### ABSTRACT

One of the main hydraulic elements to reduce noise and vibration of pipelines is a rubber-cord hose, which consists of a composite shell and attachment flanges. Within the frames of a beam model dynamic behavior of pipeline elements is described with impedance matrix  $14 \times 14$ , which can be determined by calculation or experiment. In the current paper a theoretical beam model of fluid-filled hose is introduced, taking into account with orthotropic and viscoelastic properties of composite shell. Expressions for impedance matrix elements are presented in analytical form. Some elements are measured and good agreement between predicted and measured characteristics is shown.

## 874 Footprint analysis concerning noise: approaches, tools and opportunities

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### ABSTRACT

A methodology to control noise through footprint analysis is proposed. It involves determining the noise contribution produced by significant sources in their surroundings, such as transport infrastructures (not just aircraft and airport), industrial sites and other technical facilities, or by individual sources throughout their life cycle, including motor vehicles, machinery, equipment and the typical devices to which we are exposed during working or leisure time. The main acoustic parameters must be analysed: measurement and simulation of noise indicators, comparison with the limits imposed by legislation and calculation of any overruns are expected. The paper illustrates the technical issues of the research concerning noise footprint. The aim is to provide scientific and technical support to the implementation of noise abatements and environmental sustainability. The scientific value of the research consists in the study of approaches, tools and opportunities to convert noise descriptors in population and soil units referred to the exposed number of inhabitants, by quantifying the areas where noise limits are not exceeded as well as a kind of compensation to allow sustainable development. Therefore noise footprint is not merely a graphical representation of noise contours on maps. As an example of application of footprint analysis to noise, a pilot project and the study of patented solutions are in progress.

## 1025 Breathing mechanism of a cracked rotor subject to non-trivial mass unbalance

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### ABSTRACT

The effects of dynamic loading on crack breathing mechanisms are not yet thoroughly examined in literature. This paper introduces a parameter relating crack direction to bending load direction in order to model breathing behaviour of fatigue cracks subject to mass unbalance. Crack states (open, partial and closed) for shafts subject to weight-to-unbalance force ratios of 0.5, 1 and 2 and unbalance orientation angles of  $0^\circ$ ,  $45^\circ$ ,

$90^\circ$ ,  $135^\circ$  and  $180^\circ$  were sometimes seen to be non-sequential or unchanging at particular crack depths. Additionally, the effects of varying unbalance angles and crack depth ratios on breathing mechanisms were also examined. An area moment of inertia method was used to develop a time-varying global stiffness matrix for each case and the results were found to be highly agreeable with the crack breathing behaviour in each case.

## 527 Sensitivity analysis of source region size on results of Stochastic Noise Generation and Radiation model

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### ABSTRACT

The paper deals with the Stochastic Noise Generation and Radiation (SNGR) model based on synthesizing of turbulent velocity components from results of a Reynolds Averaged Navier-Stokes (RANS) simulation. The turbulent velocity components are then used for computation of aero-acoustic sources representing the right-hand side of linerized Euler equations (LEE) describing the sound propagation. Primarily, the paper is aimed on testing the sensitivity of SNGR model solution on a source region size. Specifically, an acoustic intensity was chosen as a comparative variable computed by solving LEE via meshfree Finite Point Method (FPM). The size of source region has a direct impact on time and memory requirements during the stochastic reconstruction. As a test case, we chose a 2D free plane jet with height  $2b_0 = 30\text{mm}$  and  $M = 0.1$ . For obtaining the averaged flow results, the RANS simulation with standard  $k - \epsilon$  turbulence model was performed. Based on this averaged results, the turbulent velocity field is obtained by the synthesis of a finite sum of random Fourier modes.

## 903 Relationship between soundscape and historical-cultural elements of Historical Areas in Beijing: a case study of Qianmen Avenue

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(1) Capital Normal University, China

### ABSTRACT

With the tourism development of Historical Areas in Beijing, the soundscape of Historical Areas has changed dramatically. Whether the new soundscape of Historical Areas created by tourism could highlight Beijing's traditional culture and history, and whether the new soundscape could convey true meaning of Historical Areas to visitors and give them good tourism satisfaction, are both key issues to be solved in balancing the relationship between development and conservation of Historical Areas. Taking Qianmen Avenue of Beijing city as a studied case, this paper examined the relationships between the current soundscape of Historical Areas and the historical—cultural elements of Historical Areas. The methods of In-depth Interview and the Statistical Analysis were adopted in the paper to acquire the subjective appraisals of related experts and visitors who have experienced the soundscape. The findings of the paper showed that experts believed that the new soundscape of Qianmen Avenue had separated itself from Beijing traditional history and culture. Visitors there could not perceive the essence of Beijing' regional culture and their tourist satisfactions are associated

with the current new soundscape. Suggestions of improving and optimizing current soundscape were proposed in the final.

**454 A three-stage method for sound field reproduction in rooms with reflection boundary:theory and experiments**

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**ABSTRACT**

This paper presents a three-stage method for sound field reproduction in ordinary rooms. Optimization of speaker positions is important to reduce the number of speakers and the calculation time should be acceptable so that the algorithm can be put into practise. In the first stage of the proposed algorithm, the least absolute shrinkage and selection operator(Lasso) is used to select the most important speakers' positions for all frequencies. Then l2-norm regularization is performed in the second stage to design the FIR filters. In the third stage, a fast convolution method based on Fast Fourier Transform(FFT) is carried out to reduce the time consuming of filtering algorithm. The performance of this three-stage method is investigated by experiments for different speaker numbers. The calculation time proves the efficiency of this method and the results of experiments show that compared with the widely used inverse filtering method, the proposed method can significantly reduce the speaker number without a serious side effects on the reproduction accuracy.

**877 Reducing noise pollution by increasing sound absorption of carpets**

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**ABSTRACT**

Noise is an often underestimated health risk in our life. Most office workplaces have a general unhealthy and annoying soundscape. Architects intend to minimize this noise pollution by certain structural measures. One space-saving possibility to do this lies in the field of highly sound absorbing carpets which are predestinated due to their large surfaces. To be able to evaluate and distinguish the sound absorbing quality an evaluation criterion is necessary. In European countries this is usually the weighted sound absorption coefficient  $\alpha_w$  (according to the European/International standard EN ISO 11654). The influence of the carpets design parameters on this single-number rating is analyzed and statistically evaluated. Based on these result a prediction of the coefficient is pursued.

**857 Investigation of vibration transmission properties of compressor grommets in domestic refrigerators**

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**ABSTRACT**

As household appliances become more and more quiet every day, even the smallest contributions to product sound power levels are gaining importance. Vibration transmission through compressor grommets is such a contributor for domestic refrigerators. The vibration that originates from the

reciprocating compressor is isolated from the refrigerator body by the rubber-based grommets that are placed between the compressor and the base-plate. However, this isolation is not enough in many cases that the refrigerator body is observed to be vibrating with the same characteristics as the compressor. Also in the acoustic measurements of the refrigerator, some of the frequency contributions in the product noise are seen to be in relation with this vibration. Within this study, the transmission path of this vibration and some parameters in grommet design are investigated in detail. An evaluation methodology for the compressor grommets is developed that allows minimum vibration transmission and hence the least sound power level for the refrigerator.

**898 Modeling sound radiation from a baffled vibrating plate for different boundary conditions using an elementary source technique**

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(1) Universiti Teknikal Malaysia Melaka, Malaysia; (2) ISVR, University of Southampton, UK; (3) Universiti Kebangsaan Malaysia, Malaysia

**ABSTRACT**

Analytical models of the sound radiation a rectangular plate are often based on simply supported edges for mathematical convenience. Models for other boundary conditions also exist, but mostly these employ rather complicated analytical calculations. This paper presents an analytical model of the radiation efficiency for a baffled plate using a discrete elementary source model. The model requires only the a knowledge of the spatial distribution vibration velocity of the panel and hence this surface velocity can be calculated conveniently by using the established mobility equations for different plate boundary conditions. This is then included in the discretized Rayleigh integral to calculate the radiated sound pressure to the far-field. Variability of the radiation efficiency for different forcing locations and its average value are presented here for several combinations of boundary conditions. Experimental results are presented for free and clamped edges which show reasonable agreement with the predicted results.

**186 Practical consideration of noise from fans**

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**ABSTRACT**

Fan noise is often stated based on fan casing breakout alone, ignoring additional noise generation from other fan components, meaning operational and onsite noise levels would be higher than specified. Sources of fan noise are discussed to help identify where problem noise is being produced, and provide suggestion for better specification of attenuation devices. Anti-thrust vanes, inlet and outlet dampers, variable inlet vanes, bearings, belt drives, electric motors and VF drives are commonly neglected when stating the sound performance level of a fan. Noise resonance can also occur from incorrectly designed pedestals, casings and duct work. Noise breakthrough from expansion joints and ductwork with lesser attenuation characteristics than the casing material will increase overall noise. Dust and materials handled by fans

also introduces an additional source of noise to be considered. There are suitable options to control the overall noise of the fan as well as focused attenuation for particular fan components and accessories, both will be discussed.

**367 Research on the directive property control for a phased rectangular loudspeaker array**

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**ABSTRACT**

This paper studies the control technologies of directive property for a phased rectangular loudspeaker array. The sound field directivity pattern and sound pressure level (SPL) of the main beam was analyzed with numerical simulation and experiments. The results show that the suppression of grating lobe is most efficient when horizontal deflection angle ( $0^\circ$ ) is  $45^\circ$ . The SPL of the main beam decreased less than 1dB when the beam deflected in the plane of accuracy deviation of the main beam occurs when the vertical deflection is over  $50^\circ$ , and the deviation level is about  $5^\circ$ . The reasons resulted in SPL reduction was that the array elements are not the pulsating sphere source and the mutual acoustic impedance effect existed between elements. The directional accuracy of main beam is due to the mutual acoustic impedance and the diffraction in the edge of baffle.

**1015 A new method for monitoring far-field noise level with a few near-field sensors**

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**ABSTRACT**

The noise of electrical equipment operating outdoors in the residential areas, such as the transformers, is a growing concern. The sound of the equipment propagating to people's home should be monitored. It is sometimes convenient to measure the acceleration on the equipment or the sound pressure nearby but inconvenient to measure the sound pressure at the position of interest. This paper presents a new method to estimate the noise of the equipment with the sensors close to the equipment instead of the on-site sensors in the far field. This method employs the ideas of frequency response function measurement, and it first measures the response-response matrix from the neighbouring sensors to microphones at the desired location under different operational conditions. Then the sound pressure level under the new operational conditions can be calculated through the historical response-response matrices. The condition number of the matrix can be used to evaluate the errors and as a criterion to optimize the sensors' positions. The measurement results of a steel cylinder is also shown.

**923 A Soundscape Research on the Route Gezi Park–Tunel Square**

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**ABSTRACT**

Field studies suggest that the perceived soundscape quality of urban environments is more often related to the informational properties of the soundscape than its acoustic measures. This paper describes the perceived soundscape characteristics of the approximately two kilometer long route of Gezi Park–Tunel Square in Istanbul. To study listeners' relationships with contemporary urban environments, 30 minute soundwalks were conducted on the Gezi Park–Tunel Square route. Gezi Park, Taksim Square, Galatasaray and Tunel Square were determined as key locations on the specified route. The conducted soundwalk method combines the Positive Soundscape Project (1) and Schafer's World Soundscape Project (2). For each key location questionnaires having semantic descriptors were handed out to participants to understand their personal impressions of the key location. At the end of the route, a questionnaire with general to specific questions was distributed to evaluate the soundscape of the whole route. This paper presents the soundscape characteristics of the route and discusses the effects of the four key locations on the total soundscape perception of the route.

**240 Characterizing the ecology of the Aboriginal soundscape**

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**ABSTRACT**

The potential for noise to impact humans is an important consideration for impact assessments and planning processes. Human responses to noise in urban and rural settings, and the values that constitute such soundscapes, have been well documented in the literature. Very little, however, is known about the interactions between Aboriginal land uses and sounds and whether, if at all, Aboriginal cultural practices can shape a distinct soundscape that generates different human responses to sound. This paper considers the cultural values of an Aboriginal group with regard to sound. Analysis demonstrates that Aboriginal groups do have distinct soundscapes and values that result in different responses. This paper discusses the approximate criteria that are likely to comprise an Aboriginal soundscape and how such criteria may be characterized.

**241 Determining noise effects from industrial development on Aboriginal soundscapes: insight into best practices**

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**ABSTRACT**

Industrial development proposals frequently consider the potential effects of noise on human environments. Emerging practices often include the application of standardized assessment frameworks that focus on the health of those who may be affected. In many cases, specified methods apply pathway analysis and thresholds that presume a set of homogenous values and responses to noise. Aboriginal people in British Columbia, Canada, however, have raised serious

concerns that suggest such assessments are substantially inadequate. Whether Aboriginal groups' cultural values are sufficiently integrated into noise standards, and how such values are operationalized, is poorly understood at this time. Using a case study approach, this paper examines the standard methods by which to assess the potential noise from coal mining activities on the land use activities of an Aboriginal group. Analysis demonstrated that noise standards have not implicitly or contextually integrated components from the distinct Aboriginal soundscape. The analysis also demonstrated that current standards fail to adequately scope valued components and predict potential noise effects. This paper suggests a number of steps that may be used as initial best practices to assess the impacts of noise on the Aboriginal soundscape and how to work collaboratively to identify suitable criteria.

## Author Index

A Mahmoud, Abd El Fattah, 79  
 Aasebo, Sigve Jarl, 116  
 Abbadi, Zouhir, 65  
 Abhayapala, Thushara D, 193  
 Åbom, Mats, 205  
 Accardo, Giampiero, 141  
 Adams, Keith, **88**  
 Adnadjevic, Mirjana, **174**  
 Agha, Apoorv, **210**  
 Ahelfeldt, Thomas, **136**  
 Ahmadvand, Masoumeh, 222  
 Ahn, Sangkeun, 55  
 Ahn, Sungjong, **48**  
 Ainsle, Michael A, 169  
 Aizawa, Kai, **120**  
 Akdag, Ali, 61  
 Akdag, Nese, 61  
 Akdere, Musa, **225**  
 Akita, Takeshi, **220**  
 Al Rochmadi, Nurwachid, 48  
 Alamshah, Vahid, 156, 196  
 Albers, Albert, 146  
 Aleonard, Julien, 167  
 Alexandrou, Vasos, 158  
 Aliev, Ali E, **121**  
 Allen, Amy, 199  
 Allman-Ward, Mark, **167**  
 Altun, M Cem, 164  
 Alvarez, Noe T, 121  
 An, Deok-Soon, **210**  
 An, Liang, 77, **219**  
 Andersen, Bent, 147  
 Andreas, S, 50  
 Anfosso, Fabienne, 66  
 Ang, Boon-Wee, 210  
 Aramaki, Takuma, 59  
 Araújo, Jorge, 148  
 Arimitsu, Akihiko, 120  
 Arnold, Jörg, 110  
 Arntzen, Michael, 87, **160**  
 Arredondo, Jose, 172  
 Asahina, Mineyuki, 196  
 Ascari, Elena, 66  
 Asrul Sani, Razak, 63  
 Astley, R Jeremy, **41**  
 Atalla, Nouredine, 161  
 Atamer, Serkan, **161**  
 Attenborough, Keith, 94  
 Audoly, Christian, **53**, 117  
 Austrel, Per-Erik, 201  
 Aversano, Renato, 140  
 Ayub, Md, **121**  
 Azechi, Yoshiki, 145  
 Azizan, Mohd Amzar, **81**  
 Azzahra, Iva R Nisa, 49

Baars, Woutijn J, **178**  
 Bååth, Lars, 196  
 Bacelar Milhomem, Thiago  
 Antônio, **58**  
 Badan, Marco Aurfelio B C, **223**  
 Bae, Seung-Hoon, **70**  
 Bagha, Ashok K, **176**  
 Bahali, Sercan, **226**  
 Bai, Guofeng, **164**  
 Bajko, Jaroslav, 224  
 Bak, Christian, 74, 122, 176  
 Baliatsas, Christos, **68**  
 Ballagh, Keith Orsourn, **143**  
 Bao, Chaoying, **117**  
 Barclay, Edward A, **164**  
 Bard, Delphine, 79, 99, 122, 165,  
**166**, 177, 201, 203  
 Bard, Delphine Gérard, 127  
 Barkefors, Annea, **89**  
 Barré, Sébastien, **64**  
 Bartel, David Wayne, 189, 190  
 Bartlomé, Olin, 165  
 Bartolomaeus, Wolfram, 83  
 Bassett, Timothy Whitehead, **146**  
 Bauer, Michael, **108**, **123**  
 Beach, Elizabeth Francis, **75**  
 Beale, Linda, 54  
 Becker, Stefan, 43  
 Becker-Schweitzer, Jörg, 43  
 Beevers, Sean, 54  
 Behrendt, Matthias, 146  
 Beidenhauser, Georg, 151  
 Bekke, Dirk A, 83, **102**  
 Bellidega, Krishna Chaitanya, **179**  
 Bellmann, Michael, **149**  
 Belschner, Torsten, 146, **147**  
 Bendtsen, Hans, **147**, **153**  
 Beneš, Petr, 113, 215  
 Benke, Geza, 199  
 Bérengier, Michel, 52, **83**  
 Berge, Truls, **101**  
 Bergiers, Anneleen, **52**  
 Berry, Alain, 214  
 Berry, Bernard, 87  
 Bertagnolio, Franck, 74, 122, **176**  
 Best, Nicky, 54  
 Bethke, Christian, 72  
 Bethlehem, Terence, 174  
 Beyers, Craig, **72**  
 Bezemer-Krijnen, Marieke, **83**,  
 102  
 Bi, Chuan-Xing, **112**, 114, 126  
 Bianciardi, Fabio, **101**, 141  
 Biermeier, Thomas, 43  
 Binnerts, Bas, 169  
 Blangiardo, Marta, 54, **131**  
 Blaschke, Ralf, 43  
 Blunt, David M, **178**

Bodden, Markus, **146**, 147  
 Boeck, Magdalena, 75, 133  
 Boes, Michiel, 104  
 Bolton, J. Stuart, 106, 172  
 Bondarenko, David Bello, **58**  
 Bonnycastle, William, 186  
 Borello, Gérard, 127, 166, **183**  
 Borgeaud, David, **166**  
 Bös, Joachim, 199  
 Botteldooren, Dick, 46, **104**, 174,  
 205  
 Bouayed, Kaiss, **140**  
 Boulandet, Romain, **214**  
 Boutin, Jerome, 47  
 Boyd, Brenna N, 118  
 Boyer, Sylvain, 47  
 Boyle, James, 109  
 Braasch, Jonas, 150  
 Bradwell, Simon, **96**  
 Brandner, Paul A, 67  
 Brattico, Elvira, 54  
 Brennan, Michael J, 175  
 Brezas, Spyros, 72  
 Bristow, Abigail, 88  
 Brizzi, Laurent-Emmanuel, 137  
 Broneske, Sylvia, **122**  
 Bronkhorst, Adelbert, 87  
 Brothnek, Marek, 176  
 Brouard, Bruno, 184  
 Brown, Alan Lex, **188**, **209**  
 Brown, Stephen, 55  
 Brummund, Martin, 47  
 Bruns, Benedikt, **149**, **169**, 170  
 Buchegger, Blasius, 113, 128, **144**  
 Buchholz, Jorg M, 79  
 Budd, Lucy, 88  
 Buffo, Rainer M, 73  
 Buikema, Edwin, **155**  
 Buisson, Quentin, 117  
 Bullen, Robert, 168, 172  
 Bulte, Jean, 198  
 Burch, M, 179  
 Burdett, Matthew, 110  
 Buret, Marc, **84**, 109, 130  
 Burgemeister, Kym, 119, 135  
 Burgess, Charles, **225**  
 Burgess, Marion, **45**, 110  
 Burghignoli, Lorenzo, 123  
 Burgschweiger, Ralf, **190**  
 Burnett, Ian S, 135  
 Burroughs, Courtney B, **45**  
 Büscher, Alexander, 108  
 Bustamante, Marcelo, 202  
 Butera, Frank, **135**  
 Byrick, Wilson, 186  
 Byrick, Wilson Robert, **127**  
 Cabrera, Densil, 64, **74**  
 Cai, Richard Chao, 187

- Cai, Samuel, 131  
 Cai, Yefeng, **213**  
 Çaliskan, Mehmet, 161  
 Campbell, Alex, **203**  
 Campbell, Colin, **63, 79**  
 Campos, L M B C, **59, 202**  
 Can, Arnaud, **188**  
 Cao, Hongli, **77**  
 Cao, Yipeng, **104, 163**  
 Carley, Michael, 106  
 Carlsen, Henrik, 58  
 Carter, J Parkman, **129, 150**  
 Castellini, Paolo, 177  
 Cater, John Edward, 177  
 Cato, Douglas H, **53**  
 Cattafesta, Louis, 59  
 Caviedes, Alvaro, 61  
 Cazzolato, Benjamin S, 121, 195  
 Cekan, Michal, 162  
 Centracchio, Francesco, 123  
 Cerchiai, Mauro, 66  
 Cernik, Martin, 106  
 Cesbron, Julien, 147  
 Chan, Horus Y H, **197**  
 Chan, Woei-Leong, 195  
 Chang, Cheng-Yuan, **56, 134**  
 Chang, Daoqing, 121  
 Chanpong, Napasin, **102**  
 Chatagnon, Roger, 51  
 Chau, C K, 104  
 Chaudhari, Mangesh, 179  
 Cheer, Jordan, **89**  
 Chelliah, Kanthasamy, 157  
 Chen, Chen Yu, 165  
 Chen, Guoyue, 214  
 Chen, Hanchi, **193**  
 Chen, Hui, 154  
 Chen, Jian, 94  
 Chen, Kai, **89**  
 Chen, Kean, 42  
 Chen, Li, **74, 91, 198**  
 Chen, Lijun, 219  
 Chen, Meilong, 78  
 Chen, Meixia, **207**  
 Chen, Mingfei, 96  
 Chen, Rilun, **223**  
 Chen, Wanli, 224  
 Chen, Wuwei, 81, 100  
 Chen, Yalong, 102  
 Chen, Yan, 114  
 Chen, Yen-Sheng, 198  
 Cheng, Kin Wui, 124, **138**  
 Cheng, Li, 125, 175, 204  
 Cheng, Xiaobin, **226**  
 Cheng, Zhang, 226  
 Cheolung, Cheong, 96  
 Cheong, Cheolung, 176, 204  
 Cheramakara, Narudh, **88**  
 Chetoni, Marco, 66  
 Cheung, M K, 137  
 Chiang, Yan Kei, **125, 187**  
 Chiariotti, Paolo, **177**  
 Chida, Shohei, 95, **96**  
 Chien, Shao-Chun, 145  
 Chiles, Stephen, **51, 60**  
 Chintapalli, V Surya Narayana Reddi, **202**  
 Chisaki, Yoshifumi, 221, 223  
 Chlebo, Ondrej, 162  
 Cho, Chi-Hoon, 62  
 Cho, Jin-Rae, 70  
 Cho, Munhwan, **59**  
 Cho, Sungjin, **106**  
 Cho, Youngeun, **214**  
 Choi, Eui-Sung, 59  
 Choi, Jung-Woo, **41, 133, 194**  
 Choi, Kyung-Min, 215  
 Chong, Yong-Kim, 210  
 Chou, Chuan-wen, **145**  
 Chou, Chuan-Wen, **165**  
 Chou, Li-Chung, 73  
 Choukri, Mostapha, 101  
 Choy, Yat Sze, 125, 187  
 Christen, Jean-Loup, **184**  
 Christophe, Julien, 123  
 Chu, S H K, **144**  
 Chuang, Hsun-Cheng, 73  
 Chung, Hyuck, 143, **164**  
 Cicero, Andrea, 129  
 Cik, Michael, **152**  
 Cioch, Witold, 157  
 Clairbois, Jean-Pierre, 184  
 Clark, Charlotte, **68**  
 Clark, Paul, 168  
 Clausén, Christin, 201  
 Clements, Jacqueline, **189**  
 Clerc, Christian, 51  
 Coats, Michael David, **142**  
 Cobo, Pedro, 91  
 Cockings, Thomas, 98  
 Cohen, Brandon, **184**  
 Cohen, Graeme J, **91**  
 Colette, Julien, 208  
 Collin, Dominique, **108, 123**  
 Conlon, Stephen, **46**  
 Conomos, James, 158  
 Conte, Frédéric, **52**  
 Conter, Marco, 66  
 Cooper, Jonathan, 156, **196**  
 Corsini, Alessandro, **97**  
 Cosstick, Lloyd, 203  
 Cotana, Franco, 224  
 Côté, Nicolas, **185**  
 Craig, Jin, 192  
 Crispin, Charlotte, **99**  
 Croaker, P, **197**  
 Croaker, Paul, 67, 92, **198**  
 Croft, Briony, **55, 119**  
 Cueto, Jose Luis, **169**  
 Cui, Fangsen, **187**  
 Cutanda Henriquez, Vicente, **62**  
 Dai, Yang, 182  
 Daley, Steve, 89  
 Dance, Stephen, 69, 97  
 Dannemann, Martin, 65, 187  
 Davies, Patricia, 172  
 Davis, David James, **63, 87**  
 Davis, Lauren, **128**  
 Davy, John Laurence, 127, 128, **143, 164**  
 Dawson, Bill, 70, 168, **177**  
 Day, Christopher, 64  
 De Boer, Andre, 83, 102  
 De Clerck, Kristof, 83  
 De Coensel, Bert, 104, **205**  
 De Geetere, Lieven, 99, **143**  
 De Hoogh, Kees, 54, 131  
 De Jong, Christ A F, 169  
 De Lisle, Simon, **119**  
 De Visscher, Joëlle, 52  
 De Vivo, Luciano, 140  
 Debroux, Philippe, 83  
 Degenhardt, Jan, 170  
 Delaitre, Pauline, **205**  
 Demirbilek, F Nur, 69  
 Demontis, Maurizio, 167  
 Demuth, Katherine, 79  
 Deng, Naiqi, 207  
 Deng, Renwei, 82  
 Deng, Zhiyong, 105, 224  
 Denolf, Katleen, 52  
 Despriet, Mathias, 46  
 Destrée, Alexandra, 52  
 Devenport, William, 74  
 Dhamanekar, Abhijit, 179  
 D'Hondt, Ellie, 205  
 Dias Rodrigues, José, 148  
 Dickson, S, 179  
 Dierckx, Marc, 200  
 Dillon, Harvey, 79  
 Dimitriadis, Christina, 199  
 Ding, Boyin, 195  
 Ding, Heng, **81**  
 Dirks, Kim N, 129, 190, **191**  
 Döbler, Dirk, 64, 137  
 Dodd, George, **203**  
 Doeblér, Dirk, 133  
 Doherty, Kieran, **187**  
 Doi, Tetsuya, **212**  
 Doiron, Dany, 131  
 Dolecek, Roman, 106  
 Donavan, Paul, **52, 115**  
 Dong, Wayland, 81, 99  
 Doolan, Con J, 92, 136, 137, 157,

- 198  
Doutres, Olivier, 47, **161**  
Dowdell, Bruce, 119  
Downey, Paul, **186**  
Du, Jingtao, **70**, 125, 195  
Du, Xuhao, 75  
Duarte, Marcus A V, 223  
Dubbink, David, **171**  
Duhamel, Denis, 65  
Duncan, Alec J, **189**  
Dupère, Iain D J, 181  
Dureisseix, David, 141  
Durup, Nick, **97**  
Duschlbauer, Dominik, **201**  
Duval, Arnaud, 183  
Dwight, Richard, 119  
Dylejko, Paul, 184, **208**  
Ebisu, Shigeyuki, 151  
Ece, Mustafa, 61  
Edstrand, Adam, 59  
Ehlig, Jana, 65  
Ejsmont, Jerzy, 52, **147**  
El-kafafy, Mahmoud, 141  
Ellem, Richard, 131  
Eller, Anthony I, **53**  
Elliott, Paul, 54, 131  
Elmedhi, Hussein, **153**  
Elmer, Karl-Heinz, 149, **169**  
Elsey, Benjamin, **158**  
Emmerich, Edeltraut, 90  
Emms, Grant, 164  
Enrique, Nava Baro, 179  
Epstein, David, **51**  
Eriksson, Carolina, 195  
Espitia Hurtado, Juan Pablo, **217**  
Eugui, Inigo, 208  
Eva, Cheng, 135  
Evans, Theodore A, 179  
Evans, Tom, **156**, 196  
Ewan, MacFarlane, 199  
Faber, Nico, **116**  
Fahnlne, John, 46  
Faner, Patrick, 132  
Fang, Houlin, 226  
Fang, Shiliang, 77, 117  
Fard, Mohammad, 81, 82  
Faria, Paulina, 49  
Fastl, Hugo, 151, 173  
Faure, Olivier, **76**  
Fauville, Benoît, **212**  
Faverjon, Béatrice, 77, 141  
Fecht, Daniela, 54  
Fedrizzi, Marcus, **131**  
Felder, Martin, **110**  
Feng, Tao, 90  
Feng, Xijing, 102  
Feng, Xiujian, 58  
Ferk, Heinz, **113**, 128, 144  
Fernandez Comesaña, Daniel, 158, **200**  
Fernandez, Francisco, 169  
Fernandez-Grande, Efen, **134**  
Ferrier, Douglas, 178  
Feudo, Sara, 97  
Feurtada, Phil, 46  
Fialka, Jiri, 215  
Fiebig, André, 167, 170  
Filipan, Karlo, 104  
Filippopolitis, Marios, 143  
Filomena, Vincenzo, **140**  
Finegold, Lawrence S, 110  
Fischer, Andreas, **74**, 122, 176  
Fischer, Jan, **146**  
Fischer, Jeoffrey, **137**  
Fischer, Martin, **90**  
Fisher, Kai, 135  
Fisher, Nick, 88  
Fleming, Richard, 98  
Floud, Sarah, 54  
Forbes, Gareth L, 56  
Forester, Harold, **81**  
Forouharmajd, Farhad, **222**  
Forrest, James, **77**, 163  
Forssen, Jens, 61  
Fortunato, Lea, 54  
Fothergill, David, 82  
Franks, Graham, 82  
Freitas, Elisabete Fraga, **148**  
Fritzsche, Christoph, 73  
Fu, Jianghua, **82**  
Fujimoto, Kazutoshi, **69**  
Fukada, Saiji, **166**, 201  
Fukaya, Kigen, **42**  
Fukumori, Takahiro, 220, 222  
Fukushima, Akinori, 168  
Fullerton, Jeffrey L, **63**  
Furoh, Takayuki, **220**  
Gaekwad, Jason, **56**  
Gagliano, Antonio, 129  
Gail, Annette, 83  
Galluzzi, Valerio, 123  
Gan, Woon Seng, 210  
Ganty, Bastien, 59  
Gao, Zengxin, 150  
Garrido, Maria, 208  
Gartenburg, Paul, **203**  
Gaspar, Robert, 120  
Gattermann, Jörg, 149, 169, 170  
Gaudin, Arnaud, 65  
Gauterin, Frank, 102  
Gauthier, Quentin, 51  
Gauvreau, Benoit, 76, 180, 188  
Gavrilov, Alexander N, 148, 189  
Gelderblom, Femke B, **87**  
Geng, Lin, 112  
Genuit, Klaus, **167**, **170**  
Georgiou, Fotis, **180**  
Gerber, Julien, 167  
Gerges, Rafael, **198**  
Gerges, Samir N Y, 198, 202  
Geyer, Thomas, **73**  
Ghosh, Rebecca E, 54  
Gillijns, Steven, 146  
Gilliver, Megan, 75  
Ginn, Bernard, 134  
Gjestland, Truls, 87, 110  
Golubev, Vladimir, **73**  
Gomes, Jesper, **134**  
Gong, Shichao, 64  
Gonzalez Boix, Elisa, 205  
Gonzalez Diaz, Cristobal, **91**  
Goretti, Michele, **224**  
Gorski, Pawel, **153**  
Gosselin, Jeremy, 103  
Gosselin, Philip, 194  
Goubert, Luc, **83**, **147**  
Gourlay, Tim, 148  
Graafland, Freek, 46  
Granneman, Jan H, 155  
Granøien, Idar L N, 87  
Gries, Thomas, 225  
Griffin, Daniel, **204**  
Grimwood, Colin, **109**  
Groby, Jean-Philippe, 184  
Grzeczka, Anna, 157  
Guettler, Marcus, 112, **197**  
Guigou, Catherine, 127, 166  
Guillaume, Gwenaël, **180**, **188**  
Gulliver, John, 54, 131  
Guo, Xinhua, 174  
Guo, Yecai, 135  
Gusia, Peter Johann, 83  
Guyader, Guillaume, 117  
Guyader, Jean-Louis, 117  
Guzzomi, Andrew, 75  
Gwak, Doo Young, **166**  
Ha, Jinwoong, 48  
Haaheim, Ole Georg, 208  
Hagberg, Klas, **165**  
Haider, Manfred, **66**  
Hald, Jorgen, **173**  
Halim, Dunant, **175**  
Hall, Marshall V, **148**, **163**  
Hallez, Raphael, 59, 76  
Halonen, Jaana, 54  
Hama, Hirokazu, 166, 201  
Hamamci, Samet Feyyaz, 61  
Hamamoto, Naoki, 92  
Hambric, Stephen, **183**  
Hamdi, Mohamed Ali, 140  
Hamilton, Mark F, 178  
Han, Chao, 195  
Han, Ning, 155, **213**  
Han, Xiao, 78



- Hanawa, Kazuto, 90  
Hanna, Kristin E, 118  
Hannay, David, 103  
Hannig, Anke, 225  
Hansell, Anna, **54**, 131  
Hansen, Colin, 96, 156  
Hansen, Kristy, 156  
Hanson, David, **119**  
Harding Ferrier, Myles, **178**  
Hartig, Terry, 191  
Hartlipp, Paul, 189  
Harwood, Adrian R G, **181**  
Hasegawa, Shin, 167  
Hasemi, Yuji, 186  
Hashimoto, Takeo, 90, 152, **172**  
Hatano, Shigeko, 90, 172  
Hautus, Michael J, 55  
Havránek, Zdeněk, **113**, 215  
Hayakawa, Makoto, 222  
Hayashi, Daisuke, 210  
Hayashi, Hidechito, **59**  
Hayashi, Mikako, 151  
Hayne, Michael James, **98**  
He, Longbiao, **58**  
Heaney, Kevin D, 53, **85**  
Heed, Christer, 140  
Heikkilä, Kauko, 54  
Heilmann, Gunnar, **75**, **133**  
Heinonen-Guzejev, Marja, **54**  
Heinz, Thorsten, 167  
Heitmann, Kristof, 170  
Henderson, Laurel J, 85  
Hepworth, Peter, **110**  
Hernandez, Ricardo, 169  
Hesse, Christian, 195  
Hida, Takahiro, **94**  
Hilge, Catja, 50  
Hiraguri, Yasuhiro, 181  
Hirakawa, Susumu, **164**  
Hiramitsu, Atsuo, 186  
Hirano, Tomohiro, **115**  
Hirao, Yoshihiro, 201  
Hirata, Tomoko, 69  
Hiroshi, Matsuda, **118**  
Hiroshi, Yamaura, 100  
Hirota, Tomohito, 186  
Hirotaka, Isao, 210  
Hisano, Shotaro, **71**  
Hjort, Roy, 150  
Hladky-Hennion, Anne-Christine, 185  
Ho, Wilson, **185**  
Hoar, Christopher F J, 110, **111**  
Hobson, P, 179  
Hodgson, Susan, 131  
Hodoshima, Nao, 221  
Hohls, Silke, **43**  
Holger, David K, **60**  
Holloway, Damien, 128  
Homb, Anders, **143**  
Hong, C S, 111  
Hong, Jiyoung, **212**, 215  
Hong, Joo Young, **171**  
Hooiveld, Mariette, 68  
Hopkins, Carl, 143  
Horan, Daniel, 98  
Hordijk, Martijn, 160  
Horiuchi, Ryuzo, 72  
Hornikx, Maarten, 180  
Horoshenkov, Kirill, 184  
Hoshi, Kazuma, **181**  
Hou, Hong, **182**  
Hou, Zhichao, **65**  
Houzu, Hiroyuki, **115**  
Howard, Carl, 70, 96, 119, 121, 135, 179, 187  
Howard, Ian M, 56  
Hsieh, Yein-Rui, 73  
Hu, Bo, **84**  
Hu, Chengtai, 82  
Hu, Sheng, 155  
Hu, Yanping, 211  
Hua, Hongxing, 67, 126  
Huang, David M, 121  
Huang, Eric Hsin-Cheng, **186**  
Huang, He, 100  
Huang, Qianwen, **56**  
Huang, Xiaofan, 155  
Huang, Xiuchang, **67**  
Hui, Elizabeth, 124  
Hülsmeier, David, **43**  
Hung, Wing-tat, **101**  
Hwang, Dukyoung, 204  
Hylander, Jonny, 196  
Hynninen, Antti, **205**  
Hyun, Jaeyub, **219**  
Ichchou, Mohamed, 184  
Ideo, Mitsuomi, 216  
lemma, Umberto, **106**, 123  
Iguchi, Akihiko, 210  
Ih, Jeong-Guon, 112  
Ih, Kang Duck, 59  
Iida, Akiyoshi, 44  
Ikeda, Kazumasa, **115**  
Ikefuji, Daisuke, 213, 216, 217  
Imazu, Taku, 182  
Ingelaere, Bart, 99, 143  
Ingemansson, Victor, 201  
Inoue, Tsuyoshi, 82  
Intaratep, Nanyaporn, 74  
Inui, Yoshitaka, 211  
Ishida, Riei, 201  
Ishihama, Masao, 115  
Ishihara, Kunihiro, 44  
Ishihara, Manabu, 97, **216**, **219**  
Ishii, Hirokazu, 76, **139**, 160  
Ishii, Yutaka, 134  
Ishikawa, Ayumi, **193**, 216, 218, 221  
Ishikawa, Daiga, 78  
Ishikawa, Kenichi, 53, 66  
Ishikawa, Satoshi, 57, 71, **77**  
Ishimitsu, Shunsuke, 49, 193  
Ishimori, Akiyoshi, 196  
Ishizuka, Takashi, 45, **180**, 213  
Itako, Kazutaka, 219  
Ito, Akiyoshi, 66  
Ito, Tomoki, **193**  
Ito, Youichi, 216  
Itofuji, Takumi, **163**  
Itoh, Yoshiaki, **182**  
Ittianuwat, Ratchaphon, **82**  
Iwabuki, Hiroshi, 201  
Iwamiya, Shin-ichiro, 221  
Iwamoto, Hiroyuki, 42, 72, **125**  
Iwanaga, Keiichiro, 212  
Iwase, Teruo, 113  
Izett, Jonathan, 103  
Izuchi, Hisao, **48**  
Izui, Kazuhiro, 141  
Jabben, Jan, **206**  
Jaber, Mariam, **199**  
Jambrošić, Kristian, 74  
Jamin, David, 51  
Jandak, Vojtech, 176  
Janello, Carrie, 115  
Jang, Ji-Sung, **67**  
Jang, Sei-jin, 193  
Jang, Seokjong, 144  
Jang, Seunho, 212  
Janssen, Sabine A, 153  
Janssens, Karl, 101, 123, 141, 146  
Jarnerö, Kirs, 99  
Jen, Ming Une, 101  
Jennings, Martin, 158  
Jeon, Jin Yong, **99**, 171  
Jeong, Jeong Ho, **80**  
Jeong, Wei Bong, 70, 111  
Jeyachandran, Keerthika, 85  
Ji, Chenzhen Ji, **178**  
Ji, Hongli, **175**  
Ji, Jin Chen, 100  
Jiang, Jiandong, 119  
Jiang, Weikang, 47, 48  
Jiao, Han, **130**, 207  
Jícha, Miroslav, 224  
Jimenez, Daniel, 74  
Jin, Guoyong, 96  
Jing, Wen-Qian, **158**  
Jiricek, Ondrej, **176**  
Jo, Hyeonho, **172**  
John, Sebastian, **65**, 187  
Jones, Adrian, 178, **189**  
Jones, Nigel, 110

- Joo, Won-Ho, 67  
 Joseph, Phillip, **178**  
 Juhl, Peter, 62  
 Jukka, Tuhkuri, 72  
 Jung, B K, **111**  
 Junker, Fabrice, 76  
 Kabilan, Tharangini, **85**  
 Kaku, Jiro, 151  
 Kaku, Teruhiko, 186  
 Kambona, Kennedy, 205  
 Kamenicky, Matej, **86**  
 Kamiakito, Noboru, 201  
 Kamijo, Takahide, 45  
 Kamimizu, Takaaki, 50  
 Kamogawa, Takashi, 120  
 Kanapathipillai, Sangarapillai, 56  
 Kanase, Mahesh, **179**  
 Kaneishi, Yoshimune, 166  
 Kaneuchi, Ken, **57**  
 Kang, Dong-Soo, **194**  
 Kang, In Deuk, 89  
 Kang, Jeonghoon, 106  
 Kang, Jian, 85, 113, 171  
 Kang, Jungoo, 133  
 Kang, Yeon June, 172  
 Karimi, Mahmoud, **92**, 198  
 Kato, Kazuhito, 82  
 Kato, Shinjiro, 132  
 Kawada, Naoki, **217**  
 Kawamoto, Satoshi, 211  
 Kazama, Ryosuke, 179  
 Kean, Simon, **130**, 168, **172**  
 Kennings, Paul, **82**  
 Kenny, Silver, **138**  
 Kessissoglou, Nicole, 47, 62, 67, 74, 77, 91, 92, 126, 141, 185, 197, 198, 207  
 Keswick, Paul, **208**  
 Khan, Amir, 191  
 Khondge, Ashok, 59  
 Kihara, Masayuki, 44  
 Kijimoto, Shinya, 57, 71, 77  
 Kim, Bong-Ki, 177  
 Kim, Boseung, 106, 115  
 Kim, Byoung-sam, **223**  
 Kim, Deokman, **65**  
 Kim, H, **183**  
 Kim, Haeseung, 204  
 Kim, Heui-Won, 62  
 Kim, Hyoung Gun, 59  
 Kim, Hyung-Taek, 67  
 Kim, Hyun-Sil, **199**  
 Kim, Jae-Seung, 177, 199  
 Kim, Jinho, **212**  
 Kim, Junejong, 57  
 Kim, Jung Tae, 219  
 Kim, Ki-Hong, 221  
 Kim, Ki-Won, **133**  
 Kim, Koo-Hwan, **126**  
 Kim, Kyoung Min, 209  
 Kim, Sang-Hoon, 185  
 Kim, Sang-Ryul, 177  
 Kim, Seockhyun, **219**  
 Kim, Seonghyeon, 172  
 Kim, Sungyoung, **194**  
 Kim, Yang-Hann, **74**, 126, 133, 194  
 Kim, Yong-Joo, 210  
 Kim, Youngkey, **133**  
 Kimura, Masateru, **182**, 219  
 King, Frances, 114  
 Kinnari, Lasse, **183**  
 Kiran, Sahu, **72**  
 Kitahara, Atsushi, **95**, 199  
 Kitamura, Yasutoshi, 201  
 Kittel, Maria, 131, 165  
 Klaczynski, Maciej, **157**  
 Klaerner, Matthias, **46**  
 Klei, Christine E, **73**  
 Klein, Philippe, 52  
 Kliezing, Tanja, 225  
 Kloser, Rudy, **84**  
 Klusáček, Stanislav, 113, **215**  
 Klyuchko, Marina, 54  
 Knowles, Andy, 87, 88  
 Ko, Sangwon, **215**  
 Koba, Yosuke, 57, 71  
 Kobayashi, Koji, 198  
 Kobayashi, Masaki, 44  
 Kobayashi, Yosuke, **218**  
 Kochanowski, Radek, 119  
 Kodejska, Milos, 106  
 Koessler, Matthew W, 189  
 Koga, Takaaki, 220  
 Koh, Hyo-In, 55, 212, 215  
 Koike, Hiroshi, **66**  
 Kokusho, Masami, 53, 66  
 Kolbe, Frank, **187**  
 Komori, Shinya, **217**  
 Konabe, Ryosuke, **216**  
 Kondo, Kazuhiro, 218  
 Kong, Byunghak, **144**  
 Kong, Weitaio, **181**  
 Kopke, Uwe, 96  
 Kors, Eugene, **108**  
 Kosaka, Fumihiko, **82**  
 Kosny, Agnieszka, **199**  
 Koss, Leonard Louis, **200**  
 Kostka, Pawel, 65  
 Kouyoumji, Jean-Luc, **127**, 166  
 Kouzoubov, Alexei, **131**  
 Kragh, Jørgen, 153  
 Krajči, Luboš, 143  
 Krause, M, 47  
 Kristensen, Brian, 116  
 Kroll, Lothar, 46  
 Kropp, Wolfgang, 61  
 Kuang, Xiaohong, 82  
 Kucukcoskun, Korcan, 123  
 Kuhn, Christian, 149, 169, **170**  
 Kunimatsu, Sunao, **201**  
 Kunio, Jason, 182, 219  
 Kunka, Rainer, 110  
 Kuo, Sen M, 56, **134**  
 Kurakata, Kenji, **121**  
 Kurosawa, Yu, 180  
 Kurtz, Patrick, **159**  
 Kuwada, Masashi, **118**  
 Kuwano, Kazuki, **172**  
 Kuwano, Sonoko, **151**, 152  
 Kuyumcuoglu, Aleks, **225**  
 Kwak, Yun-sang, 115  
 Kwok, Kwun Ting, **124**  
 Kwon, Hyuk-Min, **62**  
 Kwon, Sooahn, 210  
 Kyogoku, Hideki, 222  
 Lachambre, Hélène, 117  
 Lafon, Philippe, 76  
 Lafont, Thibault, **77**  
 Lai, Joseph C S, 100, 179  
 Lai, Rong Ping, 145, 165  
 Lam, Garret C Y, 197  
 Lam, John, 86  
 Lam, Yat Ken, 101  
 Lamb, Isabelle, 132  
 Langer, P, **47**  
 Langer, Sabine C, 186  
 Lanki, Timo, 54  
 Lapka, Wojciech, **97**  
 Large, Sarah, **136**  
 Larizza, Francesco, 187  
 Larnier, David James, **128**, 143  
 Larsson, Franck, **180**  
 Larsson, Conny, **122**  
 Larsson, Sebastian, 196  
 Latimore, Mark, 139  
 Lau, Akil, **168**  
 Lavandier, Catherine, 205  
 Lavelle, Frederic, 47  
 Law, Chi-wing, 138  
 Layfield, Jonathan, 82  
 Lazlo, Helga E, 54  
 Le Bot, Alain, 77  
 Le Ray, Guillaume, 153  
 Leav, Orddom Y, **195**  
 Lebert, Erik, 68  
 Leclercq, Damien J J, **135**, **179**  
 Lee, Gary Y H, 48  
 Lee, Gillian, 124  
 Lee, Gwang-Se, **176**  
 Lee, Hyeongrae, 172  
 Lee, Hyo Jae, 204  
 Lee, Jae-Jun, 210  
 Lee, Jenny, 55

Lee, Jongho, 115  
 Lee, Joong Hyuck, 219  
 Lee, Joonhee, **118**  
 Lee, Jung-Min, **194**  
 Lee, Jung-Wook, 215  
 Lee, Kevin M, 103  
 Lee, Kyuho, 144  
 Lee, Lawrence, **137**  
 Lee, Myunghan, 133  
 Lee, Nokhaeng, **175**  
 Lee, Sang Kwon, **89**  
 Lee, Sanghyuck, 48  
 Lee, Seong-Hyun, 177, **185**, 199  
 Lee, Seung Min, 89  
 Lee, Siew Eang, 173, 192  
 Lee, Sinyeob, **115**, **204**  
 Lee, Songjune, **204**  
 Lee, Soogab, 144, 166, 212  
 Lee, Tae-keun, 223  
 Lee, Yong Keat, 56, 70, **162**, 168  
 Legarth, Søren Vase, 86  
 Legendre, C, 202  
 Lei, Xiaofei, 162  
 Leiba, Raphael, 206  
 Leissing, Thomas, 53, **117**  
 Lelong, Joel, **51**  
 Lenchine, Valeri V, **107**, **156**  
 Lercher, Peter, 152, 191  
 Leskinen, Antti, **150**  
 Leung, Kenneth, 86  
 Leung, Randolph Chi-kin, 101, 197  
 Leung, T M, **104**  
 Li, Binghui, **62**  
 Li, Can, 94  
 Li, Dengke, **121**  
 Li, Heng, **85**  
 Li, Hongqun, 130, 207  
 Li, Jiazhu, **94**  
 Li, Kun, 117  
 Li, Liaoyuan, 163  
 Li, Mingfeng, 90  
 Li, Sheng, 163, 195  
 Li, Shihuai, 178  
 Li, Wanyou, 78  
 Li, Xinxin, 105  
 Li, Xinyan, 178  
 Li, Xun, **211**  
 Li, Yinong, 141, 145  
 Li, Zhuang, **78**  
 Li, Zizheng, 103  
 Lian, Xiaomin, 57, 112, 126, 225  
 Liang, Hong, 171, **191**  
 Liao, Xiangning, **57**, 225  
 Libor, Čermák, 224  
 Licitra, Gaetano, **66**  
 Liebl, Andreas, **131**, **165**  
 Lieske, Dirk, 146

Liljergren, Mikael, 140  
 Lim, Jongyun, 59  
 Lim, Teik C, 90  
 Lim, Vincent, 211  
 Lin, I-Chun, **73**  
 Lin, Shuo-Yen, **70**  
 Lin, Wang-Lin, 114  
 Lin, Zhibin, **155**  
 Lippert, Stephan, 170  
 Lippert, Tristan, **170**  
 Listewnik, Karol, **103**  
 Liu, Aili, 105, **224**  
 Liu, Alfa, 137  
 Liu, Bilong, 121  
 Liu, Changqing, **133**  
 Liu, Daipei, **62**  
 Liu, Fucheng, 224  
 Liu, Gongmin, 181  
 Liu, Jia, 56  
 Liu, Jian, **154**  
 Liu, Li, 213  
 Liu, Lichuag, 134  
 Liu, Song, **163**, **195**  
 Liu, Wenbo, 154  
 Liu, Xueguang, **195**  
 Liu, Y, **187**  
 Liu, Yan, 78  
 Liu, Yang, 42, 125  
 Liu, Zheji, 208  
 Liu, Zhigang, 70, 125, 175  
 Lo, David, 86  
 Lohman, Walter J A, 110  
 LoVerde, John J, **81**, **99**  
 Lu, Jing, 41, **89**, 194  
 Lu, Ming-Hung, **101**  
 Lu, Zhenbo, **195**  
 M B Fard, Samaneh, **185**  
 Ma, Hui, **68**  
 MacGillivray, Alexander, **103**  
 MacGillivray, Ian, **91**, 106, 208  
 Machado Da Rosa Albuquerque, Lucas, 58  
 Mackenzie, Neil, 56, **70**, 128, 162, 177  
 Madsen, Helge Aagaard, 74, **122**, 176  
 Madsen, Jesper, 74  
 Maeda, Setsuo, **198**, 222  
 Maffei, Luigi, **74**  
 Mahn, Jeffrey, **143**  
 Makabe, Yoshiaki, **212**  
 Makino, Koichi, 139, 152, 160  
 Makinouchi, Hideo, 152  
 Malecki, Pawel, **64**  
 Mangate, Laxmikant, 179  
 Mankbadi, Reda, 73  
 Mann, Peter, 94  
 Männistö, Satu, 54

Manor, Ella, **132**  
 Manvell, Douglas, **124**, 138  
 Marburg, Steffen, 46, 47, **61**, 62, 92, 112, 185, 197  
 Marchal, Jacques, 206  
 Marchiano, Regis, 206  
 Marco, Debiasi, 195  
 Mareta, Sannia, **175**  
 Márki, Ferenc, 123  
 Martarelli, Milena, 177  
 Martens, William Leigh, 74, 132, 194  
 Martin, Tara, 84  
 Martins Defilippo Soares, Zemar, 58  
 Marton, Pavel, 106  
 Masuda, Kiyoshi, **181**  
 Masumoto, Takayuki, 44  
 Matsui, Tadashi, 216, **217**  
 Matsui, Toshihito, 57  
 Matsumoto, Junko, **220**  
 Matsumoto, Mitsuo, 152  
 Matsumoto, Toshio, 160, 168  
 Matsumoto, Yasunao, 201  
 Matsumura, Yuta, **213**  
 Matsuo, Ataru, 77  
 Matsuo, Takuma, **218**  
 Matthews, David, 84, **142**  
 Maunder, Matt, 146  
 May, Carl, 183  
 McArdle, Sean, **124**  
 McBride, David, 191  
 McBride, David Iain, **107**, 190  
 McGuckin, Damian G, 67  
 McIntosh, David James, **104**  
 McIntosh, James, 84  
 McKee, Kristoffer K, 56  
 McLaren, Stuart J, **60**, 93  
 McLeod, Ian, **139**  
 McLoughlin, James, 208  
 McMahan, Darryl, **111**  
 McNeese, Andrew R, 103  
 McPherson, Craig, 103  
 McPherson, Geoff, 103  
 Mealings, Kiri Trengove, **79**  
 Mebarek, Lassen, 140  
 Medwell, Paul R, 157  
 Meeter, Martijn, 87  
 Meissnitzer, Marlon, 113, **128**, 144  
 Melbourne, William H, 200  
 Melz, Tobias, 199  
 Mende, Michael, 180  
 Mendonça, Fred, 59  
 Mengyao, Zhu, 192  
 Merthayasa, I G Nyoman, 50  
 Mewett, David, 178  
 Meyer, Andy, 64

- Miao, Feng, **112**, **126**  
Miao, Xu-hong, 140, 206  
Michau, Marc, 214  
Micheau, Philippe, 214  
Miki, Akira, 44  
Milford, Ingunn, **116**  
Miller, Aaron, 55, 201  
Mimani, Akhilesh, **157**  
Min, Dongki, **57**, 106  
Min, Fujiang, 64  
Min, Hequn, **114**  
Min, Kyongwon, 65  
Ming, Pingjian, 181  
Minorikawa, Gaku, 44  
Mioduszewski, Piotr, **102**, 147, 148  
Miranda, João G O, 223  
Misdariis, Nicolas, **167**, **206**  
Mitchell, Andrew, **196**  
Mitchell, Josh, 168  
Miyakawa, Shigeru, 78  
Miyazawa, Masashi, 44  
Mizunami, Tazu, 121  
Mizuno, Hiroaki, 82  
Mkrm Esa, Nahed, 79  
Mleczko, Dominik, 157  
Moazenahmadi, Alireza, **70**  
Mochizuki, Maya, **216**  
Modak, S V, 176  
Modler, Niels, 65, 187  
Mohamed, Zamri, 102  
Mohan, Anjana, 85  
Mohan, R S, **95**  
Mohd Nor, Mohd Jailani, 225  
Moiny, Francis, 212  
Mokry, Pavel, **106**  
Möllerström, Erik, **196**  
Monner, Hans Peter, 195  
Moore, Simon, 62  
Moore, Stephen, 184  
Morange, Jean-Louis, 117  
Mordillat, Philippe, 140  
Moreau, Danielle, 92, 137  
Mori, Hisho, **53**, 66  
Mori, Masaaki, **44**  
Moriyama, Takashi, 154  
Morinaga, Makoto, **152**  
Morita, Kengo, 69  
Morley, David, 131  
Mossberg, Frans, **105**  
Mounter, David, 135  
Muehleisen, Ralph T, 157  
Muhammad, Noryani, 225  
Muir, Bruce R, **226**  
Mulcahy, N Lex, **67**  
Mulgrave, Joe, 55  
Müller, Uwe, 123  
Munyard, Andrew, 84, 142  
Murao, Tatsuya, **154**  
Murphy, Kristen, 98  
Murray, Timothy, 203  
Musil, Milos, 162  
Muto, Kenji, 212, **214**  
Myck, Thomas, 139  
N G, Isaac, 86  
Nagahata, Koji, **171**  
Nagamatsu, Masao, **173**  
Nagano, Yuki, **222**  
Nagaoka, Hironori, 53, 66  
Naish, Daniel A, **69**, **188**  
Naka, Yusuke, 212  
Nakagawa, Seiji, 193  
Nakajima, Takahiro, 44  
Nakajima, Yasutaka, 180  
Nakamura, Hiroki, **95**, 96, 182, 199  
Nakamura, Kentaro, **174**  
Nakamura, Kinji, **75**  
Nakamura, Masanori, 210  
Nakano, Kota, **218**  
Nakasako, Noboru, **114**  
Nakatani, Akiko, 198  
Nakatani, Hidenori, 198  
Nakatani, Satoshi, 49  
Nakayama, Masashi, **49**  
Nakayama, Masato, 114, 213, 216, 217, 218, 220, 222  
Nakayama, Shohei, 214  
Nakayama, Yumiko, **214**  
Nam, Sangwon, 57  
Namba, Seiichiro, 151, 152  
Name, Neil, 168  
Nash, Anthony, **49**  
Naveed, Yasir, 185  
Navvab, Mojtaba, 75  
Nazli, Che Din, **63**  
Negreira, Juan, **99**, 166, 203  
Neki, Yuma, 114  
Nelisse, Hugues, 47  
Nelson, James, **132**  
Neubauer, Reinhard, **113**  
Neugebauer, Stefan, **137**  
Newman, Michael James, **208**  
Ng, Isaac, 109  
Nguyen, Lap, 73  
Nguyen, Quoc Viet, 195  
Nguyen, Thu Lan, **154**  
Nicolas, Epain, 192  
Nie, Hong, 175  
Nie, Wenjing, 68  
Niedoba, Pavel, **224**  
Nijhof, Marten J J, **169**  
Nila Inangda, Keumala, 63  
Nilsson, Erling, 63, 79  
Ning, Han, 89  
Ninomiya, Masaki, 55  
Nirong, Li, 89  
Nishi, Takahiro, 115  
Nishida, Pedro P R, 223  
Nishida, Shinichiro, 135, 154  
Nishiguchi, Masato, 48  
Nishimura, Koichi, 57  
Nishimura, Masaharu, **135**, 154  
Nishiura, Takanobu, 213, 216, 217, 218, 220, 222  
Nishiwaki, Shinji, 141  
Nitidara, Ni Putu Amanda, **50**  
Niu, Feng, 58  
Nobuo, Machida, 118  
Nocera, Francesco, 129  
Nocke, Christian, **50**, **99**  
Noguchi, Eiji, 53, 66  
Nolte, Bodo, 190  
Noor, Noor Azlan Mohammed, 111  
Norris, Stuart Edward, 177  
Notario, Antonio, **160**  
Notarnicola, Lorenzo, 140  
Notley, Hilary, 68  
Novak, Colin, **120**, **122**, 177, 201, 203  
Nurul Amira, Abd Jalil, 63  
Oberst, Sebastian, 100, **179**  
Ochmann, Martin, 190  
Oda, Ippei, 59  
Ogata, Saburo, **88**  
Oh, Chisung, 59  
Oh, Seong Min, 99  
Oh, Seungjae, **205**  
Öhlund, Olof, 122  
Ohm, Byungsik, 210  
Ohshio, Yoshitaka, **213**  
Ohta, Takehiro, 132  
Ohya, Masaharu, 179, 180  
Ohzawa, Tsukasa, 115  
Oikawa, Yasuhiro, 94  
Okada, Hiroyuki, 166  
Okada, Yasuaki, **168**  
Okamoto, Noriko, **50**, 145  
Okubo, Kan, 180, 213, 217  
Okumura, Hiraku, 194  
Okumura, Tetsuya, 59  
Okutsu, Yasuhiko, **92**  
Okuzono, Takeshi, 50, 114, **128**, 145  
Oliveira, J M G S, 202  
Ollilla, Tapani, 92  
Ollivier, Francois, 206  
Olsen, Erling Sander mann, **58**  
Oltean-Dumbrava, Crina, **184**  
Omata, Nobuaki, **199**  
Onishi, Akio, 97  
Onitsuka, Hirofumi, 44  
Ono, Yuichi, **97**, 216

- Oono, Teruhito, 78  
Opsata, Adam, **64**  
Öqvist, Rikard, **127**  
Orino, Yuichiro, 211  
Ortiz, Santiago, 91  
Osada, Ryosuke, 214  
Osafune, Toshikazu, 201  
Oshima, Takuya, 44, **45**, 181  
Osman, Haisam, 161  
Osumi, Ayumu, 216  
Ota, Atsushi, 220  
Ota, Yoshitaka, 211  
Otsuru, Toru, 50, **114**, 128, 145  
Ott, Mark, **202**  
Ottermo, Fredric, 196  
Ouchi, Yasuhiro, 94  
Ouisse, Morvan, 184  
Ouyang, Shan, **133**  
Owaki, Ryoma, 77  
Özgen, Gökhan O, 161  
Ozkurt, Nesimi, 61  
Pääkkönen, Rauno, **92**  
Padmanabhan, Chandramouli, 202  
Paez, Daniel, **61**  
Page, Wyatt H, 60, **93**  
Pan, Jie, 41, **75**, 89, 142, 155, 204  
Pan, Xia, **163**  
Pang, Fu-zhen, **140**, **206**, **209**  
Pang, Jian, 64, 82  
Panton, Lilyan, **128**  
Papantoni, Veatriki, **195**  
Park, Dongchul, 172  
Park, Hyunkyuu, 65  
Park, Jang-Seok, **215**  
Park, Jin-young, 223  
Park, Junhong, 55, 57, 65, 106, 115, 204  
Park, Kihwan, 214  
Park, Seo-Ryong, 144  
Park, Tae Hong, 159  
Park, Young Min, **209**  
Park, Youngjin, 175, 193  
Parker, Andrew, 55  
Parnell, Jeffrey, **45**  
Pascioni, Kyle, **59**  
Patania, Francesco, **129**  
Patrício, Jorge, 49  
Paurobally, Roshun, 89  
Pawlik, Pawel, 157  
Pearse, John R, 127, 143, 164, 183  
Pearson, Claire, 54  
Pedersen, Frank, **116**  
Pedersen, Torben Holm, 153  
Peeters, Bart, **141**  
Pellegrini, Riccardo, 106  
Peng, Bo, 57, **225**  
Peng, Jeffrey, **168**  
Peng, Zhao, **118**  
Perez Cabo, David, 158  
Persson, Kent, 177, 201  
Peters, Herwig, 47, **62**, 77, **91**, 126, 163, 185, 207  
Petersen, Dick, 70, **119**  
Petit, Yvan, 47  
Pheasant, Rob, 191  
Phillips, Andrew, 184  
Pikula, Stanislav, 215  
Polack, Jean-Dominique, 217  
Poletti, Mark Alister, **174**  
Pommerenck, Keith, 149  
Popov, Atanas, 175  
Porteous, Ric, **92**, **137**  
Porter, Michael B, **85**  
Porter, Nicole, **88**  
Potma, Charlos, 206  
Pottim, Karunakar, 134  
Pott-Pollenske, Michael, 108  
Prakash, Manisha, 157  
Prasetyo, I, 50  
Priego, Javier Cristino, 169  
Prime, Zebb, 92, **136**, 137  
Prisutova, Jevgenija, **184**  
Probst, Fabian, **144**  
Probst, Wolfgang, **46**  
Protheroe, Daniel, **64**  
Psota, Pavel, 106  
Pun, L S C, 104  
Putner, Jakob, 151  
Putra, Azma, **225**  
Qin, Xiuyuan, **221**  
Qiu, Jinhao, 175  
Qiu, Xiaojun, **41**, 89, 114, 135, 155, 194  
Qu, Yegao, **126**  
Quinn, David C., **168**  
Quirt, David, 80  
Quoy, Mathias, 205  
Rachman, Arinda Puspita, 49  
Radford, Craig, 84  
Radosz, Jan, **80**  
Raman, Ganesh, **157**  
Ramasamy, Kalaiselvi, 85  
Randall, Robert Bond, 56, 142  
Ranjan, Rishabh, **134**  
Rao, Dan, **71**  
Rao, Zhiqiang, 67  
Rasa, Alexander, **161**  
Rasmussen, Birgit, **80**  
Rawlings, Samantha, 81  
Readhead, Mark L, **103**  
Reda, Ahmed M, **56**  
Reda, Alfredo, 93  
Redonnet, Stéphane, **198**  
Reed, Tracy, 132  
Reger, Robert, 59  
Rennies, Jan, 43  
Ribeiro, Carlos, 205  
Richardson, Sylvia, 54  
Rigoll, Gerhard, 173  
Robertson, Robin, **189**  
Robertson, William S, 195  
Robinson, Amanda, **79**  
Robinson, David Paul, **93**  
Rodkin, Richard, **149**  
Roger, Michel, 73  
Ronowski, Grzegorz, 52  
Rose, Michael, 195  
Rösel, Reinhard, 137  
Rose-Munro, Leanne, 79  
Rouillard, Vincent, 200  
Roulo, Eric, 132  
Rousset, Céline, 53  
Ruber, Karel, **56**  
Ruhnau, Marcel, 170  
Ryliskis, Andre-Pierre, 208  
Ryu, Yunseon, 182  
Ryue, J, 111, 183  
Sabato, Adolfo, 93  
Sabato, Alessandro, **93**  
Sabo, Yasuyuki, 201  
Sabourin, Ivan, 203  
Saeki, Tetsuro, 221  
Said Youssef, Rabab, **79**  
Saine, Kari, 92, 150  
Saito, Hidetoshi, **55**  
Sakagami, Kimihiro, 128  
Sakalli, Ozgun, 225  
Sakamoto, Ichiro, 115  
Sakamoto, Shinichi, **76**, **168**, **211**  
Sakuma, Tetsuya, 44  
Sakurama, Kazunori, 135, 154  
Sales, Diego, 169  
Salomons, Erik M, 46, **110**, **153**  
Saltmarsh, Kyle, 142  
Sambuc, C, 202  
Sanada, Akira, 42  
Sanchez, Diana, **87**  
Sandberg, Göran, 122, 177, 201, 203  
Sandberg, Ulf, 66, 147, **148**  
Sang, Zhiming, 42  
Sano, Naoko, 220  
Sano, Takaichi, 167  
Sano, Yasuyuki, 201  
Sari, Deniz, **61**  
Sarkar, A, 78, 95  
Sarradj, Ennes, 73  
Sarrazin, Mathieu, **146**  
Sarwono, Joko, 48, **49**, 50  
Sato, Daigo, 55  
Sato, Hiroshi, **80**, **121**, **186**  
Sato, Hiroyuki, 196

- Sato, Naru, **179**  
 Sato, Tomokazu, 216  
 Sato, Yuta, **210**  
 Satoh, Toshikazu, **219**  
 Sattelmayer, Thomas, 109  
 Saurenman, Hugh, **132**  
 Savery, John, 169  
 Sawalhi, Nader, 70  
 Sawatari, Katsumi, 115  
 Schael, Stefan, **67**  
 Schäfer, Ingo, 190  
 Schanda, Ulrich, 143  
 Scheel, Henning, 192  
 Schell-Majoor, Lena, 43  
 Scherrer, Jean-Marc, 50  
 Scheuren, Joachim, **61, 151**  
 Schlittenlacher, Josef, **152**  
 Schmidt, Jan-Henning, **186**  
 Schneeweiss, Helmut, 199  
 Schoenwald, Stefan, 80, 114, 203  
 Schomer, Paul D, 109, **170**  
 Schram, Christophe, **123, 200**  
 Schuhmacher, Andreas, 182  
 Schulte-Fortkamp, Brigitte, **43**  
 Schulze, Moritz, 109  
 Schwela, Dietrich H, **110**  
 Segers, Arjo, 46  
 Seide, Gunnar, 225  
 Seigner, Maxime, 51  
 Sekhar, A Seshadri, 78, 95  
 Semperlotti, Fabio, 46  
 Semura, Junichi, 115  
 Sentop, Ayca, **164**  
 Seo, Yun-Ho, **177, 199**  
 Seong, Weonchan, 172  
 Seong, Yeolwan, 166  
 Seong-hun, Kim, **96**  
 Sepahvand, K, 47  
 Seppänen, Saara, 92  
 Sepulveda, Frank, 129  
 Seume, Joerg R, 197  
 Seung, Heo, 96  
 Sgard, Franck, **47**  
 Shajarati, Amir, 149  
 Shamoon, Charles, **159**  
 Shanks, Emma, **158, 159**  
 Shanov, Vesselin N, 121  
 Shao, Jianwang, **145**  
 Sharp, Calum, **55**  
 Sheikh, Mahbub Alam, **173, 192**  
 Shen, Saiyan, 130  
 Shen, Wen Zhong, 74  
 Shepherd, Daniel, **55, 107, 129, 190, 191**  
 Shepherd, Micah, 183  
 Sherlock, Matt, 84  
 Shi, Dongyan, 95, **130, 161, 207, 208, 209**  
 Shi, Jie, 84  
 Shi, Peicheng, 81  
 Shi, Shengguo, 84  
 Shi, Shuangxia, **96**  
 Shi, Xianjie, 161  
 Shieh, Ping-Fei, 73  
 Shield, Bridget, 97  
 Shilton, Simon, 110  
 Shimizu, Kenta, 55  
 Shimoyama, Koji, **154**  
 Shimura, Masayuki, **201**  
 Shin, Eontak, 48  
 Shin, Ho-Chul, **94**  
 Shin, K K, 111  
 Shin, Sung-Hwan, **90, 172**  
 Shin, TaeJin, 89  
 Shinichi, Sakamoto, 70  
 Shinohara, Naoaki, 88, **139**  
 Shinohara, Taishi, 44  
 Shinohara, Toshihiro, 114  
 Shirahama, Seiji, 59  
 Shirataki, Jun, 219  
 Shiratori, Koji, 135  
 Shyafina, Nurain, 225  
 Siegmund, Thomas, 106  
 Silva, Hugo, 148  
 Sim, Malcolm, 199  
 Simões, Gonçalo, **49**  
 Simons, Dick G, 160  
 Simpson, Cassandra, 84  
 Singh, Rajendra, **60**  
 Singh, Sarabjeet, **96**  
 Sjökvist, Lars-Göran, 99  
 Sjöström, Anders, 122, **177, 201, 203**  
 Skjellerup, Peter, 149  
 Skoda, Sabrina, **43**  
 Skvortsov, Alex, 91, **106, 208**  
 Smidt Lützen, René, 149  
 Smith, Michael, **60**  
 Smith, Wade A, **142**  
 Smuk, Mel, 68  
 Snider, Royce, 183  
 Sobecki, Brandon, **172**  
 Sokolov, Aleksei, **224**  
 Son, Daehyuk, **193**  
 Son, Hyeon-Jang, 210  
 Søndergaard, Bo, **105**  
 Søndergaard, Lars Sommer, **86**  
 Song, Hong-bao, 140, 206, 209  
 Song, Jonathan, 107, 156  
 Soria, Julio, 131  
 Sottek, Roland, **120, 192**  
 Souron, Quentin, 185  
 Southgate, Dave, 88  
 Spagnol, Joseph Patrick, **224**  
 Späh, Moritz, 165  
 Sparke, Clayton James, **125**  
 Spehr, Carsten, 136  
 Spessert, Bruno M, 90  
 Spinosa, Vittoria, 54  
 Srinath, R, **78**  
 Srinivasan, K, 179  
 Stache, Martin, **112**  
 Stahlfest Holck Skov, Rasmus, 147  
 Stalter, Frank, **102**  
 Stansfeld, Stephen, 68  
 Steffens, Jochen, 43  
 Steiger, Katerina, 106  
 Stein, Philipp, 149, 169, 170  
 Stempfel, Guillaume, 117  
 Sternad, Mikael, 89  
 Stewart, Greg, 208  
 Stigwood, Duncan, 136  
 Stigwood, Mike, 136  
 Stollery, Phil, 124  
 Stone, Brian, 75  
 Strommer, Kjell, 116  
 Stumpf, Eike, 73  
 Sugawara, Masayuki, 139  
 Sugie, Satoshi, **113**  
 Suhara, Yuko, 213  
 Suheri, Nanang, 48  
 Sui, Fusheng, 133, 164  
 Sullivan, Rory, 97  
 Sun, Deyu, 226  
 Sun, Guohua, **90**  
 Sun, Hongmei, 75, 142  
 Sun, Hongtu, 223  
 Sun, Hyosung, **211**  
 Sun, Philip, 165  
 Sun, Wei, **145**  
 Sun, Yu, 84  
 Susini, Patrick, 206  
 Suzuki, Satoshi, 221  
 Suzuki, Shin-nosuke, 219  
 Svensson, Carsten, 63, 79  
 Swider, Pascal, 141  
 Swieczko-Zurek, Beata, **52, 147**  
 Sychla, Hauke, 170  
 Sydney, Harris, **84**  
 Syred, Frank, 82  
 Szabo, Attila, 211  
 Szeto, Wing Kwok, 109  
 Tachibana, Hideki, **107, 108, 152**  
 Taehoon, Kim, 96  
 Tagawa, Norio, 213, 217  
 Tagaya, Akira, 220  
 Taherzadeh, Shahram, 94  
 Tajika, Terutoshi, 168  
 Takada, Masayuki, **221**  
 Takagi, Kentaro, 82  
 Takahashi, Hironobu, 72, 220  
 Takahashi, Yousuke, 210  
 Takanashi, Koki, **221**

- Takanashi, Toshikazu, **76**  
 Takeda, Yoji, 55  
 Takeda, Yuichiro, 167  
 Tamer Bayazit, Nurgun, 164, 226  
 Tamesue, Takahiro, **221**  
 Tamura, Fumio, 167  
 Tamura, Yuki, **94**  
 Tan, Andy C C, 69  
 Tan, Mei Yen, 129  
 Tanaka, Manabu, 186  
 Tanaka, Nobuo, 42, 72, 125  
 Tanaka, Toshihiro, 135  
 Tang, Dakai, 42, 71  
 Tang, Dong, 206  
 Tang, Hongyun, **48**  
 Tang, Shiu Keung, **69**, 86, 104, 125, 144  
 Tao, Jiancheng, **155**, 213  
 Tarabra, Marco, 82  
 Taraldsen, Gunnar, 87  
 Tari, Alborz, 140  
 Taryma, Stanisław, 52, 102  
 Tate, Simon, 146  
 Tatekura, Yosuke, 214, 223  
 Tatsuno, Junya, 222  
 Teague, Peter, **158**  
 Teng, Pengxiao, **174**, 223  
 Terashima, Takane, 193, **216**, 218, 221  
 Tervaniemi, Mari, 54  
 Teti, Luca, 66  
 Thierbach, Roman, 139  
 Thivant, Michael, 51  
 Thompson, David, 225  
 Thompson, James, 45  
 Thompson, Rhys, 225  
 Thorne, Bob, **136**, **156**  
 Thorne, Robert, 107  
 Tian, Jin, **67**  
 Tian, Jing, 121, 226  
 Tickell, Colin, **138**  
 Tiittanen, Pekka, 54  
 Tijs, Emiel, 200  
 Tim, Walton, 134  
 Tingay, James, 93  
 Tinney, Charles E, 178  
 Tkanashi, Toshikazu, 76  
 Toepken, Stephan, **192**  
 Toi, Takeshi, 90, 120  
 Tokunaga, Yasunobu, 193, 216, **221**  
 Tomasini, Enrico Primo, 177  
 Tomiku, Reiji, 50, 114, **145**  
 Tominaga, Toru, 69  
 Tomita, Takuro, 223  
 Tong, Yean-ghing, 69  
 Tong, Yuhui, 75, 204  
 Tonin, Renzo, **211**  
 Tortora, Cecilia, 97  
 Totaro, Nicolas, 77  
 Travaglione, Ben, **84**  
 Trevorrow, Brendan, **91**  
 Trimoreau, Benjamin, **149**  
 Trimpop, Mattias, **94**, **212**  
 Tripodi, Matthew, 187  
 Troclet, Bernard, 184  
 Trojanowski, Roman, 215  
 Trollé, Arnaud, 99  
 Tso, Yan, 163  
 Tsuchiya, Takao, 213, 217  
 Tsui, Kwong-lam, 69  
 Tsujimura, Sohei, 220  
 Tsukioka, Hidebumi, 152  
 Tsurumi, Yasuaki, 118  
 Tu, Tsung-Hsien, **198**  
 Tu, Ying, 133  
 Turner, Stephen, 109  
 Turunen, Anu W, **54**  
 Tusciano, Manolo, 140  
 Uchida, Hidenobu, 201  
 Uebo, Tetsuji, 114  
 Ueda, Mari, **220**  
 Uemura, Masanori, **78**  
 Ueta, Tomotaka, 53, **66**  
 Ule, Helen, 120, 122, 177, 201, 203  
 Ullrich, Wolfram Christoph, **109**  
 Ullucci, Graziano, 97  
 Usagawa, Tsuyoshi, 221, 223  
 Uszakiewicz, Hans-Günter, 180  
 Utami, Sentagi Sesotya, **48**, 49  
 Utsuno, Hideo, 42  
 Vaclavik, Jan, 106  
 Valeau, Vincent, 137  
 Van De Kerckhove, Rik, 68  
 Van De Par, Steven, 43  
 Van De Wyer, Nicolas, 123, **200**  
 Van Der Auweraer, Herman, 101, 146  
 Van Der Eerden, Frits, **46**  
 Van Der Ploeg, Fokke D, 155  
 Van Dyck, Dries, 200  
 Van Kamp, Irene, 68, **188**  
 Van Oosten, Nico, **123**  
 Van Poll, Ric, 188  
 Van Renterghem, Timothy, **46**  
 Van Wyk, Kenric, **98**  
 Vanhooreweder, Barbara, 52  
 Vansant, Koen, **76**  
 Varanasi, Srinivas, **106**  
 Vasseur, Jérôme, 185  
 Vegh, Serge, **119**  
 Verhaeghe, Kevin, 146  
 Verhagen, Henk L M, 153  
 Verleyen, Lenert, 83  
 Verstappen, Andre P, **183**  
 Viallet, Guilhem, 47  
 Viggen, Erlend Magnus, 101  
 Vindahl Kringelum, Jon, 149  
 Vinokur, Roman, **182**  
 Voelkel, Katharina, **72**  
 Volk, Florian, 173  
 Völzl, Raphael, 143  
 Von Estorff, Otto, 170  
 Von Lindern, Eike, **191**  
 Vonrhein, Benjamin, 75  
 Vorländer, Michael, 74  
 Vuj, Trong Dai, **65**  
 Vuye, Cedric, 52  
 Wada, Tomoyuki, **216**  
 Waddington, David, 55  
 Waki, Yoshiyuki, 199  
 Walker, Urs, **116**  
 Wall, Martin, **140**  
 Walters, Sheldon, **69**  
 Wang, Daiwei, **105**  
 Wang, Dongqiang, 162  
 Wang, Hongbo, **211**  
 Wang, Lily M, **105**, 118  
 Wang, Qingshan, 161, 209  
 Wang, Ren-Hung, 198  
 Wang, Rujia, 112, 126  
 Wang, Semyung, 205, 214, 219  
 Wang, Shuping, 155  
 Wang, Xiaonan, **187**  
 Wang, Xu, 102  
 Wang, Xun, **57**, 226  
 Wang, Ye, 195  
 Wang, Ying, 187  
 Wang, Zhikai, 130, 207  
 Wang, Ziteng, **112**, 126  
 Wareing, Robin R, **127**, 143, 164  
 Warusfel, Olivier, 217  
 Wasala, Sahan Hasaranga, **177**  
 Wassermann, John, 45  
 Watanabe, Motoya, **72**  
 Watanabe, Yoshiaki, 211  
 Watkins, Simon, 102  
 Watry, Derek, 132  
 Watts, Greg, **191**  
 Weber, Reinhard, 192  
 Wehr, Reinhard, 66  
 Wei, Haiqiao, 102  
 Wei, Jianhui, 207  
 Wei, Zhengyu, 182  
 Weinandy, Rene, **139**  
 Weisbeck, Jeffrey, 202  
 Welch, David, **129**, 190, 191  
 Wen, Junjie, 112, 126  
 Wen, Wei, 64  
 Wessels, Peter W, 46, 153  
 Wheatley, Glenn Robert, **124**  
 White, Kim, **87**  
 Wiciak, Jerzy, **215**

Wiciak, Margareta, 215  
Wijnant, Ysbrand H, 83, 102  
Wilkes, Daniel Ryan, 62, 142, **148**  
William, A, 50  
Williams, Roger, 167  
Williams, Warwick, 75  
Wilson, Preston S, 103, 129  
Wiseman, Susan, **129**  
Withdrawn1,, **85**  
Withdrawn2,, **71**  
Withdrawn3,, **50**  
Withdrawn4,, **78**  
Withdrawn5,, **209**  
Withdrawn6,, **97**  
Withdrawn7,, **76**  
Withdrawn8,, **126**  
Withdrawn9,, **86**  
WithdrawnA,, **104**  
WithdrawnB,, **151**  
Witthaus, Sina, **197**  
Wittstock, Volker, 72, 186  
Wochner, Mark S, **103**  
Wolfert, Henk, **150, 206**  
Wong, Cheung-lam, 138  
Wong, Kin Man, 111  
Wong, Wylog, 185  
Woo, Jung-Han, **112**  
Wood, Shane, 131  
Woodcock, James, 55  
Woon Seng, Gan, 134  
Woźniak, Ryszard, 102  
Wright, Armin, 132  
Wszolek, Tadeusz, 157  
Wszolek, Wiesław, 157  
Wu, Chengjun, **162**  
Wu, Chuang, 209  
Wu, Dian, 109  
Wu, Han, 95  
Wu, Helen, 224  
Wu, Hongjian, **207**  
Wu, Lifu, **135**  
Wu, Marco, **109**  
Wu, Ming, 213  
Wu, Shuoxian, 130  
Wu, Xian, 145  
Wunderli, Jean Marc, 160  
Xia, Guang, 100  
Xia, Yinzhu, 75  
Xiang, Dabing, 102  
Xiao, Yegui, 154  
Xiao, Ying, 174  
Xie, Bosun, **42**  
Xie, Charles, 171  
Xie, Hui, 85  
Xie, Kun, 207  
Xu, Deshui, 70  
Xu, Guangzhong, 145  
Xu, Ji, 90

Xu, Kun, 207  
Xu, Liang, **126**  
Xu, Wang, 181  
Xu, Weimin, 133  
Xu, Xiaomin, 82  
Xu, Xuezhong, **226**  
Xu, Young, 223  
Yabe, Akito, 201  
Yadav, Manuj, 64  
Yagi, Kazuo, 214  
Yalcindag, Nazli, 61  
Yamada, Daisuke, 118  
Yamada, Ichiro, 139, **159**  
Yamada, Keisuke, **42, 72**  
Yamada, Takayuki, 141  
Yamada, Tomomi, **151**  
Yamagata, Kenta, 42  
Yamaguchi, Makoto, 50  
Yamaguchi, Masao, **90**  
Yamaguchi, Michiyuki, 219  
Yamaguchi, Takao, **44**  
Yamamoto, Ippei, 152  
Yamamoto, Katsuya, **196**  
Yamamoto, Kohei, 160  
Yamamoto, Mari, **223**  
Yamamoto, Takashi, **141**  
Yamasaki, Yoshio, 94  
Yamashiro, Mitsuo, 97  
Yamashita, Yoichi, 213, 218, 222  
Yamauchi, Katsuya, **167**  
Yamazaki, Toru, 95, 96, 182, 199  
Yan, Chen, **192**  
Yan, Shenggang, **71**  
Yan, Xinping, 56  
Yang, Desen, 84  
Yang, Diange, 112, 126  
Yang, Fan, 200  
Yang, Guodong, 104  
Yang, Haosen, 67  
Yang, Ji, **77, 141**  
Yang, Jianhua, 182  
Yang, Jun, **100, 164, 213, 226**  
Yang, Junmei, 226  
Yang, Liuqing, 211  
Yang, Ping, 58  
Yang, Ruichao, 162  
Yang, Tiejun, 70, 125, **175, 195**  
Yang, Wonseok, **55**  
Yang, Yichun, 174, 223  
Yano, Takashi, 154  
Yao, Liang, **100**  
Yao, Shuai, **117**  
Yashiro, Kazuyuki, 132  
Yasuda, Yosuke, 44  
Yasuno, Yoshinobu, 151  
Yatabe, Kohei, 94  
Yates, David, 203  
Yeh, Po Hung, 145

Yen, Benjamin, 203  
Yeung, David, 86  
Yeung, Maurice, **86, 109**  
Yim, Stephen, 86  
Yin, Hai Ping, 65  
Ying, Lechun, 187  
Yintao, Wei, **102**  
Yli-Tuomi, Tarja, 54  
Yokoshima, Shigenori, 154  
Yokota, Akinori, 201  
Yokota, Takatoshi, 139, **160**  
Yokoyama, Hidefumi, **132**  
Yokoyama, Hiroshi, **44**  
Yokoyama, Sakae, 76, **152**  
Yonehara, Makiko, **222**  
Yonemoto, Yuichi, **180**  
Yong-Kim, Chong, 134  
Yoon, Kiseop, 166  
Yoshida, Junji, 78, 115, 172, **173**  
Yoshida, Masahi, 219  
Yoshida, Motoomi, 53, 66  
Yoshida, Tsuyoshi, 145  
Yoshimura, Junichi, 80, 113  
Yoshimura, Takuya, 95, 118, 163  
Yoshino, Hirokazu, 222  
Yoshino, Shun, **223**  
Yu, Haoxin, **42, 71**  
Yu, Jen-Fang, 198  
Yu, Lei, **171, 191**  
Yu, Shuwen, **78**  
Yu, Xiang, **204**  
Yu, Xiongying, **64**  
Yuan, Chunhui, **162**  
Yuan, Guoqing, 67  
Yzermans, Joris, 68  
Zacharias, Frank-Christian, **110**  
Zajamsek, Branko, 136, **156**  
Zaki, Nuawi, 225  
Zander, Anthony C, 121, 179  
Zanni, Alberto, 88  
Zawieska, Wiktor M, 80, 153  
Zeisler, Annett, **45**  
Zeitler, Berndt, **80, 114, 203**  
Zellmann, Christoph, **160**  
Zhan, Pei, 164  
Zhang, Aman, 130  
Zhang, Cong, 56  
Zhang, Dongdong, **141**  
Zhang, Jiping, **109, 130**  
Zhang, Junjie, 162, **207**  
Zhang, Kaipeng, **95**  
Zhang, Lei, 109  
Zhang, Liangyong, 226  
Zhang, Limin, 155  
Zhang, Linke, 155  
Zhang, Ming Di, 191  
Zhang, Nong, 100, 145  
Zhang, Runze, 104, **163**



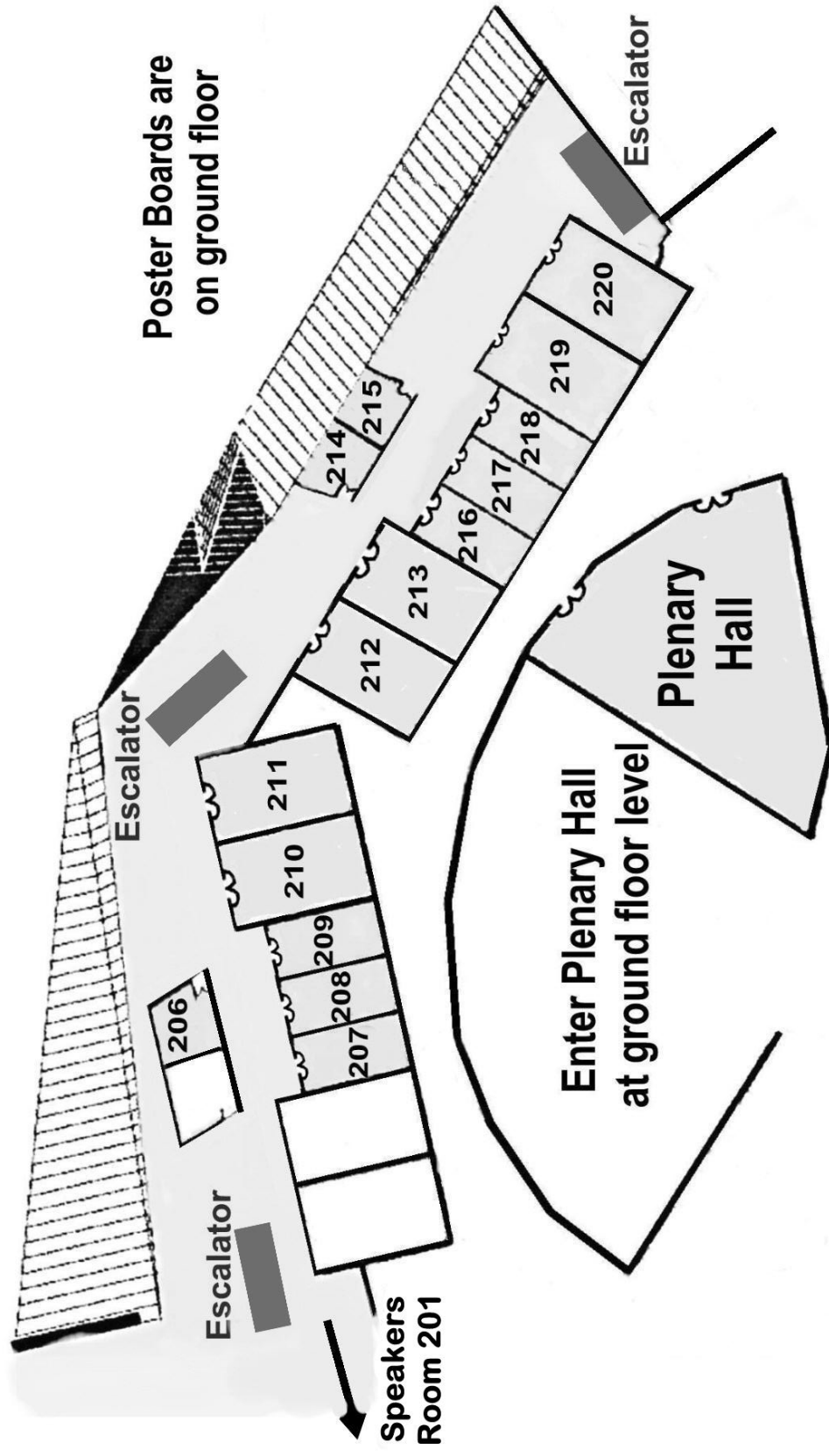
Zhang, Tao, 95  
 Zhang, Tianmu, **208**, 209  
 Zhang, Weichen, 187  
 Zhang, Weihua, 81  
 Zhang, Wen, 193  
 Zhang, Xiaonei, 71  
 Zhang, Xiao-Zheng, 112, 126  
 Zhang, Xin, 130  
 Zhang, Xuetao, **120**  
 Zhang, Yilin, **47**  
 Zhang, Yong-Bin, **114**  
 Zhang, Yufei, 70, **125**  
 Zhang, Zhenguo, 67  
 Zhang, Zhi, **100**  
 Zhang, Zhi Yong, **53**

Zhao, Anbang, **190**  
 Zhao, Dan, 178  
 Zhao, Jing, **100**  
 Zhao, Kang Sai, 191  
 Zhao, Linfeng, 100  
 Zhao, Yingjiu, 48  
 Zhao, Yuezhe, 130  
 Zhao, Zhishan, 190  
 Zheng, Chang-jun, 126  
 Zheng, Jianwen, **194**  
 Zheng, Jing, 75  
 Zheng, Ling, 141  
 Zheng, Sifa, 57, 225  
 Zhong, Bo, 58  
 Zhong, Zhenmao, 48

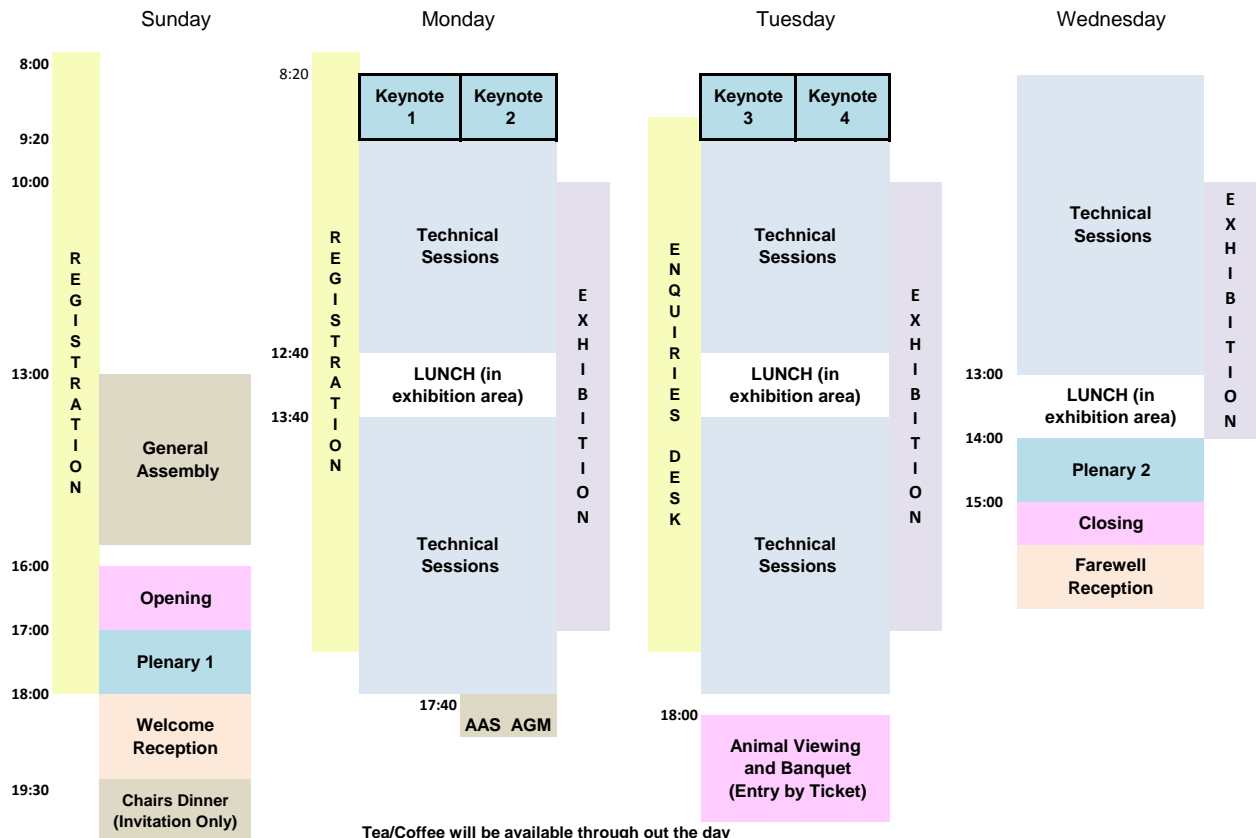
Zhou, Bin, 190  
 Zhou, Han, 110  
 Zhou, Liubin, 175  
 Zhou, Yude, 133  
 Zhu, Dawei, 67  
 Zhu, Minggang, 175, 195  
 Zhuang, Zhong, 208, 209  
 Ziaran, Stanislav, **142**, **162**  
 Zinoviev, Alex, 189, **190**  
 Zöller, Marek, 83  
 Zoontjens, Luke, **98**  
 Zou, Haishan, **155**



# LECTURE ROOMS ON SECOND FLOOR



## INTER.NOISE 2014 PROGRAM OVERVIEW



Tea/Coffee will be available through out the day

Refreshments available in exhibition area

Monday, Tuesday : 10:40 - 11:10 and 15:20 - 15:50

Wednesday: 10:20 - 11:00

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