AIA-DAGA 2013

Conference on Acoustics

AIA-DAGA 2013 MERANO

EAA Euroregio - EAA Winter School

18-21 March 2013 in Merano

Program

DEGA

AIA ASSOCIAZIONE ITALIANA di ACUSTICA

European Acoustics Association EAA

AIA-DAGA 2013
Conference on Acoustics, Merano
EAA Euroregio - EAA Winter School
including
- 40th Italian Annual Conference on Acoustics (AIA)
- 39th German Annual Conference on Acoustics (DAGA)

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View onto Merano - unknown painter (early 19th century),
Civic museum of Merano

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Workshops and pre-colloquium

	Monday 18 March 2013
	Workshop "Classroom acoustics" Room: Kurhaus, Kursaal
14:00	Tommasini, Pfeifer, Peretti: Opening
14:20	Brokmann: Room acoustic regulations for classrooms - a European perspective (56)
14:40	Oberkalmsteiner, Canale, Verdi, Astolfi, Prodi, Peretti: Reverberation time in educational environments in South Tyrol (56)
15:00	Prodi: On the influence of acoustics on speech intelligibility and learning inside classrooms (57)
15:20	Astolfi: Influence of classroom acoustics on the vocal load of teachers (57)
15:40	Giordano, Nadalin, Raimondo, Astolfi, Bottalico, Riva, Garzaro: Noise and reverberation effect on vocal effort of primary school teachers (58)
16:00	Fussi: Having a resonant voice in the noise: techniques for assessing the vocal cost and safeguard against professional voice diseases (58)
16:20	Tiesler: Noise - Stressor for Students and Teachers! Acoustic Ergonomics of School (59)
16:40	Maffei: On the possibility to increase the acoustic performance of classrooms with simple and economic projects (59)
17:00	Discussion
17:45	Höllrigl, Minnei: Conclusions

	Monday 18 March 2013
	Pre-colloquium "Computation, Simulation and Modelling in Acoustics" Room: Puccini Theatre
13:00	Kropp, Scheuren: Opening
13:10	Blanchet: Vibro-Acoustics Application Specific Requirements: Taking advantage of increased computing power with new or existing approaches to fulfil them (61)
13:35	Ewert: Surface and volume propagation methods for broadband sound prediction with synthetic turbulent sound sources (62)
14:00	Ochmann: Modelling of acoustical Green's functions above impedance planes by a superposition integral (62)
14:25	Svensson: Modelling scattering with high orders of edge diffraction (63)
14:50	Pause
15:10	Kob: Modelling of the Singing Voice (63)
15:35	Nolte: Damping, Dispersion and Classification (64)
16:00	Pieringer: On the modelling of wheel/rail noise (64)
16:25	Beckenbauer, Kropp: A mixed physical and statistical approach for the prediction of tyre/road noise (65)
16:50	Kropp, Scheuren: Closing words

	Friday 22 March 2013
	Workshop "The overall quality in buildings: environment, energy, acoustics" Room: Kurhaus, Kursaal
09:00	Mussner, Casolari, Peretti: Opening
09:20	Lercher: Road traffic noise exposure and its effects on health and quality of life (66)
09:35	Fedrizzi: The Noise Mapping in South Tyrol (67)
09:50	Klammsteiner, Di Bella: Quality and sustainability in buildings: from design to testing (67)
10:20	Neubauer, Scamoni: The acoustic classification in Italy and Germany: perspectives and opportunities (68)
10:50	Demattio: The KlimaHaus Certification for non-residential buildings: acoustic comfort and evaluation protocols (68)
11:10	Barbaresi, Semprini: Acoustical design and testing issues of multi-storey wooden buildings (69)
11:30	Zecchin, Raisa: Problems of technical equipment integration in buildings (69)
11:50	Elia: Voluntary and mandatory standards in Italy (69)
12:05	Pichler: Catalogue of structural elements in architectural acoustics (70)
12:20	Discussion
12:50	Santa: Conclusions

Tuesday, 19 March 2013

Kurhaus, Kursaal

9:00 **Opening and award ceremony**
- Welcome addresses and music
- DEGA Helmholtz Medal presented to Prof. Wolfgang Lauterborn (see p. 42 and lecture at p. 53)
- DEGA Lothar-Cremer Award presented to Prof. Janina Fels (see p. 42 and lecture at 55)
- Presentation of DEGA Student Award (see p. 43)
- Report on AIA awards
- Presentation of AIA "Special Award" (see p. 43)

10:30 Coffee break

11:00 **Plenary lecture Nicola Prodi: "Acoustics of Historical Opera Houses in Italy: Past, Present, and Future"** (53)

11:45 **Product forum** (38)

13:00 Lunch break

14:00 **Poster session** (see below)

14:40 **Plenary lecture Werner Lauterborn: "The Secret Life of Bubbles in a Sound Field"** (53)

Poster Session Tuesday (Gallery of Kursaal)

	Acoustic measurem.	**Urban planning**	**Ultrasound in medic.**	**Signal proc. in audiolog.**	**Electro-acoustics**	**Medical acoustics**
14:00	Preti: swine solid fraction (150)	Magrini: quality index (154)	Jamshidi Rad: therapeutic transd. (157)	Bschorr: Ohr-Modell (158)	Jungmann: room compens. (136)	Wirtz: CI localization (161)
14:00	Putner: accelerometers (151)	Natale: noise awareness (154)	Magnetto: oxygen nanobubbles (157)	Buiat: probe calibration (159)	Mazur: permutation ambig. (137)	Rader: bone cond. implant (162)
14:00	Presciutti: headphones (151)	Hintzsche: Lärmkartierung (155)			Farnetani: home theatre (137)	Jäckel: prosodic features (162)
14:00	Barth: travel-time tomogr. (152)	Mietlicki: HARMONICA (155)				
			Ultrasounds	**Room acou. criteria**	**Effects of noise**	**In vivo measurem.**
14:00	Peruzzi: riflessioni laterali (152)	Silvaggio: HUSH results (156)	Holstein: spatial spread (102)	Yuksel Can: Turkish music (158)	Siegmann: noise and sleep (159)	Merz: hearing protectors (160)
14:00	Dealessandri: heavy duty industry (153)	Papa: requalification (156)			Mariconte: head-/hearphones (160)	Silingardi: musicians in stages (161)
14:00	Amadasi: field reconstruction (153)					

Poster Session Tuesday (Gallery of Kursaal)							
	Hearing system	**Working place**	**Numerical acoust. 1**	**Tyre/road noise**	**Virtual acoustics**		**Wind turb. noise**
14:00	Ewert: fundamental freq. (163)	Ramus: glass bottles (142)	Díaz-Cereceda: SEA-like (149)	Osele: motorway surface (164)	Werner: environment perc. (118)	Malecki: auraliz. quality (121)	Cesini: micro turbine (94)
14:00		Lori: olive harvest (143)	Al-Kharabsheh: insulation (149)	Chetoni: rubber asphalt (164)	Moritz: gear failures (118)	Siegel: geometr. methods (121)	Masullo: wind farm (94)
14:00		Preti: rotary pick-up (143)	Paul: simplified enclosure (150)		Werner: binaural response (119)	Noisternig: IRCAM's hall (122)	Pies: residential areas (94)
14:00		Malfèr: pneum. screwdrivers (144)			Schröder: openMat (119)	Pulkki: spatial audio (122)	
	Music acoustics	**Speech quality**	**Speech recogn.**	**Vehicle acoustics**			
14:00	Huberth: timbre production (112)	Antons: ERP and ratings (75)	Gerazov: ASR features (163)	Savitski: sliding friction (131)	Markovic: xylophone (120)	Rychtárikova: 3D absorbers (122)	
14:00	Berdahl: haptic feedback (112)	Soloducha: model scores (76)		Stampka: cavity modes (131)	Klein: HRTF adaption (120)		
14:00	Primavera: hybrid reverberation (113)						

Tuesday, 19 March 2013 (continued)

	Kurhaus					Puccini	Terme
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Speech quality	**Uncertainties**	**Rail/wheel noise 1**	**Outdoor sound pr.**	**Wind turb. noise**	**Building acoustics**	**Ultrasounds**
15:30	Hansen: realistic situation (71)	Heiß: ISO/IEC 98-3 (76)	Venghaus: STARDAMP method (80)	Wei: rigid barrier (85)	Bartelt: trailing edge flaps (89)	Hessinger: window insulation (95)	Schröder: distance sensor (99)
15:50	Möller: quality prediction (71)	Hohenwarter: meteor. conditions (77)	Betgen: STARDAMP tool (81)	Heimann: complex terrain (85)	Bekiropoulos: turbine airfoils (90)	Secchi: sound red. index (95)	Koch: cleaning efficiency (99)
16:10	Kettler: noise modulation (72)	Bisceglie: temporal sampl. (77)	Dittrich: train pass-bys (81)	Hornikx: urban flow field (86)	Becker: hybrid method (90)	Liegl: dampening shutters (96)	Olfert: Schlieren tomogram (100)
16:30	Ullmann: intrusiveness (72)	Casini: traffic noise tests (78)	Czolbe: railway emission (82)	Guillaume: validation (86)	Klaas: one-man measur. (91)	Ruggeri: glazing systems (96)	Nowak: energy loss (100)
16:50	Köster: new paradigm (73)	Lechner: tests in Austria (78)	Venghaus: rail roughness (82)	Ziemann: forest areas (87)	Mura: high-power farm (91)	Manzi: glazing sound (96)	Eisener: sound films (101)
17:10	Skowronek: conferenc. systems (73)	Garai: noise barriers (79)	Liepert: railway bridges (83)	Trimpop: forest damping (87)	Mura: wind plant (92)	Herget: fassaden (97)	Mettin: translating bubbles (101)
17:30	Buerger: speech enhancem. (74)	Bertellino: househ. appliances (79)	Wanker: Brenner railway (83)	Kim: vegatation treatm. (88)	Engelen: wind turbines (92)	Landini: ventilated roof (97)	Cairos Barreto: sodium line emiss. (101)
17:50	Guse: multiservice scenario (74)	Probst: quality assurance (80)	Czolbe: Isarco valley (84)	Kluth: tunnel prediction (88)	Kameier: noisy turbines (93)	Oberrauch: wooden roofs (98)	Kümmritz: spher. Inclusions (102)
18:10	Brücker: glottal jet (75)		Starnberg: AcouTrain (84)	Wolf: temperature gradient (89)	Serpilli: micro turbine (93)	Niederstaetter: comm. chamber (98)	

20:00: **Get together** (Hot buffet + draft beer + live music - Kurhaus, Kursaal)

	Terme		Civic Rooms		Cultural Centre			Urania
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Speech in rooms 1	**Music acoust. 1**	**Virtual acoust. 1**	**Auralisation**	**Vehicle acoustics**	**Micro loudsp.**	**Working place 1**	**Numerical acoust. 1**
15:30	Oberkalmsteiner : reverberation (103)	Rucz: reed pipes (107)	Bernschütz: spherical (113)	Maillard: traffic noise (123)	Pawlowski: vehicle crash (127)	Klippel: nonlinearities (132)	Maue: uncertainties (138)	D'Alessandro: alum. panels (144)
15:50	Iannace: hist. classrooms (103)	Preukschat: reed vib. (108)	Brinkmann: HRTF (114)	Hoffmann: prediction tool (123)	Triebel: artificial rain (127)	Höhne: linear parameters (132)	Wahler: round robin test (138)	Bittner: pump housings (145)
16:10	Visentin: classroom noise (104)	Gloos: organ building (108)	Ziegelwanger: num. HRTF (114)	Fiebig: road traffic noise (124)	Stangl: gearbox whining (128)	Wukau: small transduc. (133)	Ruppert-Pils: elem. schools (139)	Karger: energy FEM (145)
16:30	Andrijašević: CCV-CVC (104)	Angster: research organ (109)	Rasumow: HRTF phase (115)	Forssen: truck sound (124)	Hunken: Diesel metric (128)	Beer: flat enclosure (133)	Waldmann: own instrument (139)	Andersson: boundary (146)
						Electro-acoust. 1		
16:50	Rennies: speech reflection (105)	Pitsch: scaling pipes (109)	Wendt: vertical sources (115)	Segura Garcia: nuisance (125)	Grosse: vehicle detection (129)	Leckschat: HF loudspeaker (134)	Notbohm: hospital noise (140)	Genuini: quantum mech. (146)
17:10	Neher: speech cafeteria (105)	Stever: Klangschalen (110)	Richter: spherical harm. (116)	Aletta: influence of vision (125)	Browne: LWRT quality (129)	Shabalina: subwoofer direct. (134)	Brockt: machine emission (140)	Stütz: TD-BEM (147)
17:30	Jørgensen: noisy speech (106)	Mores: Hanneforth (110)	Batke: ambisonics rend. (116)	Naßhan: hybrid auralization (126)	Heinrichs: periodic impulsiven. (130)	Volmer: face masks (135)	Förster: industrial noise (141)	Diekmann: structural optimiz. (147)
17:50	Weißgerber: CI and reverb. (106)	Batke: attack transients (111)	Jin: binaur. rendering (117)	Heutschi: turbine auraliz. (126)	Nau: partial sources (130)	Seidler: understanding (135)	Probst: baffle systems (141)	Jonckheere: trimmed cavit. (148)
18:10	Kerber: CI in reverb. room (107)	Grothe: bassoon, bassoforte (111)	Frank: source widening (117)			Behler: cathedral Münster (136)	Telsnig: open plan offices (142)	Nava: pulse interaction (148)

Wednesday, 20 March 2013

	Kurhaus					Puccini	Terme
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Psycho-acoustics	**Effects of noise**	**Rail/wheel noise 2**	**Sound-scaping**	**Environm. noise**	**Building acoustics**	**Ultrasound in med.**
08:40	Hots: loudn. integration (165)	Windelberg: cardiovasc. disease (175)	Steinbach: acceptance (184)	Yang: music features (193)	Paviotti: env. noise impact (205)	Wolff: VDI 4100 (217)	Jenderka: diagn. ultrasound (230)
09:00	Töpken: multi-tone sounds (165)	Krahé: brain reaction (175)	Reichart: rail vehicles (185)	Puglisi: vegetation (193)	Paviotti: ongoing activities (206)	Bietz: DIN 4109 update (217)	Ueberle: heart imaging (230)
09:20	Klein-Hennig: tone complexes (166)	König: experiments (176)	Eichenlaub: brake noise (185)	Zorzanello: sound documentation (194)	Licitra: noise in cities (206)	Borghi: buildings in Italy (218)	Kohout: cancer therapy (231)
09:40	Egger: suprathreshold (166)	Mattia: stress correlation (176)	Kohrs: brake discs (185)	Hwang: religious spaces (194)	Jäcker-Cüppers: directive END (207)	Demattio: buildings certific. (218)	Haller: dose definition (231)
		Urban planning					
10:00	Schell-Majoor: masked thr. (167)	Luzzi: smart cities (177)	Gutmann: wheel roughn. (186)	Voigt: Berlin soundwalk (195)	Weber: noise policy (207)	Rovere: acoustic protocol (218)	Bessonova: tissue-mimicking (232)
10:20	Heeren: partial loudness (167)	Wolfert: traffic noise (177)	Göbl: new railway route (186)	Drever: silent soundwalk (195)	Myck: aircraft regulations (208)	Demattio: office buildings (219)	Troia: thermocromic gel (232)
10:40	Fels: selective attention (168)	Bristow: university campus (178)	Huber: rolling stock (187)	Botteldooren: soundscape monit. (196)	Piuri: Milan Movida (209)	Schneider: plasterboard walls 1 (219)	Guiot: oxygen nanotherapy (233)
			Tyre/road noise 1				
11:00	Neugebauer: localization (168)	Eggers: decision tool (178)	Bellucci: EU desiderata (187)	Preis: audio-visual interact. (196)	Roy: open air cinema (209)	Reinhold: plasterboard walls 2 (220)	Musacchio: ultrasound absorp. (233)
							Medical acoustics
11:20	Kayser: speaker localization (169)	Gallo: Turin action plan (179)	Gewalt: DfSS approach (188)	Filipan: soundsc. recordings (197)	Kropsch : austrian farms (210)	Kohrmann: light slabs 1 (220)	Nicoletti: stress test (234)
11:40	Scheuren: ISO 532 revision (169)	Michelsen: highway enlarging (179)	Männel: paving stones (188)	Manrique-Ortiz: quiet zones (197)	Giannardi: runway layouts (210)	Buchschmid: light slabs 2 (221)	Völker: binaur. schemes (234)

12:15 Kursaal: **Plenary lecture Martin Schleske: "On the Use of Scientific Tools in Today's Violin Making"** (54)

12:55 Lunch break

14:00 Gallery: **Poster session** (see next page)

14:40 Kursaal: **Plenary lecture Roberto M. Gavioso: "Speed of Sound in Fluids"** (54)

	Terme		Civic Rooms		Cultural Centre			Urania
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Speech in rooms 2	**Music acoust. 2**	**Virtual acoust. 2**	**Hearing system**	**Intake + exhaust**	**Electro-acoust. 2**	**Working place 2**	**Numerical acoust. 2**
08:40	Seeber: improving hearing (239)	Saati Khosros-hahi: tar box (249)		Dau: texture analysis (269)	Elnemr: IC-engine noise (278)	Merkel: virtual microph. (288)	Sickert: hearing protection (297)	Guettler: FEM accuracy (309)
09:00	Prodi: effortful listening (240)	Berdahl: guitar feedback (250)	Käsbach: low reverberation (261)	Iben: auditory model (270)	Ubertino: in-duct source (279)	Hillen-brand: electret mic. (288)	Dantscher: attenuation (298)	Kalten-bacher: flexible (309)
09:20	Astolfi: voice care (240)	Greb: music reception (250)	Tronchin: subj. evaluation (261)	Oetjen: roughness calc. (270)	Bönnen: actice exhaust (279)	Palacino: spatial pick-up (289)	Peretti: bus vibrations (298)	Peiffer: double wall TL (310)
	History of Acoustics	**In vivo measur.**				**Hydro-acoustics**		
09:40	Alippi: Istituto di Acustica (241)	Zamorano: orchestra shields 1 (251)	Klockget-her: spatial perc. (262)	Sottek: temporal loudn. (271)	Krüger: gasoline engines (280)	Homm: underwa-ter noise (289)	Peretti: forklift vibrations (299)	Pena Fer-nandez: supersonic jet (310)
10:00	Meyer: conc. hall design (241)	Schulte: orchestra shields 2 (251)	Oberem: equalizati-on (262)	Pause	Pommerer: exhaust system (280)	Blanchet: virtual hydroph. (290)	Nataletti: new advances (299)	Mócsai: adaptive technique (311)
				Signals in audiology				
10:20	Mehnert: hist. collection (241)	Pazen: damage risk (252)	Wefers: filter exchange (263)	Dillier: sound coding (271)	Hansson: active resonator (281)	Schael: merchant ships (290)	Pause	Marter: absorption modeling (311)
		Room ac. criteria					**Machin. noise**	
10:40	Hoffmann: Ernst Mach (242)	Blauert: room pa-rameters (252)	Wefers: fast convo-lution (263)	Tognola: amplifier device (272)	Vorobeva: dissip. mufflers (281)	Nejedl: RV Planet (291)	Tomasini: rotating machinery (300)	Piscoya: transmiss. loss (312)
					Vehicle si-mulation			
11:00	Corinth: eardrum vibration (242)	Skålevik: preference predic. (253)	Mauro: audio con-volution (264)	Sankows-ky-Rothe: ear canal (272)	Vansant: pass-by noise (282)	Stiller: diver detection (291)	Dalle: low noise hopper (300)	Waubke: layered soil (312)
11:20	Bettucci: acoustics in Italy (243)	Lauten-bach: stage crit. (253)	Knauber: inverse ray tracing (264)	Marquardt: coherence reshaping (273)	Miccoli: determ. methods (282)	Abshagen: sonar app-lications (292)	Pleban: opencast mines (301)	Burg-schweiger: combinati-on (313)
11:40	Ianniello: noise in Italy (243)	Lokki: high frequen-cies (254)	Bomhardt: reflections (265)	Martin: binaural algorithm (273)	Belyi: Abaqus simul. (283)	Ciappi: wall pressure fluc. (292)	Carletti: mobile machines (301)	Schaal: damping layers (313)

Wednesday, 20 March 2013 (continued)

	Poster Session Wednesday (Gallery of Kursaal)						
	Psycho-acoustics	**Soundscaping**		**Environmental noise**		**Building acoustics**	
14:00	Ewert: AFC framework (174)	Poma: greenery systems (198)	Grasso: Turin soundmap (202)	Bischof: Liechten-stein (208)	Hirsch: noise mapping 2 (320)	Luison: dry systems (226)	Candelari: green mod. system (228)
14:00	Ernst: difference limens (174)	Cordeiro: social networks (198)	Liu: city parks (324)	Remigi: Venice harbour (215)	Verdolini: action effec-tiveness (321)	Rizzi: acoust. retraining (226)	Fausti: index comparison (229)
14:00		Andringa: core affect (199)	Boubezari: NY high line (325)	Engel: data analysis (216)	Cerchiai: rubber pavements (321)	Demattio: hospitality build. (227)	Majandi: privacy index (229)
	Speech processing						
14:00	Bissiri: glottal stop (328)	Drever: hand dryers (199)	Czopek: vibrating bracelet (325)	Scavazza: countryside sound (216)	Wolfert: Eurocities (322)	Abate: ancient buildings (227)	Mastino: WTG envelope (229)
14:00	Lipski: age effects (329)	Ruiz: classif. procedure (201)		Craig: noise maps (320)	Bettarello: noise in Tuscany (322)	Semprini: flanking transmis-sion (228)	

	Kurhaus					**Puccini**	**Terme**
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Psycho-acoustics	**Urban planning**	**Tyre/road noise 1**	**Sound-scaping**	**Environm. noise**	**Building acoustics**	**Active control 1**
15:30	Macdonald: modulated noise (170)	Mietlicki: Paris ring road (180)	Schulze: thin layers (189)	Dökmeci: indoor study (200)	Vaucher De La Croix: permanent monit. (211)	Scheck: lightw. stairs part 1 (221)	Ghandchi: energy harvesting (235)
15:50	Schoenma-ker: aud. streaming (170)	Zambon: Milan road noise (180)	Liepert: low noise surface (189)	Dubois: signal accounts (200)	Caniato: speaking people (211)	Fichtel: lightw. stairs part 2 (222)	Späh: complex structure (235)
16:10	Hauth: level dependency (171)	Badino: area of Genoa (181)	Baistrocchi: raised crosswalks (190)	Kogan: urban study sites (201)	Kühner: AHAAH (212)	Geyer: lightweight test (222)	Alujevic: tuned mass dampers (236)
16:30	Rossi: stroop effect (171)	Alonso: socioac. diagnosis (181)	Bartolomae-us: wind influence (190)	Schulte-Fortkamp: context and health (202)	Cerniglia: noise mana-gement (212)	Sanavi: wall-floor-junction (223)	Bös: AdRIA research (236)

	Poster Session Wednesday (Gallery of Kursaal)							
	Struct.-b. sound	**Room acoustics**		**Signal process.**	**Transport noise**	**Active systems**	**Machin. noise**	**Physical acoust.**
14:00	Nowak: plate structure (307)	Cocchi: restoration work (258)	Dietrich: ITA toolbox (259)	Strecha: autom. subtitles (326)	Zei: binned fit approach (330)	Iwanski: fluid-loa. structure (319)	Romano: electric motors (304)	Bschorr: Wellen-ausbreit. (246)
14:00	Pathan: modific. of plates (308)	Quaranta: Asisium Theatre (258)	Dietrich: loudsp. distortion (260)	Dalga: estimation errors (326)	Spoglianti: highway noise (330)		Skowronek: ball bearings (305)	Norambuena: metamaterials (246)
14:00	Romano: piping fatigue (308)	De Cesaris: Rossini th. (258)	Mangano: Palacult. Messina (260)	Necciari: time-freq. transform (327)			Holstein: emission sensors (305)	Abramovich: composites (246)
	Thermo-acoustics		**Sandwich materials**		**Offshore struct.**	**Flow acoustics**	**Noise control**	**Numerical acoust. 3**
14:00	De Jong: thermoac. engine (329)	Orsini: acoust. renovation (259)		Matern: automatic clustering (327)	Zaslavski: echo location (331)	Laguna: radial mode an. (323)	Fischer: emission blenders (323)	Trojanowski: 2-layer piezo (318)
14:00			Holstein: attractiveness (324)	Asendorf: gain maximaz. (328)				Bianco: metallic spheres (319)

	Terme		**Civic Rooms**		**Cultural Centre**			**Urania**
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Physical acoustics	**Room ac. criteria**	**Virtual acoust. 2**	**Scene analysis**	**Vehicle simulation**	**Comput. Aeroac.**	**Machin. noise**	**Numerical acoust. 3**
15:30	Hirsekorn: grain scatt. noise (244)	D'Orazio: Bonci theatre (254)	Rychtáriková: self-localisat. (265)	Salvati: highly reverberant (274)	Foken: thin structures (283)	Kreuzinger: HVAC compon. (293)	Tamm: inertia properties (302)	Rescheleit: moving sources (314)
15:50	Uppenkamp: functional MRI (244)	Stephenson: parameter def. (254)	Majdak: CTC localization (266)	Baumgartner: sagit. planes (274)	Bouvet: el. powertrain (284)	De Gennaro: zonal LES 2 (293)	Schirmer: steam turbine (302)	Pohl: reunification (314)
16:10	Lauterborn: pair interaction (245)		Pelzer: reflection factors (266)	Bendixen: sound predictability (275)	Onescu: catalytic converter (284)	Reppenhagen: hybrid appr. (294)	Linke: transfer matrix (303)	Retka: volume sources (315)
16:30	Frommhold: droplet imp. (245)		Pörschmann: room modific. (267)	Volpe: EyesWeb XMI (275)	Fernandez C.: particle velocity (285)	Becker: climatronic systems (294)	Bethke: lab. qualification (303)	Bachner: ducts dispersion (315)

Wednesday, 20 March 2013 (continued)

	Kurhaus					Puccini	Terme
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Psycho-acoustics	**Urban planning**	**Tyre/road noise 1**	**Sound-scaping**	**Environm. noise**	**Building acoustics**	**Active control 1**
16:50	Biberger: envelope processing (172)	Caldas: Brazilian airports (182)	Bückers: quiet road traffic 3 (190)	Mossberg: interdiscipli-narity (203)	Brandstätt: air transport system (213)	De Geetere: lightweight construction (223)	Stein: power transfer matrix (237)
17:10	Vázquez: Scile software (172)	Carati: study of Rome (182)	Winroth: air-pumping (191)	Lercher: contextual perspective (203)	Campo-longo: neighbour noise (213)	Churchill: timber plate (224)	Klaus: double-glaz. window (237)
17:30	Raufer: HRTF meas. (173)	Bellomini: city of Florence (183)	Stalter: driving torque (191)	Delaitre: contrast indicator (204)	Knauß: meteorology (214)	Schmidt: timber ceilings (224)	Thyes: active masking (238)
17:50	Kattner: pitch ratios (173)	Niessen: action plan eval. (183)	Hoever: rolling noise (192)	Axelsson: quality (204)	Hirsch: muzzle blasts (214)	Stange-Kölling: walking noise (225)	Tschesche: wolf note elim. (238)
18:10		Stoppioni: environm. certific. (184)	Kropp: rolling resistance (192)	Steffens: househ. appliances (205)	Badino: SILENV project (215)	Prato: lab. insulation (225)	Karsten: DEA applicability (239)

20:00: **Conference dinner** (extra fee, at Forsterbräu Merano, Corso Libertà, 90)

	Terme		Civic Rooms		Cultural Centre			Urania
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Acoustic measur. 1	**Room acoust. 1**	**Virtual acoust. 2**	**Scene analysis**	**Vehicle simulation**	**Comput. Aeroac.**	**Machin. noise**	**Numerical acoust. 3**
16:50	Kuipers: small array (247)	Bork: small room modes (255)	Pollow: rectang. rooms (267)	Rosenkranz: vibration synt. (276)	Bouvet: BE energy method (285)	Maihöfer: car excitation (295)	Carl: gear transmission (304)	Mayer: uncertain models (316)
17:10	Opdam: reflection coeff. (247)	Behrens: worshippers (256)	Klein: arbitrary directivity (268)	Imbery: vibration influence (276)	Bertolini: multilayers (286)	Hüppe: aeroac. analogy (295)	Pause	Dilba: hierarch. matrix (316)
							Struct.-b. sound 1	
17:30	Weihe: recipr. calibration (248)	Zander: sports halls (256)	Rettberg: spherical beamform. (268)	Papetti: audio-tactile int. (277)	Semerak: FEA multilayer (286)	Akkermans: rotor noise (296)	Abele: random FEM (306)	Fiala: scattered fields (317)
17:50	Neubauer: calibration method (248)	Drechsler: diffusivity coeff. (257)	Kaiser: array modes (269)	Josupeit: speech localization (277)	Bonfiglio: mech. properties (287)	Adachi: airfoil profile (296)	Schmelter: sheet metal (306)	Gehlken: halfspace formul. (317)
18:10	Milz: ISO 126101 (249)	Shtrepi: scale factor (257)		Merchel: body vibrations (278)	Langhof: double walls (287)	Rurkowska: high-lift config. (297)	Kletschkowski: struct. param. (307)	Ferreira: Rayleigh model (318)

Thursday, 21 March 2013

	Kurhaus					Puccini	Terme
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Applic. of Psychoac.	**Sandwich materials**	**Tyre/road noise 2**	**Sound-scaping**	**Environm. noise**	**Building acoustics**	**Active control 2**
08:40	Verhey: active and passive (332)	Piana: sandwich struc. (341)	Schnieders: C3 tires (349)	Schulte-Fortkamp: resources (358)	Talasch: Vienna maps (366)	Angelini: large rooms (375)	Röglin: car vibrations (384)
09:00	Putner: dieselness (332)	Marchesini: point mobility (342)	Pfaffelhuber: LWRT panels (350)	Kang: relationships (358)	Cerniglia: railway maps (367)	Scholl: ISO 717 (376)	Heuss: control strategies (385)
09:20	Robart: eVADER study (333)	Orrenius: weight minimiza. (342)	Kindt: rotating tire (350)	Brambilla: urban spaces (359)	Giering: hotspot identif. (367)	Granzotto: single numbers (376)	Krause: local treatments (385)
09:40	Sukowski: interview benefit (334)	Milani: precast panels (343)	Lindberg: rim behaviour (351)	Hug: sound thinking (359)	Petz: embedded parks (368)	Cremonini: in-situ insulation (377)	Rohlfing: ANC for ducts (386)
10:00	Seiler: ship quality (334)	Aratari: floor retrofitting (343)	Marmaroli: speed estim. (351)	Lam: dense cities (360)	Votsi: combined network (368)	Rodrigues A. Monteiro: heavyweight walls (377)	Haase: open rotor (386)
			Transport noise				
10:20	Altinsoy: EU sound label (335)	Pause	Kathmann: traffic data (352)	Jang: urban parks (360)	Ascari: noise indicator (369)	Neubauer: LF insulation (378)	Krause: airplane noise red. (387)
		Absorbing materials					**Thermo-acoustics**
10:40	Skoda: subconsc. perception (335)	Perrot: cellular foams (344)	Fend: guide posts (352)	Leus: city of Antwerp (360)	Hammel-mann: noise mapping 1 (369)	Pedersoli: COST questionnaire (378)	Mariappan: Rijke burners (387)
						ISO 10052	
11:00	Lepage: disturbed broadcast (336)	Roozen: poro materials (344)	Guarnaccia: linearity (353)	Aspuru: Bilbao strategy (361)	Köpfli: geogr. information (370)	Alphei: optimal positions (379)	Morgans: combustor (388)
11:20	Müsch: disturbed broadcast (336)	Göransson: response sensit. (345)	Petrovic: neural networks (353)	Qu: wind turb. noise (361)	Valero: source recogn. (370)	Pontarollo: field measu-rement (379)	Assier: vortical di-sturbances (388)
11:40	Bahmer: rate discri-mination (337)	Schiavi: Ergun-Wu equation (345)	Asdrubali: mapping project (354)	Hong: noise barrier (362)	Berlier: temp. gradient (371)	Di Bella: equipment noise (380)	Han: heat release resp. (389)

12:15 Kursaal: **Plenary lecture Detlef Krahé: "Low-Frequency Sound - a Special Sound"** (55)

12:55 Lunch break

14:10 Kursaal: **Plenary lecture Janina Fels: "Trends in Binaural Technology"** (55)

	Terme		Civic Rooms		Cultural Centre			Urania
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Acoustic measur. 2	**Room acoust. 2**	**Virtual acoust. 3**	**Signal process.**	**Speech recogn.**	**Arrays for aero.**	**Struct.-b. sound 2**	**Numerical acoust. 4**
08:40	Tarizzo: frescoes damage (393)	Guski: reverb. time (400)	Pomberger: field decompos. (409)	Müller-Trapet: absorption (417)		Kokavecz: enhanced localis. (434)	Patil: coupled plates (443)	Weber: barrier tops (452)
09:00	Telle: fluctuating noise (393)	Vercammen: diffusion (400)	Spors: virtual array (409)	Walzer: adaptive cancelling (417)	Kitzig: noisy speech (426)	Kröber: spec. broadening (434)	Meinzer: traveling wave (443)	Schmelzer: baffl. piston (452)
09:20	Sacchi: plane fields (394)	Bonsi: Joyce equation (401)	Sladeczek: modal aliasing (410)	Schepker: improving intellig. (418)	Spille: analysis + recogn. (426)	Ahlefeldt: array measurem. (435)	Bowyer: black hole eff. (444)	Chobeau: PML implement. (453)
09:40	Budde: DE optimisation (394)	Lorenz-K.: ten churches (401)	Fazi: WFS implement. (410)	Berkhoff: steerable sources (418)	Meutzner: preprocessing (427)	Herold: covariance matrix (435)	Bauer: operational data (444)	Keuchel: 3D speed up (453)
10:00	Fernandez C.: noise separation (395)	Hak: sports halls (402)	Horvat: multichannel loudsp. (411)	Scharrer: array classific. (419)	Morales Cordovilla: recognizer (427)	Haxter: pressure fluctua. (436)	Mathiowetz: cont. interfaces (445)	Gravenkamp: waveguides (454)
				Otoacou. emiss.		**Measur. techniq.**		
10:20	Lindemann: Hochleist.-laser (395)	Lachenmayr: concert halls (402)	Schneider: geometry influence (411)	Duifhuis: cochlear waves (419)	Ngouoko: distrib. equalization (428)	Sturm: force identification (436)	Langfeldt: fuselage sound (445)	
10:40	Schulz: duct flow (395)	Méndez: room raytracing (403)	Firtha: field reproduction (412)	Elliott: wave decomposit. (420)	Schädler: stepwise integration (428)	Knöfel: air conditioning (437)	Klaerner: kinetic energy (446)	
11:00	Nordborg: high-speed train (396)	Witew: spatial fluct. (403)	Zotter: ambisonic decoders (412)	Janssen: non-linear ampl. (420)	Hofmann: extreme reverb. (429)	Stache: beam model (437)	Mohamady: multi-struc. sys. (446)	
11:20	Ebner: infrasound (396)	Iannace: ear of Dionysius (404)	Schultz: IIR-pre-filters (413)	Sisto: nonlinear amplifier (421)	Omologo: voice interaction (429)	Lohmann: scattering in TPA (438)	Stahl: fuselage structure (447)	
11:40	Kling: airborne ultrasound (397)	Farcas: performance room (404)	Wierstorf: localization (413)	Dalhoff: pulsed DPOAE (421)	Fischer: EML platform (430)	Philippen: measured forces (438)	Sayer: velocity orders (447)	

Thursday, 21 March 2013 (continued)

	Kurhaus					Puccini	Terme
	meeting room 1	meeting room 2	conference room	Czerny hall	Lentner hall	Theatre	room 1
	Active systems	**Absorbing materials**	**Transport noise**	**Sound-scaping**	**Environm. noise**	**Protection at home**	**Thermo-acoustics**
15:00	Bruhnken: in-ear headphones (337)	Vivolo: absorber char. (346)	Peschel: Tempo 30 (354)	Gallo: historical centers (362)	Khutter: Vienna planning (371)	Kurz: timber construction (380)	Fernandes: impinging flames (389)
15:20	Behn: ANC headpones (338)	Meister: impedance tubes (346)	Chudalla: diffrac. mitigation (355)	Nencini: training school (363)	Salz: Berlin action plans (372)	Pavarin: building elements (381)	Luzzato: limit cycle satur. (390)
15:40	Priese: psychoa-coustics (338)	Dragonetti: surface impedance (347)	Johannsen: airport surcharges (355)	Drechsler: educational action (363)	Richard: action plans (372)	Sass: pedestrian doors (381)	Di Vita: premix burner (390)
16:00	Simanowski: ship engine (339)	Zolanvari: granular materials (347)	Vogelsang: aircraft noise (356)	Lavia: body language (364)	Schlachter: road noise abatem. (373)	Bay: inlets-outlets (382)	Heckl: matrix burner (391)
16:20	Foht: large system (339)	Horoshen-kov: plants absorption (348)	Petz: air transport noise (356)	Witchel: body language (364)	Conter: noise red. devices (373)	Bianucci: waste water (382)	Hoeij-makers: feedback (391)
16:40	Pondrom: eVADER alert (340)	Pompoli: honeycomb panels (348)	Dreitler: Vienna subway (357)	Elliott: pleasantn. rating (365)	Krukle: ma-nagement models (374)	Desar-naulds: hammer (383)	Dar Ramdane: CFD valid. (392)
				A-weight.			
17:00	Jiricek: double-layer panel (340)	Adelman-Larsen: on/off (349)	Schady: Middle Rhine (357)	Hohmann: A-weighting (365)	Klaeboe: economic analyses (374)	Ruff: install. walls (383)	Baccoli: piezo system onset (392)
17:20	Kleinhen-rich: small rooms (341)			Grigo: addition rules (366)	Kärst: low-noise asphalt (375)	Rabold: multi-storey build. (384)	

18:00: **Closing ceremony and farewell reception** (Kurhaus, Kursaal)

	Terme		Civic Rooms		Cultural Centre			Urania
	room 2	room 3	Civic room	Exhibition room	Movie theatre	Music room	Exhibition room	Alton
	Acoustic measur. 2	**Room acoust. 2**	**Virtual acoust. 3**	**Otoacou. emiss.**	**Speech process.**	**Flow acoustics**	**Noise control**	**Offshore struct.**
15:00	Wittstock: unit watt (397)	De Ruiter: outdoors-indoors (405)	Völk: ventriloquism (414)	Mauermann: distortion (422)	Warzybok: semantic ability (430)	Müller: car model (439)	You: tail rotor (448)	Luebben: underw. soundscape (454)
15:20	Sacchi: p-v microprobes (398)	Iannotti: classr. comfort (405)	Farina: tour of Parma (414)	Fedtke: ear canal probes (422)	Kangatharan: vowel space (431)	Geyer: propeller test (439)	Fastl: helicopter sound (448)	Lippert: pile driving noise (455)
15:40	Sieland: meas. system (398)	Hennings: primary school (406)	Cubick: hearing aid test (415)	Gummer: vibration DPOAEs (423)	Kasess: nasals (431)	Zanon: zonal LES 1 (440)	Businger: aerodynamic load (449)	Schwarz: pile driving offshore (455)
16:00	Virnich: wired measurement (399)	Baumann: Hotel Toblach (406)	Goossens: office planning (415)	Epp: cochlear psychoac. (423)	Schubotz: vowel ident. (432)	McKinlay: refrigerator fan (440)	Gabriel: side mirror (449)	Gerdes: offshore farms (456)
16:20	Fischer: audio apps. (399)	Morandi: theatre stages (407)	Madsen: telepresence (416)	Drexl: bounce phenom. (424)	Tschöpe: meas. devices (432)	Zayani: skewed fans (441)	Schimmelpfennig: body gaps (450)	Gerke: NMS part 1 (456)
16:40		Schröder: office rooms (407)	Hess: face tracking (416)	Tognola: bispectral approach (424)	Schalk-Schupp: formats (433)	Heinze: cylinder-plate (441)	Münsterjohann: convection (450)	Bellmann: NMS part 2 (457)
17:00		Lorenz-K.: course design (408)		Moleti: otoac. response (425)	Heeren: dynamic cues (433)	Reichenberger: flap side edge (442)	Scheit: ventilation noise (451)	Bellmann: NMS part 3 (457)
17:20		Vallejo: Cremer in Spain (408)		Van Hengel: comparison (425)		Witthaus: engine compressors (442)	Horn: spatial measurem. (451)	Elmer: hydro dampers (458)

Benvenuto dei Presidenti della Conferenza

Cari colleghi,

Vi invitiamo a Merano, una delle cittadine più belle del Sud Tirolo, da metà ottocento sede di villeggiatura termale apprezzata in tutta Europa. La sua lunga tradizione turistica e la sua storia millenaria Italiana/Tedesca/Austriaca rendono questa cittadina un ideale luogo di incontro per le popolazioni di lingua tedesca e italiana.

Non poteva quindi celebrarsi in un posto maggiormente adeguato una Conferenza come la nostra che mira a rendere proficua l'interazione tra acustici tedeschi, austriaci, svizzeri da un lato e italiani dall'altro. Questi aspetti sono stati pienamente colti dagli Enti Pubblici dell'Alto Adige, che hanno fornito da subito sostegno e collaborazione. A loro va il nostro sincero ringraziamento.

Come è noto, la Conferenza fa parte di una serie di eventi periodici promossi dalla Deutsche Gesellschaft für Akustik (DEGA) per favorire la cooperazione e i rapporti con i Paesi limitrofi. Nel 1990 la Conferenza si è svolta in Austria, nel 1998 in Svizzera, nel 2004 in Francia e nel 2009 in Olanda. Quest'anno è la volta dell'Italia!

La Conferenza costituisce il 39° Congresso annuale della DEGA e il 40° Convegno annuale dell'Associazione Italiana di Acustica (AIA). Per coinvolgere gli acustici, in particolare dei Paesi limitrofi, essa è stata riconosciuta come evento Euroregio dalla European Acoustics Association (EAA). La Conferenza si avvale non solo della collaborazione della Österreichische Gesellschaft für Akustik (AAA), della Schweizerische Gesellschaft für Akustik (SGA-SSA) e dell'Agenzia Provinciale per l'Ambiente di Bolzano, ma anche, come è consuetudine, dei seguenti enti: DPG, ITG, VDE, NALS, DIN e VDI.

Come si è detto alla Conferenza parteciperanno acustici di lingua tedesca e italiana, ma molte sono le adesioni che sono pervenute da altri Paesi, non solo europei: complessivamente attendiamo circa 1000 persone. La Conferenza costituirà quindi una vera e propria manifestazione internazionale, che contribuirà, ci auguriamo, al progresso dell'acustica in ambito scientifico e tecnico, sviluppando la cooperazione tra colleghi provenienti da tutto il mondo.

La Conferenza si svolgerà presso il Kurhaus, magnifico edificio in stile *liberty* nel centro storico di Merano, affacciato sulla Passeggiata lungo il Passirio. In questa sede ci attendono una sala per le sessioni plenarie (Kursaal), 5 sale per sessioni in parallelo, nonché ampi spazi per gli spazi espositivi e per il coffee break; quest'ultimo sarà continuato per consentire la presentazione del maggior numero di comunicazioni orali.

Altre cinque sedi saranno utilizzate per le sessioni in parallelo, tutte a pochi minuti a piedi, da un lato o dall'altro del fiume Passirio: il Teatro Puccini anch'esso in stile *liberty*, l'albergo Therme, il Centro della Cultura di via

Cavour, la Sala Civica di via Huber e l'Università Popolare Urania di via Ortwein.

La Conferenza si svolgerà in tre giornate, da martedì 19 a giovedì 21 marzo 2013. L'elevato numero di abstract accettati (786) sarà suddiviso in 662 presentazioni orali da tenersi in 15 sessioni parallele e 124 poster da discutere in 2 sessioni giornaliere. Sono previste 6 importanti *keynotes* che saranno tenute da 4 colleghi tedeschi e da 2 italiani.

Come sempre le tematiche delle sessioni verteranno non solo su argomenti classici, ma anche su temi particolarmente attuali. La Conferenza coniugherà così interessi di carattere generale e particolare, ricerca e tecnologia, assicurando ai partecipanti la massima fruizione.

Gli spazi espositivi per le aziende saranno oltre 35, tutti al Kurhaus: i partecipanti alla Conferenza avranno quindi la possibilità di conoscere le novità nel campo degli strumenti, dei materiali e dei software. Per le aziende impegnate in acustica e per quelle locali sono previste varie forme di sponsorizzazione della Conferenza, che renderanno più ricca la manifestazione.

Prima della Conferenza, lunedì 18 marzo pomeriggio, si terranno il Precolloquium organizzato dalla DEGA al Teatro Puccini (*Computation, simulation and modelling in Acoustics*) e il workshop organizzato dall'AIA al Kursaal (*Acustica e ambienti scolastici*). Venerdì 22 marzo mattina si terrà il secondo workshop AIA sempre al Kursaal (*La qualità globale in edilizia: ambiente, energia, acustica*). Da evidenziare che i due workshop AIA saranno principalmente rivolti ai tecnici, agli uffici pubblici e alle imprese dell'Alto Adige, che le tematiche sono state individuate insieme agli Enti Locali e che i relatori parleranno nella loro lingua madre, in tedesco o in italiano, con traduzione simultanea. Si è voluto in questo modo rendere ancora più concreta e manifesta l'interazione tra la Conferenza e il territorio che la ospita.

Nei giorni precedenti la Conferenza, l'European Acoustics Association (EAA) organizzerà presso il Kurhaus una *Winter School* rivolta a giovani studenti e ricercatori: un corso di base (*Approaching Acoustics*) da venerdì 15 a domenica 17 marzo e cinque corsi specialistici (*Hot Topics in Acoustics*) da sabato 16 a domenica 17 marzo. Complessivamente sono attesi oltre 200 giovani.

Immediatamente prima e dopo la Conferenza sono previsti altri eventi, come ad esempio incontri e seminari organizzati da alcune *COST Actions*, l'Assemblea generale e le riunioni del *Board* e del *Technical Committee* della EAA, dell'AIA e della DEGA.

La sera di martedì 19 marzo attendiamo tutti i partecipanti al Kursaal dove è previsto un buffet caldo, birra alla spina, musica dal vivo e tanto altro. Il Kursaal contribuirà così a determinare un *melting pot*, amalgamando insieme culture differenti, cementando vecchie amicizie e creandone di nuove.

La cena sociale sarà tenuta la sera di mercoledì 20 marzo. Altri eventi saranno organizzati dall'Azienda di Soggiorno di Merano, che ringraziamo per la collaborazione fornita in tutta la fase preparatoria dell'evento.

Non vanno infine dimenticate le famose Terme, proprio davanti al Kurhaus, dove molti di Voi potranno ritemprarsi a termine delle giornate dedicate alla nostra disciplina.

Tutti noi dell'intero staff organizzativo della Conferenza AIA-DAGA / Euroregio 2013 abbiamo fatto del nostro meglio per assicurarVi il più proficuo e piacevole soggiorno, ma ricade su di Voi, cari colleghi, sui Vostri contributi scientifici e sulla Vostra cordiale partecipazione, il merito dell'indubbio successo che si profila per la *nostra* Conferenza di Merano.

Ciao. Ci vediamo tutti nell'incantevole città di Merano!

Alessandro Peretti e Joachim Scheuren
(Conference Chairs)

Grußwort der Tagungsleiter

Liebe Kolleginnen und Kollegen,

Wir heißen Sie überaus herzlich in Meran willkommen, einem der schönsten Orte Südtirols, der seit der Mitte des 19. Jahrhunderts in Europa berühmt ist und wegen seiner Bäder auch sehr geschätzt wurde. Seine tausendjährig wechselvolle italienisch/deutsch/österreichische Geschichte wie auch seine große touristische Tradition und seine offizielle Zweisprachigkeit machen Meran zu einem idealen Treffpunkt italienisch und deutsch sprechender Personen und Einrichtungen. Es war daher fast zwingend, die Lage und den Charakter von Meran zu nutzen, um mit der Gemeinschaftstagung AIA-DAGA 2013 die Beziehungen zwischen den "ortsnahen" italienischen, deutschen, österreichischen und schweizerischen Akustikern zu fördern und zu vertiefen. Erfreulicherweise haben sich einige öffentliche Einrichtungen Südtirols diesem Ziel angeschlossen und unsere Tagung von Anfang an tatkräftig unterstützt. Hiefür sind wir zutiefst dankbar.

Dies ist nun die fünfte Gemeinschaftstagung, mit der die Deutsche Gesellschaft für Akustik, DEGA, die Zusammenarbeit und den Austausch mit benachbarten akustischen Gesellschaften fördern will. Nach Österreich 1990, der Schweiz 1998, Frankreich 2004 und den Niederlanden 2009 ist nun die Reihe an Italien!

Es war naheliegend, bei der gemeinsamen Ausrichtung der 40. Jahrestagung der Italienischen Gesellschaft für Akustik, AIA, und der 39. Jahrestagung der DEGA auch die Akustiker anderer, insbesondere der umliegenden Länder mit einzubeziehen. Neben der unmittelbaren Unterstützung durch die akustischen Gesellschaften Österreichs (AAA) und der Schweiz (SGA) wird dies vor allem durch die Aufwertung zu einer Euroregio-Konferenz der Europäischen Akustischen Vereinigung, EAA, zum Ausdruck gebracht. Ihnen allen, aber auch der Umweltbehörde der Provinz Bozen sowie den deutschen Mitträgergesellschaften DPG, ITG im VDE und NALS im DIN/VDI, sei für ihre Unterstützung an dieser Stelle sehr herzlich gedankt.

Die Teilnehmerzahl übersteigt den Kreis der Deutsch und Italienisch sprechenden Akustiker, da viele Kollegen aus anderen, auch außereuropäischen Ländern ihre Teilnahme angekündigt haben, sodass wir insgesamt etwa 1000 Teilnehmer erwarten. Damit wird die Tagung zu einem internationalen Ereignis, das mit dem Ausbau der Zusammenarbeit zwischen Kollegen aus allen Teilen der Welt auch zur Fortentwicklung unserer Disziplin, der Akustik, beitragen wird.

Die Konferenz findet im Kurhaus statt, einem stattlichen Jugendstilgebäude am Ufer der Passer im historischen Zentrum von Meran. Dieses Gebäude besitzt einen prachtvollen Kursaal für Plenarveranstaltungen, 5 weitere

Räume für Parallelveranstaltungen sowie große Flächen für die Ausstellung und den durchgehenden Ausschank von Kaffee. Weitere fünf Gebäude, die alle in unmittelbarer Nähe des Kurhauses an beiden Ufern der Passer liegen, bieten Platz für die restlichen Parallelsitzungen: das ebenfalls im Jugendstil errichtete Puccini Theater, das Hotel Terme, das Kulturzentrum in der Cavourstraße, der Bürgersaal in der Huberstraße und die Urania in der Ortweinstraße.

Die Tagung, die von Dienstag, den 19. bis Donnerstag, den 21. März drei ganze Tage dauert, umfasst sechs Plenarvorträge sowie 786 angemeldete Beiträge (662 mündliche Vorträge in 15 Parallelsitzungen und 124 Poster in 2 täglichen Sitzungen).

Mit der inhaltlichen Behandlung vieler klassischer und aktueller Themen werden die Sitzungen den unterschiedlichen Interessen und Ansprüchen grundlegender und angewandter Forschung wie auch der technologischen Umsetzung und praktischen Anwendung entsprechen und somit zu einem umfassenden Informationsaustausch zwischen den verschiedenen Disziplinen der Akustik beitragen. Die Fachausstellung im Kurhaus umfasst mehr als 35 Stände und zeigt die neuesten Entwicklungen bei akustischen Geräten, Materialien, Verfahren und Softwareprodukten auf. Daneben wurden akustischen und lokalen Firmen und Einrichtungen verschiedene Sponsormodelle angeboten, um das Informationsangebot der Tagung zu erweitern.

Unmittelbar vor der eigentlichen Tagung finden am Montag, den 18. März, nachmittags im Puccini Theater ein von der DEGA organisiertes Vorkolloquium (*Computation, simulation and modelling in Acoustics*) und im Kursaal ein von der AIA organisierter Workshop (*Classroom Acoustics*) statt. Ein weiterer von der AIA organisierter Workshop wird sich nach der Tagung am Freitag, den 22. März vormittags im Kursaal mit der Qualität von Gebäuden beschäftigen (*Global quality in buildings: environment, energy, acoustics*). Beide AIA Workshops, deren Themen mit örtlichen Einrichtungen gemeinsam festgelegt wurden, richten sich in deutscher oder italienischer Sprache (mit simultaner Übersetzung) insbesondere an lokale Teilnehmer (technisch Interessierte, öffentliche Einrichtungen und Firmen) aus Südtirol. Auf diese Weise haben wir versucht, eine enge Verbindung zwischen der Tagung und ihrem gastgebenden Umfeld herzustellen.

An weiteren Vortagen, von Freitag, den 15. bis Sonntag, den 17. März, wird im Kursaal eine von der EAA organisierte Winter School jungen Studenten und Forschern einen Grundlagenkurs (*Approaching Acoustics*) und fünf parallele Spezialkurse (*Hot Topics in Acoustics*) anbieten, zu denen insgesamt 200 Teilnehmer erwartet werden. Daneben runden viele weitere Veranstaltungen, etwa zusätzliche Sitzungen und Seminare im Rahmen von COST Aktionen, Mitgliederversammlungen, Vorstands- Beirats- und Fachausschusssitzungen von EAA, AIA und DEGA das umfangreiche Tagungsprogramm ab.

Am Dienstag, den 19. März abends erwarten wir alle Tagungsteilnehmer im Kursaal zu einem gemeinsamen geselligen Abend mit warmem Buffet, Live Musik und einigem mehr. Hier treffen, wie in einem Schmelztiegel, Menschen unterschiedlicher Herkunft aufeinander, um alte Beziehungen und Freundschaften zu vertiefen oder neue aufzubauen. Ein Tagungsdinner am Mittwoch, den 20.März, bietet weitere Kontaktmöglichkeiten. Darüber hinaus wird die Kurverwaltung Meran, bei der wir uns an dieser Stelle ganz herzlich für Ihre tatkräftige Unterstützung seit den frühesten Planungstagen bedanken möchten, weitere Veranstaltungen organisieren und anbieten. Schließlich sollten Sie die berühmte Meraner Therme direkt gegenüber dem Kurhaus am anderen Ufer der Passer nicht vergessen, wo Sie nach einem geschäftigen Konferenztag ausruhen und entspannen können.

Wir alle, das vollständige Organisationsteam der AIA-DAGA/Euroregio 2013, haben unser Bestes getan, um Ihnen einen möglichst angenehmen und fruchtbaren Aufenthalt in Meran zu ermöglichen. Nun liegt es auch an Ihnen, liebe Kolleginnen und Kollegen, mit Ihrer aktiven, freundlichen Teilnahme und mit Ihren Beiträgen die Tagungsplattform zu nutzen und zu gestalten und so zu einer unvergesslichen Zeit in der wunderbaren italienisch/deutsch/österreichisch geprägten Stadt Meran zu machen.

Ciao und auf Wiedersehen in Meran

Alessandro Peretti und Joachim Scheuren
(Conference Chairs)

Welcome address of the conference chairs

Dear colleagues,

We warmly welcome you to Merano, one of the most beautiful towns in South Tyrol which, since mid of 19th century, is well known and appreciated all over *Europe* for its baths. Its millennial Italian/German/Austrian history, its long tourist tradition and its bilingualism make this town an ideal meeting venue for people speaking German and Italian. Thus, no any other most appropriate place could host the AIA-DAGA 2013 Conference which would strengthen and improve the cooperation among German, Austrian, Swiss and Italian acousticians. This objective has been shared with the South Tyrol public Institutions too, which have supported and sponsored the Conference since its early stage of organization. We are deeply grateful for their valuable cooperation.

As known, the Conference is the fifth in the series promoted by the Deutsche Gesellschaft für Akustik (DEGA) to encourage cooperation and exchange with its neighbouring countries. The first Conference was held in 1990 in Austria, followed by Switzerland in 1998, France in 2004 and Netherlands in 2009: in 2013 it is the turn of Italy!

To additionally address acousticians from other, in particular neighbouring countries, the Conference, including the 39th annual congress of DEGA and the 40th annual congress of the Associazione Italiana di Acustica (AIA), has been acknowledged as Euroregio event by the European Acoustics Association (EAA). Apart from the immediate cooperation of Österreichische Gesellschaft für Akustik (AAA), Schweizerische Gesellschaft für Akustik (SGA-SSA) and Provincial Agency for Environment of Bolzano, the traditional co-sponsorship of DPG, ITG of VDE, and NALS within DIN and VDI was greatly appreciated.

The participation to the Conference includes more than acousticians of German and Italian language as many from other countries, not only European, have been registered: about one thousand participants are expected. Thus, the Conference will be an international event which, hopefully, will contribute to the growth of acoustics by strengthening the cooperation among colleagues from all over the world.

The Conference venue is the Kurhaus, a beautiful *liberty*building in the historical center of Merano, facing the Passirio riverside. This building has a large room for plenary lectures (Kursaal), 5 rooms for parallel sessions, large spaces for exhibition and coffee break, the latter served continuously to save time for the numerous oral presentations. Other five buildings will host the parallel sessions, all at few minute walking distance from Kurhaus on both sides of Passirio river: the Puccini theatre, in *liberty* style too, the Terme hotel, the Cultural Center in Cavour street, the Civic Room in Huber street and the Urania Center in Ortwein street.

The Conference will run from Tuesday 19 to Thursday 21 March 2013. The very high number of abstracts accepted (786) will be divided into 662

oral presentations in 15 parallel sessions and 124 posters shown in 2 daily sessions. Six plenary keynotes by 4 German and 2 Italian lecturers are scheduled too.

As practice, the sessions will deal with classical and topical subjects, combining different interests, basic and applied research, technological implementation and practical application in order to offer a broad range of information covering several disciplines of acoustics. The technical exhibition includes more than 35 booths, all hosted at Kurhaus and it will show the latest news and developments in acoustic instrumentation, materials, software products and so on. Various modalities of sponsoring were available for acoustic and local companies in order to enrich the Conference offer.

Before the Conference, Monday 18th March afternoon, the Precolloquium organized by DEGA at Puccini theatre (*Computation, Simulation and modelling in Acoustics*) and the workshop organized by AIA at Kursaal (*Classroom Acoustics*) are scheduled. Friday 22nd March morning a further workshop organized by AIA (*Global quality in buildings: environment, energy, acoustics*) will be held at Kursaal. The two AIA workshops are mainly oriented to local audience (South Tyrol technicians, public institutions and companies) as the topics have been chosen in agreement with the local Institutions and the lecturers will speak in their mother tongue, German or Italian, and simultaneous translation will be provided. We thus wanted to strengthen the link between the Conference and the hosting territory.

In the days before the Conference, the European Acoustics Association (EAA) will organize at Kurhaus a Winter School for young students and researchers, including a basic course (*Approaching Acoustics*) from Friday 15 to Sunday 17 March and five specialized courses (*Hot Topics in Acoustics*) run in parallel from Saturday 16 to Sunday 17 March. An audience of about 200 participants is expected. Many other events are scheduled immediately before and after the Conference, such as meetings and seminars organized by some *COST Actions*, General Assembly, Board and Technical Committee meetings of EAA, AIA nad DEGA.

Tuesday 19 March evening we expect to meet all the participants at Kursaal to enjoy a joint social night with hot buffet, live music and more. This event will offer a *melting pot* where different cultures will join, old friendships will strenghten and new ones will be created. The Conference dinner is scheduled on Wednesday 20 March. Other events will be organized by the Meran Tourist Office: we are grateful for its cooperation since the early stage of Conference organization. Finally, do not forget the famous Terme, just in front of Kurhaus on the opposite Passirio riverside, where many of you could relax after the very busy days of the Conference.

We all, the full Conference organization staff of AIA-DAGA/Euroregio 2013, did our very best to set up the conditions for your most comfortable and fruitful stay in Merano, but, dear colleagues, the expected success of *our* Conference in Merano is mainly due to your scientific contributions and your active and warm participation. Use and further develop this

platform and thus make it an unforgettable stay in the wonderful, Italian/German/Austrian inspired city of Merano!

Ciao and see you in Merano

Alessandro Peretti and Joachim Scheuren
(Conference Chairs)

General information

AIA-DAGA 2013 Conference on Acoustics
EAA Euroregio, 18-21 March 2013

including:
- 40th Italian Annual Conference on Acoustics (AIA)
- 39th German Annual Conference on Acoustics (DAGA)
- EAA Winter School

organized by:
- Acoustical Society of Italy (AIA)
- German Acoustical Society (DEGA)

in cooperation with:
- European Acoustics Association (EAA)
- Austrian Acoustics Association (AAA)
- Swiss Acoustical Society (SGA-SSA)

and the support of:
- German Physical Society (DPG)
- Information Technology Society (ITG in VDE)
- German Standards Committee NALS in DIN and VDI
- Environmental Protection Agency - Autonomous Province of Bozen/Bolzano Südtirol

Conference venue
Merano is a beautiful small town located in the heart of Southern Tirol / Südtirol, close to the Dolomites. The main Conference venue is Merano's Kurhaus, a magnificent building in Jugendstil, which equally impresses artists, musicians, scientists and congress participants.

Address:
Kurhaus Congress Center Merano
Corso Libertà 31
I-39012 Merano, Italy

Telephone and Fax during the conference:
Telephone number registration desk: +39 3457082038
Fax number registration desk
(to be used only if strictly necessary): +39 0473 27 01 99

Conference chairs
- Alessandro Peretti (AIA)
- Joachim Scheuren (DEGA)

Technical program chairs
- Giovanni Brambilla (AIA)
- Wolfgang Kropp (DEGA)

Technical program committee
- Eleonora Carletti (AIA)

- Sabine Langer (DEGA)
- Gaetano Licitra (AIA)
- Luigi Maffei (AIA)
- Martin Ochmann (DEGA)

Advice and support
- Peter Svensson (EAA)
- Hervé Lissek (SGA-SSA)
- Gregor Widholm (AAA)

General secretary
- Eleonora Carletti (AIA)
- Martin Klemenz (DEGA)

Treasurer and Exhibition manager
- Francesca Pedrielli (AIA)

EAA Winter School
- Luigi Maffei (AIA)
- Michael Vorländer (DEGA)
- Kristian Jambrošic (EAA)

Local organizing committee
- Antonino Di Bella
- Fabrizio Oliver
- Georg Pichler
- Flavio Ruffini
- Alessandro Schiavi
- Diego Tartarotti
- Luca Verdi

Conference secretariat
Segreteria AIA
c/o IMAMOTER-CNR
Via Canal Bianco, 28
44124 FERRARA (ITALY)
e-mail: info2013@aia-daga.eu

Languages
It is highly recommended that papers are presented in English in order to reach as much of the audience as possible. However presentations in German and Italian are also allowed. In order to facilitate understanding by all participants the presentation slides should be in English.

Workshops and pre-colloquium
Two workshops (with simultaneous translation Italian/German) and a pre-colloquium (in English) are scheduled immediately before and after the Conference and are free of charge for interested persons. Please note that the workshops require a registration, see the website for further details http://www.aia-daga.eu (-> workshops and precolloquium):

- Workshop **"Classroom acoustics"** (Monday, March 18), see page 56
- Pre-colloquium **"Computation, Simulation and Modelling in Acoustics"** (Monday, March 18), see page 61
- Workshop **"The overall quality in buildings: environment, energy, acoustics"** (Friday, March 22), see page 66

Conference opening
The opening of the conference starts on Tuesday, March 19, at 9:00 in the Kursaal and will involve welcome addresses and music. Subsequently, awards of AIA and DEGA will be presented - please find detailed information on on pages 42. After a coffee break, the first plenary lecture and a product forum will be presented in the Kursaal.

Plenary lectures
Invited lectures will focus on hot topics of general interest:

- *Acoustics of Historical Opera Houses in Italy: Past, Present, and Future*
  Nicola Prodi, Engineering Department, Ferrara University (p. 53)
- *The Secret Life of Bubbles in a Sound Field*
  Werner Lauterborn, 3rd Institute of Physics, Göttingen University (p. 53)
- *On the Use of Scientific Tools in Today's Violin Making*
  Martin Schleske, Master Studio for Violinmaking, Stockdorf (p. 54)
- *Speed of Sound in Fluids*
  Roberto Gavioso, Istituto Nazionale di Ricerca Metrologica (INRIM), Torino (p. 54)
- *Low-Frequency Sound - a Special Sound*
  Detlef Krahé, Bergische Universität Wuppertal (p. 55)
- *Trends in Binaural Technology*
  Janina Fels, Institute of Technical Acoustics, RWTH Aachen University (p. 55)

Structured sessions
The following structured sessions are composed of initiated contributions and have been organised by experts:

- 50 years of A-weighting, where from, where to?
  (Claudio Guglielmone, Beat Hohmann), p. 365
- Acoustic urban planning (Sergio Luzzi, Henk Wolfert), p. 177
- Advanced measurement techniques: Operational TPA, force identification (Claudio Guglielmone), p. 436
- Advances in sound absorbing materials (Francesco Pompoli), p. 344
- Application of ultrasound in medicine
  (Renato Spagnolo, Volker Wilkens), p. 230
- Applications of psychoacoustics (Hugo Fastl, Francesca Pedrielli), p. 332

- Auditory and multimodal scene analysis (Ercan Altinsoy, Federico Fontana, Bernhard Seeber), p. 274
- Auralisation of environmental noise (Jens Forssén, Kurt Heutschi, Massimiliano Masullo), p. 123
- Computational aero-acoustics in industrial applications (Michele De Gennaro, Michael Grünewald, Manfred Kaltenbacher), p. 293
- Demands on room acoustic criteria (Simone Secchi, Uwe Stephenson), p. 252
- Digital signal processing in audiology (Norbert Dillier, Rainer Martin), p. 271
- Environmental noise: END and legislation (p. 205) / noise from sources (p. 209) / noise mapping (p. 366) / action planning (p. 371) (Thomas Beckenbauer, Michael Jäcker-Cüppers, Bernd Lehming, Gaetano Licitra)
- Experience with the ISO 10052 (Antonino Di Bella, Alfred Schmitz), p. 379
- History of acoustics (Adriano Alippi, Rüdiger Hoffmann), p. 241
- Hydroacoustics: Source identification, sound propagation, and communication (Jan Abshagen, Elena Ciappi, Ingo Schäfer), p. 289
- In vivo acoustic measurements in musicians and music instruments (Wilfried Kausel, Malte Kob, Lamberto Tronchin), p. 251
- Intake and exhaust noise (Eugène Nijman), p. 278
- Listening and understanding speech in rooms (Arianna Astolfi, Torsten Dau, Bernhard Seeber), p. 103 and 239
- Machinery noise (Joachim Bös, Eleonora Carletti), p. 300
- Micro loudspeaker: Characterization, simulation and measurement (Gottfried Behler), p. 132
- Microphone arrays for aeroacoustics (Paolo Castellini, Ennes Sarradj, Carsten Spehr), p. 434
- Modelling outdoor sound propagation (Dietrich Heimann, Maarten Hornikx), p. 85
- Models of the hearing system and psychoacoustic quantities (Roland Sottek), p. 269
- Music acoustics (Malte Kob, Robert Mores, Lamberto Tronchin), p. 107 and 249
- Noise and vibration at the working place (Pietro Nataletti, Reimer Paulsen), p. 138 and 297
- Noise control for machinery and domestic environment (Reinhard Lerch), p. 448
- Noise protection at home (Patrizio Fausti, Roland Kurz), p. 380
- Numerical acoustics 1+2 (Sergio de Rosa, Steffen Marburg), p. 144 and 309
- Numerical simulation in vehicle acoustics (Wolfgang Foken, Giuseppe Miccoli, Daniela Siano), p. 282
- Otoacoustic emissions and cochlear modeling (Birger Kollmeier, Arturo Moleti, Manfred Mauermann), p. 419
- Rail/wheel noise (Stefan Lutzenberger, Marco Masoero), p. 80 and 184
- Recent advances on sound and vibration active control (Joachim Bös, Paolo Gardonio), p. 235 and 384

- Robust speech recognition (Martin Heckmann, Dorothea Kolossa, Maurizio Omologo), p. 426
- Sandwich materials (Anders Nilsson, Edoardo Piana), p. 341
- Soundscaping: understanding and exchanging (p. 193) / collecting and documenting (p. 200) / harmonising (p. 202) / creating and designing (p. 358) / outreaching and training (p. 362) (Jian Kang, Brigitte Schulte-Fortkamp, Luigi Maffei)
- Speech quality perception and assessment (Sebastian Möller, Alexander Raake), p. 71
- Thermoacoustics (Maria Heckl), p. 387
- Tyre/road noise (Thomas Beckenbauer, Wolfgang Kropp), p. 187 and 349
- Uncertainties in the evaluation of environmental noise (Massimo Garai, Christian Kirisits), p. 76
- Underwater noise due to construction and operation of offshore structures (Tanja Grießmann, Stephan Lippert), p. 454
- Virtual acoustics (Angelo Farina, Filippo Fazi, Sascha Spors, Franz Zotter), p. 113, 261 and 409
- Wind turbine noise (Stefan Becker, Domenico Borello, Gianni Cesini), p. 89

EAA Winter School
A ”Winter School” for young acousticians is organized and sponsored by EAA during the days before the Conference (from 15 to 17 March). The Winter School will be held at the Kurhaus, AIA and DEGA will cosponsor the event. Included is also a sponsored social program with get-togethers, evening events and a lot of opportunities of ”student meets expert”. Please find the detailed program on page 46.

Oral presentations
All oral presentations are scheduled as follows:

- **15 minutes lecture**
- **3 minutes discussion**
- **2 minutes break** (possibility to change rooms)

This schedule should be strictly observed. It is not possible to exceed 15 minutes for a presentation.

In each room, a laptop, a beamer, and an audio loudspeaker are available. The laptops are equipped with actual Windows, MS-Office and Acrobat Reader. Please store your presentation on a CD-ROM or a USB flash drive, bring it to the conference and make sure to transfer it to the laptop of your technical room well before your session starts. It is not allowed to use personal laptop computers for presentations. Please perform a virus check on your data storage device. For power point presentations, we recommend to create an additional file, which is system-independent. Please choose ”pack and go” in the file menu. Since we don’t assure the compatibility of your presentation with the installed power point version, a preview corner will be available to check your slides during the conference.

Posters
Posters will be divided in two distinct groups, the first displayed on Tuesday and the second on Wednesday. The poster authors will be present during their poster session (both sessions are scheduled on Tuesday and Wednesday between 14:00 h and 14:40 h) and will be prepared for discussions and clarifications.

Posters will be mounted on full boards with sizes of 1,80 m height and 1 m wide. The recommended poster size is A0 (1,19 m height and 0,84 m wide). The material necessary to fix posters on the boards will be provided by the conference organizers.

Late posters
The deadline for submitting oral presentations was 1 November 2012. Nevertheless, ”late posters” are still accepted until February 28, unless the maximum number of possible posters is reached before. The manuscripts of these late posters will be also included in the conference proceedings.

Preparation of manuscripts
The manuscripts shall be submitted online via

http://www.aia-daga.eu (-> authors)

latest March 29, 2013. They can be submitted as PDF or Word file.
The page format and the appearance (fonts, tables etc.) shall be uniform: Manuscripts shall be formatted as a two-column style document, and they can have a length of two, three, or four pages. Authors shall use the Word or LaTeX templates on

http://www.aia-daga.eu (-> authors).

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Diamond sponsor (local)

- Brauerei FORST AG / Birra FORST SpA, Italy

Sapphire sponsors (local)

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- studio ergon, Italy

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- Rehau SpA, Italy

Bronze sponsors

- BSW Berleburger Schaumstoffwerk GmbH, Germany
- dBWaves, Germany
- HEAD acoustics GmbH, Germany
- ODEON A/S, Denmark

Technical exhibition

Besides the scientific conference, there will also be an exhibition offering a forum for contacts and exchange between theory and practice. The exhibition enables companies to present their products and services.

The exhibition is open from March 19 to March 21. The exhibition spaces are all placed inside the Kurhaus (Conference venue) in strategic positions. Interested companies can register via

http://www.aia-daga.eu (-> exhibition)

For information on participation, please email to:
exhibition2013@aia-daga.eu.

Until December 31, 2012, the following companies have already registered at the exhibition:

- AAC Electronics GmbH, Germany
- Accon Italia srl, Italy
- Acoustics Engineering, The Netherlands
- Aesse Misure srl, Italy
- Braunstein + Berndt GmbH, Germany
- Bruel & Kjaer Italia srl, Italy
- BSW Berleburger Schaumstoffwerk GmbH, Germany
- Celenit S.p.A., Italy
- DataKustik GmbH, Germany
- G.R.A.S. Sound & Vibration A/S, Denmark
- Geberit Marketing e Distribuzione SA - Filiale Italiana, Italy
- GfS - Gesellschaft für Sonder-EDV-Anlagen mbH, Germany
- HEAD acoustics GmbH, Germany
- IAC - Industrial Acoustics Company GmbH, Germany
- Isolgomma srl, Italy
- LCC Consulting AG Software Engineering, Switzerland
- Microflown Technologies, The Netherlands

- Müller-BBM GmbH / Müller-BBM VibroAkustik Systeme GmbH, Germany
- Noisemeters srl, Italy
- Norsonic AS, Norway
- Norsonic-Tippkemper GmbH, Germany
- Novicos GmbH, Germany
- NTi Audio AG, Liechtenstein
- ODEON A/S, Denmark
- PCB Piezotronics srl, Italy
- SINUS Messtechnik GmbH, Germany
- Soundtec GmbH, Germany
- Spectra srl, Italy
- SPEKTRA Schwingungstechnik und Akustik GmbH, Germany
- Stapelfeldt Ingenieur GmbH, Germany
- Sto Italia srl, Italy / Sto AG, Germany
- Svantek Italia, Italy / Svantek Deutschland, Germany / Svantek, Poland
- Vibro-acoustic srl - SCS & Partners, Italy
- Wolf Bavaria GmbH, Germany
- Wölfel Meßsysteme Software GmbH + Co. KG, Germany
- ZINS Ziegler-Instruments GmbH, Germany

Product forum
A product forum has been included in the Programme. It takes place at Kursaal, on Tuesday 19, from 11:45 to 13:00.

AIA and DEGA members general assemblies
On Monday afternoon, March 18, at 18:00 the general assemblies of AIA and DEGA will take place at Kurhaus and Puccini Theatre, respectively.

For AIA, the official invitation and the agenda will be sent by email to all the members.

For DEGA, the official invitation and the agenda will be published in the upcoming ”Sprachrohr” newsletter.

Meetings of technical committees
During the conference, several meetings of technical committees of AIA and DEGA will take place. Please find an overview of rooms and times on page 486. The official invitations to the meetings will be distributed within the societies.

EAA/DEGA student and young professionals meetings
The EAA Young Acousticians Network and the DEGA Young Professionals will hold two joint events for students and young professionals during the AIA-DAGA:

- **Young Acousticians - Icebreaker**: On the first day of the EAA winter school an icebreaker event will take place.

The aim of this meeting is to bring all the participants from the approaching acoustics courses and also the hot topics courses from the winter school together to get to know each other. The Young Acousticians - Icebreaker takes place on Friday, 15th of March, from 18:00-20:00 in the Lentner Hall (Kurhaus Meran).

- **Young Acousticians Meeting**: The Young Acousticians Meeting will take place on the day of the pre-colloquium, Monday, 18th of March, from 18:00-20:00 in the Lentner Hall (Kurhaus Meran). The aim of this meeting is to create an informal ambience for networking and exchange. All students, young acousticians, senior scientists and company representatives are kindly invited.

EAA Best Paper and Presentation Awards

The European Acoustics Association (EAA) will offer six Best Paper and Presentation Awards to young researchers who will present a paper as first author at the Euroregio 2013 conference. These awards are sponsored by the Head Genuit foundation. Each award is worth € 500. The award winners will be selected by a jury nominated by the EAA Board. The selection will be based upon the quality of both the content of the paper and its presentation. The award winners will be announced at the closing ceremony of the conference. For more information see aaa.aia-daga.eu (-> authors).

Evening events and social program

The evening events included in the social program are:

- Buffet dinner at Kursaal, music included, on March 19, 20:00 to 22:00
- Dinner in restaurant (extra fee), on March 20, at Forsterbräu Merano (Corso Libertà, 90)
- Farewell drink, on March 21, at 18:30

Lunch

There are more than enough possibilities near the conference venues to go out for lunch during the lunch break. The Merano Tourist Office suggests the following list of the restaurants located in the central area of Merano:

- Forsterbräu, Corso Libertá 90, +39 0473 23 6535
- Giardino, Passeggiata Lungo Passirio 2, +39 0473 270406
- Sigmund, Corso Libertá 2, +39 0473 237749
- Europa, Corso Libertá 178, +39 0473 232376
- Bistro Terme, Piazza Terme 9, +39 0473 252043
- Gatto Nero, Corso Libertá 12-14, +39 0473 233713
- Fino, Passeggiata Lungo Passirio 38, +39 0473 211800
- Hasen Jos, Portici 204, +39 0473 232599
- Laubenkeller, Portici 118, +39 0473 237706
- Seibstock, Portici 227, +39 0473 237107

An updated list of restaurants/cafeterias, with the indication of the agreed price, will be included in the conference bag.

Conference registration
Preferably, registration should be carried out via the conference website

http://www.aia-daga.eu

Alternatively, you can register via a printed registration form which is added to this program book (see page 487) or can be found on the website. Payment is possible by debit entry (only from Germany), bank transfer (IBAN), or credit card. You can choose the method of payment on the registration sheet.

Any fee includes:
- Abstract and conference proceedings on CD-ROM
- Get together (hot buffet + draft beer + live music) on 19 March
- Workshops organized by AIA and pre-colloquium organized by DEGA

Participation fees

class	member[a]	student	retired[b]	€ early[c]	€ late[d]
1	no	no	no	330,-	390,-
2	yes	no	no	250,-	300,-
3	yes	no	yes	165,-	200,-
4	yes/no	yes	no	65,-	90,-

[a]: Member of AIA, DEGA, DPG, ITG, VDI, VDT, EPA-BZ, and all other EAA societies

[b]: Also valid for unemployed persons. Not valid for non-members (these are cat. 1)

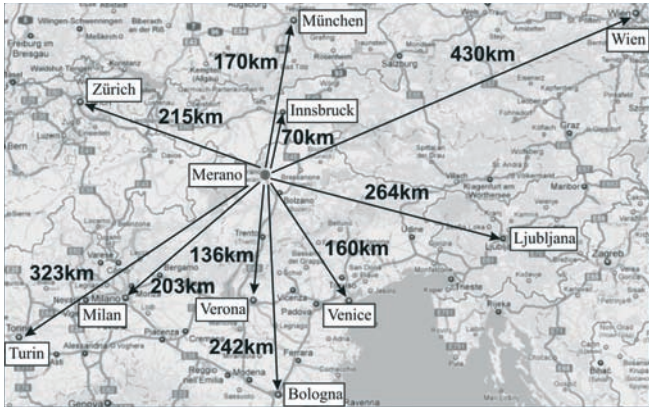
[c]: Fee incl. 21% VAT (Italy) if registered before Jan. 31, 2013

[d]: Fee incl. 21% VAT (Italy) if registered after Feb. 1, 2013

Congress proceedings
The manuscripts of the contributions (oral and poster presentations) will be published as CD-ROM. Every registered participant will obtain this CD-ROM during summer 2013 automatically. Later orders are possible at a rate of € 55 (incl. VAT).

Online conference planner
From February 2013, the conference timetable published on the website http://www.aia-daga.eu (-> program) will include the possibility to compose a personal conference schedule, by taking the session dates into your outlook/ICal calendar. If you klick on a certain lecture, the related link is placed at the bottom of the abstract text.

Transportation



- By car: Merano is 30 km away from Bolzano. Bolzano is along the motorway Munich-Innsbruck-Brenner-Bolzano-Verona
- By train: A train every 30 minutes links Merano to Bolzano (35 minute trip) from 6 to 22 h
- By air: Bolzano airport is linked only to Rome. Shuttle buses from Munich, Innsbruck and Verona airports (and from Innsbruck railway station) are provided by the conference organization. Each participant can book one or more single way or return tickets via the conference website until January 31, 2013. The cost is 20,- € per person for single way, 40,- € per person for return ticket

Hotel reservation and tourism

The booking service is managed by the Merano Tourist Office, see

http://www.aia-daga.eu (-> accommodation)

Useful information on tourism proposals are also available.

Important dates

- 31 January 2013: Deadline for early registration
- 15-17 March 2013: EAA Winter School (p. 46)
- 18 March 2013: Workshop ”Classroom acoustics” (p. 56) and pre-colloquium (p. 61)
- 19-21 March 2013: Conference program
- 22 March 2013: Workshop ”The overall quality in buildings” (p. 66)
- 29 March 2013: Deadline for paper submission
- Summer 2013: Distribution of the proceedings (CD) to the participants

Allgemeine Informationen in deutscher Sprache

Eine deutsche Übersetzung der ”General Information” (ab Seite 31) wird im DEGA-Sprachrohr Nr. 60 veröffentlicht, welches ab Mitte Februar 2013 an alle DEGA-Mitglieder verschickt wird bzw. auf der Webseite www.dega-akustik.de heruntergeladen werden kann.

DEGA/AIA awards

DEGA Helmholtz Medal for Prof. Werner Lauterborn

The Helmholtz Medal 2013 of the German Acoustical Society (DEGA) will be presented to Prof. Dr. Werner Lauterborn. With this award, the DEGA honors his outstanding contributions in research and teaching to cavitation, nonlinear dynamics, and acoustic chaos.

Werner Lauterborn studied physics at the University of Göttingen, where Prof. Erwin Meyer became his academic tutor. He received his Ph.D. in 1968 and his venia legendi in 1974, based on his Habilitation thesis about "cavitation using laser light". For this work, he was awarded the Physikpreis 1976 of the German Physical Society. In 1987, he accepted a call to the TH Darmstadt, and in 1994, he moved back to his Alma Mater, to become director of the Third Physical Institute (DPI). In his work, Prof. Lauterborn combined experiments and numerical simulations, already at an early point in time (1970's), when the use of computers was still quite new. His scientific interest covered a wide range, from acoustics and optics to nonlinear dynamics and numerical techniques, and he represented this breadth of interests also in his teaching. Prof. Lauterborn continued working with his Ph.D. students and former colleagues also after his retirement in 2007 and he remains an active participant of the DAGA conferences.

The German Acoustical Society is grateful for Prof. Lauterborn's contributions to acoustics and is proud to have him as a recipient of its highest honor. The board of DEGA

The board of DEGA

DEGA Lothar-Cremer Award for Prof. Janina Fels

The Lothar Cremer Award 2013 of the German Acoustical Society will be presented to Prof. Dr.-Ing. Janina Fels. Ms. Fels receives this award for her innovative and remarkable work in the fields of binaural technique and medical acoustics.

She completed her PhD at the Institute of Technical Acoustics of RWTH Aachen University in 2008, and stayed at this institute as senior engineer and from 2012 as assistant professor. Based on her PhD research upon binaural hearing of children, she established a broad field of research and teaching – including binaural techniques in audiology, auditory perception in complex environments, noise effects, orientation for blind persons, and a lecture "medical acoustics" in the Faculty of Electrical Engineering and Information Technology of RWTH Aachen University. Janina Fels has an excellent international reputation – as reviewer for international journals, as session chair, and as expert in international standardization committees.

The German Acoustical Society is proud of awarding Ms. Fels - a young and talented researcher, standing at the beginning of an exciting career.

The board of DEGA

DEGA Student award

The DEGA Student Award 2013 will be presented to

- **MSc Robert Baumgartner**

for his Master Thesis ”Modelling sagittal-plane sound localization with the application to subband-encoded head-related transfer functions” (University of Music and Performing Arts Graz), see lecture on p. 274.

AIA Awards for young Italian acousticians

The Associazione Italiana di Acustica (AIA) awards the best degree and PhD theses on acoustics, Giacomini and Sacerdote awards, respectively, during its annual Conference which, usually, takes place in June. In addition AIA acknowledges other grants to young scientists and students to support their participation at the AIA Conference (Barducci award) and other International events on Acoustics.

In 2013 the 40th annual AIA Conference will be included in the joint conference AIA-DAGA 2013 and will be held in Merano, from 18 to 21 March, much earlier than its usual occurrence. For this reason, the AIA board decided to postpone the ceremony of Giacomini and Sacerdote awards in a later event and to acknowledge the Barducci award to 10 Italian PhD students and young researchers to encourage their participation at the EAA Winter School. The applicants to the Barducci grant 2013 have to submit an abstract to AIA-DAGA conference and to attend one of the hot topic courses at the EAA Winter School.

AIA ”Special Award”

The AIA ”Special Award” will be acknowledged to the AIA member who gave a remarkable contribution to the activities of the association in 2012-2013.

European Acoustics Association (EAA)

The European Acoustics Association (EAA) is a non-profit entity established in 1992 that includes in its membership societies predominantly in European countries interested in to promote development and progress of acoustics in its different aspects, its technologies and applications.
The main objectives of the EAA are to:

- promote and spread the science of acoustics, its technologies and applications, throughout Europe and the entire world,
- interface with associations whose activities are related to acoustics,
- establish contacts across member associations and other public and private bodies,
- promote the formation of national acoustical societies in European countries where these do not exist, and to support and strengthen activities of existing national associations, respecting the principle of subsidiarity,
- publish a European journal on acoustics, in printed as well as in electronic format,
- organize and promote congresses, publish books and monographs, and engage in all those activities that are connected with the diffusion, promotion and development of acoustics,
- establish agreements for collaboration with European and international entities in order to better serve the objectives of EAA,
- stimulate education activities and platforms in acoustics at all educational levels, both academic and professional,
- promote and divulge the establishment and implementation of norms and recommendations in the various fields of acoustics.

EAA gathers 32 acoustical societies and serves more than 8500 individual members in the following countries: Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland, France, FYROM, Germany, Greece, Hungary, Iceland, Italy, Latvia, Lithuania, Morocco, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Netherlands, Turkey, Ukraine and United Kingdom.

EAA is democratically organized (one vote per country) with a general assembly, a board and an executive council.

EAA web: www.eaa-fenestra.org; www.european-acoustics.net
EAA contact (General Secretary): secretary@european-acoustics.net

EAA Technical Committees: Computational Acoustics, Hydroacoustics, Musical Acoustics, Noise, Psychological and Physiological Acoustics, Room and Building Acoustics, Ultrasound.

EAA Products:

Acta Acustica united with Acustica is an international, peer-reviewed journal on acoustics. It is the journal of the EAA. It is published by Hirzel Verlag. See www.acta-acustica-united-with-acustica.com for more information. EAA members receive Acta Acustica united with Acustica online as part of their membership.

EAA Nuntius is the "acoustic messenger" of EAA to vitalize communication between and in the European acoustical societies on a variety of topics. It is published monthly in electronic format and distributed via e-mail to all EAA members.

EAA Index, published every 3 years, contains general information concerning each member Society (addresses, history, profile), an individual membership directory (data of all individual members of each Society including main field of interest) and a directory of Sustaining Members, institutions or companies with brief activity descriptions.

EAA Documenta Acustica is the literature distribution system of the EAA. It distributes conference and symposia proceedings as well as books, reports and theses.

EAA Fenestra is the website of EAA. Fenestra provides information on the association and its members (products, technical committees, organisational structure and policies, contact information), up-to-date news, upcoming events, links to other non-profit organisations in acoustics, a job market and much more.

EAA Schola is an online platform for education in acoustics in Europe: www.european-acoustics.net/schola. Through Fenestra, it offers information on university acoustics courses in Europe at different levels (Bachelor, Master, Ph.D.).

EAA Young Acousticians Network is a non-profit student initiative within the EAA with the primary goal to establish a community for Master and PhD students and researchers in the field of acoustics. It organises student events at scientific conferences and provides services that contribute to the community, including a monthly newsletter.

Forum Acusticum is the triennial international convention organised by a national acoustical society on behalf of EAA. It is, in effect, a forum comprising a variety of different activities: high-quality scientific congress with invited plenary lectures, structured sessions, invited and contributed papers, an exhibition that includes commercial firms, laboratories and agencies, social meetings of acousticians with receptions, visits and awards.

Euronoise is the European Conference and Exhibition on Noise Control, coordinated by the EAA Technical Committee Noise and organised by a national acoustical society on behalf of EAA.

Euroregio is an expression of EAA support for traditional regional events organized by groups of countries. Where appropriate, the regional events can be extended towards a full European and international scale.

EAA symposia are scientific meetings under the aegis of the EAA with a focus on specialised fields. They are typically organized by one or more member societies of EAA in conjunction with the Technical Committee of EAA.

EAA supports with grants and best paper and presentation awards the active participation of students and young researchers at EAA major events (Forum Acusticum, Euronoise, Euroregio).

EAA Summer and Winter Schools are conceptualized as events where Bachelor, Master and PhD students of acoustics, as well as other young acousticians, can learn about a variety of new accomplishments in the field of acoustics in half day or full day courses. The first EAA Summer School was held in Ljubljana in 2010, and the second is in Merano in 2013, both connected to the Euroregio conferences.

EAA Winter School

Coordinators: Kristian Jambrosic, Luigi Maffei, Michael Vorländer

A ”Winter School” for young acousticians will be organized and sponsored by EAA during the days before the AIA-DAGA 2013 Conference on Acoustics. The Winter School will be held at the Kurhaus (venue of the Conference). AIA and DEGA will cosponsor the event. Included is also a sponsored social program with get-togethers, evening events and a lot of opportunities of ”student meets expert”.

Courses

1. ”Approaching Acoustics” course (max 100 participants, no registration fee, free hotel accommodation for 3 nights: Thu. 15/3 in, Sun. 17/3 out). Start Friday 15.03.2013 at 8:30; end Sunday 17.03.2013 at 15:00.
The course is reserved for undergraduate students in the third year or for students in a Master program. Acoustic fundamentals are briefly illustrated, and various fields of applications related to job profiles are introduced (Hearing, Measurements, Acoustic materials, Noise control, Room acoustics, Sound Design, Underwater Sound, Ultrasound, Musical Acoustics).

2. Five parallel courses on ”Hot Topics in Acoustics” (max 50 participants/course, participants must register at the Conference at the specific registration fees). Start: Saturday 16.03.2013 at 8:30; end: Sunday 17.03.2013 at 15:00. The courses are reserved to PhD students and young researchers (under 40 years old) that are already involved in acoustics studies.

Approaching Acoustics
Room: Kurhaus Lentner hall

Organizer: Michael Vorländer

This course is intended to teach young students the fundamentals of acoustics and to make them aware of the opportunities for a professional career in acoustics. Teachers are experts in the field, not only academic teachers but also professionals in acoustics with background in industry or consulting.

Friday, 15 March 2013 (fundamentals):

8:30-10:15 **What is acoustics?** (Michael Vorländer, RWTH Aachen University, Germany)
Fundamentals of vibrations and waves, plane and spherical waves, sources - directivity and power, reflections, diffraction and scattering, sound descriptors - the decibel and other quantities, ... and what to do with all that?

10:30-12:00 **Hearing** (Steven van der Par, Oldenburg University, Germany)
Human auditory system, physics and physiology of the peripheral auditory system, examples: use of masking models in low-bit rate audio coding and spatial audio reproduction over headphones using dummy-head recordings.

14:00-15:30 **Measurements** (Peter Svensson, NTNU Trondheim, Norway)
Transducers, calibration and frequency response, dynamic range, measurement uncertainty, measurement of transfer functions, or impulse responses

16:00-17:30 **Acoustic materials** (Paolo Bonfiglio, University of Ferrara, Italy)
Understanding and applications of elastic and porous material for noise and vibration control: Definition of acoustic quantities (sound absorption and transmission) and basics on wave propagation in elastic and porous materials.

Saturday, 16 March 2013 (applications):

8:30-10:00 **Noise Control** (Joachim Scheuren, Müller-BBM, Germany)
Relevance of noise control; registration, evaluation and assessment of noise; noise limits and regulations; strategies for noise control; technological approaches and examples; areas of research.

10:30-12:00 **Room acoustics** (Martijn Vercammen, Peutz Consultants, The Netherlands)
Sound modes in rooms, wavefield models in room acoustics, sound absorption, geometrical room acoustics, statistical room acoustics, evaluation of room acoustics, areas of research, and example: design considerations for a lecture hall.

14:00-15:30 **Sound Design** (Klaus Genuit, HEAD acoustics, Germany)
Sound design is important for product sound design and soundscape.

Practical applications of psychoacoustics and sound design can be found in the field of automotive industry.

16:00-17:30 **Underwater Sound** (Michael Taroudakis, University of Crete, Greece)
Historical facts on the use of sound in water, sound as an efficient carrier of information in water, applications of Underwater Acoustics: commercial and non-commercial applications, environmental applications, marine bioacoustics, Forward and inverse propagation problems in the sea.

Sunday, 17 March 2013 (applications):

8:30-10:00 **Ultrasound** (Juan Gallego Juarez, CISC Madrid, Spain)
Ultrasound in numerous scientific, technological and medical areas. Application of low-intensity ultrasound (non-destructive testing, medical diagnosis, ..). Application of high-intensity ultrasound in material engineering and medicine.

10:30-12:00 **Musical Acoustics** (Murray Campbell, Edinburgh University, United Kingdom)
Fundamentals of sound generation and radiation, theoretical and experimental approaches.

13:30-15:00 Exams - final certificates

Hot Topics in Acoustics

Course A. **Cutting Edge in Spatial Audio**
Room: Kurhaus Czerny hall

Didactic organizer: Franz Zotter

Admitted: spatial audio is not an entirely new subject. Nevertheless research has been bringing forward big leaps and cutting-edge technology in spatial audio for the entire last decade, with many excellent experts contributing to research and development. We can bluntly say that today our understanding of spatial audio is unprecedented in many ways: We know much more about neural mechanisms of spatial hearing, experimental data are available that cover many relationships in great precision, and models of spatial hearing become more precise and applicable. On the other hand, we can demonstrate various high-quality sound reinforcement systems showing the power of binaural (headphone-based) or loudspeaker-based holophonic technologies, such as wave field synthesis and Ambisonics, or parametric audio coding methods exploiting psychoacoustic effects. Virtual acoustics rendering systems with room auralization are complemented by recording concepts such as spherical arrays with improved spatial resolution, distributed intelligent array technologies for audio scene transcription, and parametric audio coding for first order microphone arrays. The audible result is finally most relevant: profound evaluation of the various technical methods is currently being researched. It reveals where methods are most effective, and which combinations of technology could yield our research into an interesting future.

Saturday, 16 March 2013

- 8:30-9:20 Spatial audio in vertical planes: psychoacoustic experiments and models (Piotr Majdak)
- 9:30-10:00 First introduction round for participants
- 10:30-11:15 Neurological processing of spatial hearing in our brain and parametric spatial audio (Ville Pulkki)
- 11:45-12:00 Second introduction round for participants
- 14:00-14:45 Spherical array processing for the decomposition of spatial sound (Craig Jin)
- 15:15-15:30 Third introduction round for participants
- 16:00-16:45 Sound field analysis using distributed microphone array networks (Maurizio Omologo)
- 17:15-17:30 Fourth introduction round for participants

Sunday, 17 March 2013

- 8:30-9:15 Spatial sound synthesis with loudspeakers (Sascha Spors)
- 9:30-10:00 Virtual source localization in wave field synthesis (Hagen Wierstorf)
- 10:30-11:30 Psychoacoustic experiments with loudspeaker-based virtual acoustics (Florian Völk)
- 11:30-12:00 Source width of horizontal amplitude panning (Matthias Frank)
- 13:30-15:00 Exams

Course B. **FEM and BEM: Computational Acoustics**
Room: Kurhaus meeting room 2

Didactic organizers: Andrew Peplow, Martin Ochmann

Many physicists and engineers are interested in the reliable simulation of processes using computational methods in which acoustic waves are scattered by obstacles with applications arising from many diverse subjects. Topics which are ”live” in computational acoustics research today span a broad, subject and application, base which cannot be covered by these lectures. However we shall present a useful perspective of various modern methods that have undergone specific research previously and are now widely available to the researcher today. We shall also present new techniques in finite elements including methods which exploit the underlying physics to reveal a powerful scientific method for the study of noise and vibration transmission in waveguides. But for more general domains flexible discretization techniques for the solution of coupled wave propagation problems will be discussed. Here we have to deal with the tricky situation of non-conforming grids appearing at the common interface of two subdomains. We demonstrate the applicability of the discussed method for two practical examples in mechanical-acoustic coupling arising in vibroacoustics and computational aeroacoustics. Boundary element methods have undergone significant growth in availability and use for researchers and engineers recently. Here we shall show how to extend the applicability

of BEM as an integral equation formulation by using special Green's functions and as a tool with applications in flow noise not normally associated to this method.

Saturday, 16 March 2013

- 8:30-10:00 Perspectives of acoustical FEM and BEM hot topics (Andrew Peplow)
- 10:30-12:00 Waveguide finite elements (Elisabetta Manconi)
- 14:00-15:30 Non-matching grid techniques for acoustical FEM (Manfred Kaltenbacher)

Sunday, 17 March 2013

- 8:30-10:00 New Green's functions for BEM (Martin Ochmann)
- 10:30-12:00 Special applications of BEM in flow acoustics (Rafael Piscoya)
- 13:30-15:00 Exams

Course C*. **Synergies between Environmental Noise Control and Soundscape Approach**
Room: Kurhaus conference room

Didactic organizers: Jian Kang, Brigitte Schulte-Fortkamp

This course will explore the development from conventional environmental noise control to soundscape approaches. Based on the EU COST Action on 'Soundscapes of European Cities and Landscapes', the course will cover basic concepts and understanding of Noise Control and Soundscapes, and health impacts trough acoustic environments but also standards and guidelines, and practical examples concerning soundscapes. The multidimensional Soundscape approach is emphasizing on the way the acoustic environment is perceived, experienced and understood by the individual and by society (ISO/TC 43/SC 1/WG 54). Moreover, it accounts for people's concerns and integrates the exposed people as experts. The process of tuning of noise pollution or sound design with respect to the expertise of people's mind is related to the strategy of triangulation of interdisciplinary data. Moreover, the Soundscape approach provides the frame work to integrate contextual and subjective variables to improve the respective Soundscape with regard to quality of life. The course will be taught by both researchers and practitioners. The course will be assessed by written exams, with 18 questions. It is expected that students will come from various disciplines, with some basic knowledge in acoustics.

Saturday, 16 March 2013

- 8:30-9:15 Basic concepts in environmental noise control and soundscapes (Brigitte Schulte-Fortkamp)
- 9:15-10:00 Soundscape framework (Jian Kang)
- 10:15-11:00 Auditory cognition and soundscape (Dick Botteldooren)
- 11:00-12:00 Health inclusive - why? (Peter Lercher)

- 14:00-14:45 The soundscape approach as a tool for the environmental assessment of new large scale projects Part 1 (Luigi Maffei)
- 14:45-15:30 The soundscape approach as a tool for the environmental assessment of new large scale projects Part 2 (Luis Bento Coelho)
- 15.45-16:30 Standards applicable to soundscape studies (Truls Gjestland)
- 16:30-17:30 Panel

Sunday, 17 March 2013

- 8:30-09:15 Practical soundscape examples (Lisa Lavia)
- 9:15-10:00 Practical soundscape examples (Max Dixon)
- 10:15-11:00 Practical soundscape examples (Dick Botteldooren)
- 11:00-12:00 Practical soundscape examples (Brigitte Schulte-Fortkamp, Jian Kang)
- 13:30-15:00 Exams

*This course is sponsored by COST TD-0804 "Soundscape of European Cities and Landscapes"

Course D. **Understanding Musical Instruments in Theory and Praxis**
Room: Kurhaus meeting room 1

Didactic organizer: Malte Kob

This course will cover the generation, propagation and perception of sounds created by musical instruments. Lectures layout the basic principles of sound generation in wind instruments, string instruments and the human voice. For each instrument group appropriate methods for assessing different quality aspects relevant to players and listeners are presented and their principles and limitations are discussed. In the workshops participants will have the opportunity to apply their knowledge and to gather hands-on experience by measuring acoustic characteristics of musical instruments and the human voice. For air driven instruments acoustic impedance, pulse response and radiated sound are measured and it will be demonstrated how theses results can be interpreted in a musical context to derive practically relevant characteristics like intonation, responsiveness and sound quality. For string instruments the bridge mobility will be measured and deflection shapes of the instrument's body which correspond to prominent structural resonances will be identified. It will be shown how the modal structure is associated with the sound quality of the instrument. For the singing and speaking voice it will be demonstrated how usually invisible physiological characteristics of the Larynx can be measured or estimated and how typical voice disorders can be studied by computer simulation.

Saturday, 16 March 2013

- 8:30-10:00 Welcome, Introduction to Voice Acoustics (Malte Kob)
- 10:30-12:00 Introduction to Brass Instrument Acoustics (Wilfried Kausel)
- 14:00-15:30 Introduction to Violin Acoustics (Lamberto Tronchin)
- 16:00-17:30 Workshop on Voice assessment (Malte Kob)

Sunday 17, March 2013

- 8:30-10:00 Workshop on Brass instrument acoustics (Wilfried Kausel)
- 10:30-12:00 Workshop on Violin Acoustics (Lamberto Tronchin)
- 13:30-15:00 Exams

Course E*. **Introduction to Aeroacoustics**
Room: Kurhaus Ohmann room

Didactic organizer: Yves Auregan

Air flows are used to transfer heat and mechanical work in a large number of technical processes and systems distributed including ventilation systems in vehicles and buildings, cooling systems in laptops and engines, IC-engine, power plants, gas transportation, gas turbine intake/exhaust systems, etc. Frequently there is an associated generation of unsteady flow and pressure, which inevitably leads to sound generation. Sound produced by various airflow systems is responsible for an important part of community noise problems. The aim of this course is to give an introduction to aero-acoustics from the basic concepts to some concrete applications. The course begins with an introduction to the fundamental equations and principles of aero-acoustics, including the concept of acoustic analogy. This is followed by a lecture on the propagation in flow ducts including the effect of silencers in presence of flow. A sequence will be devoted to the measurements technique. The second part will be dedicated to the acoustical sources induced by airflow. The first source will be the noise induced by vortices i.e. the whistling. The second source studied will be the noise induced by turbulence I.e. the jet noise. The last source will be the noise induced by the rotating machines.

Saturday, 16 March 2013

- 8:30-10:00 Introduction to Fluid dynamic and Aeroacoustics (Christophe Schram)
- 10:30-12:00 Aeroacoustics for confined low Mach number flows (Yves Auregan)
- 14:00-15:30 Measuring techniques (Hans Bodén)
- 16:00-17:30 Linear Aero-acoustic models and whistling (Mats Åbom)

Sunday 17, March 2013

- 8:30-10:00 Noise from turbulence and jet noise (Christophe Schram)
- 10:30-12:00 Introduction to the noise of rotating machines (Mats Åbom)
- 13:30-15:00 Exams

*This course is sponsored by ITN Marie Curie ”Silent Air Flows in transport, buildings and power generation - FlowAirS”

Plenary lectures

Tue 11:00 Kursaal Plenary lectures Tuesday

Acoustics of Historical Opera Houses in Italy: Past, Present, and Future

Nicola Prodi
Università di Ferrara, Dip. di Ingegneria

The cultural heritage of historical opera houses is recognized as one of the most relevant in the country due to the widespread presence of theatres in the territory and to their vitality in the Italian cultural life, which span over almost four centuries. Acoustics inside historical theatres can be regarded itself as an immaterial heritage which calls for proper conservation, fruition and valorization. In the last decade, driven by the acoustical heritage concept, there has been as surge of interest towards the documentation of the peculiar opera house acoustics and a National research project was accomplished for this specific task too. Together with previous and later available data this body of measures provided a useful set of information to support renovations and to better understand how the acoustics work. Moreover, thanks to the unique mix of opera, which entails multiple sound sources heard and seen from quite different locations, the historical theatres provided the ideal grounds to investigate specific issues. In particular the competition between stage and pit sources and the resulting preferred listening conditions were analyzed and the audio-visual interaction at theatre places was studied to understand how such preference is formed.

Tue 14:40 Kursaal Plenary lectures Tuesday

The Secret Life of Bubbles in a Sound Field

Werner Lauterborn
3rd Institute of Physics, University of Göttingen

Bubbles abound in nature wherever water flows. They also prominently figure in human settings, as there are engineering (erosion of propellers), chemistry (bubble reactors), health care (coated ‘medical’ bubbles) and physics (bubbly flows, ultrasonic cleaning). From this wide range of bubble topics the physics of bubbles in a sound field is selected. It has long been a secret, and in many respects still is, how bubbles perform in a sound field: how they clean or erode surfaces, how it comes about that they emit light, etc. The involved dynamics underlying these processes is addressed in two ways, by investigating the nonlinear oscillations and their stability and by a deeper look into the interior of bubbles via molecular dynamics (MD) calculations. Bubble oscillations are categorized by their positional, shape and dissolution stability in the parameter space of bubble size, sound field pressure amplitude and sound field frequency. The notion of a bubble habitat is used for presenting the essential bubble survival spaces. The processes inside a gas and vapor bubble, in particular upon a strong collapse, are investigated with up to 10 million hard sphere particles in MD simulations. The formation of a hot, high density core is observed.

Wed 12:15 Kursaal Plenary lectures Wednesday

On the Use of Scientific Tools in Today's Violin Making

Martin Schleske

Master Studio for Violinmaking, Stockdorf

Nowadays, the prevailing opinion about the great Italian masters of violinmaking from the 18th century is that those famous makers created their epochal works based on "gut" feeling. Since modern science did not yet exist, the development of the violin must have been a purely "instinctive" process. I intend to question this viewpoint by sketching out a brief outline of science and research in the field of violinmaking. The violin owes its development to "empirical art". The instrument did not develop in a milieu of spontaneous capriciousness but rather through ïntegral intuition".

Using examples of instruments made by Antonio Stradivari (1644 - 1737) as well as those of contemporary masters, methods and tools will be presented that show how structural dynamic measurements and psychoacoustic evaluations can be of practical benefits in the workshop of the violinmaker. Although similar in their overall loudness (a quantity relevant to their dynamical potential) and their tone-to-tone fluctuations of loudness (a quantity relevant to their dynamic balance), differently judged violins clearly differ in their specific loudness patterns, which seem to be useful to describe their tonal color (timbre). Tonal examples will show how specific changes in material and design relate to specific changes in sound.

Wed 14:40 Kursaal Plenary lectures Wednesday

Speed of Sound in Fluids

Roberto Maria Gavioso

Istituto Nazionale di Ricerca Metrologica (INRIM), Torino

The speed of sound is a physical quantity determined by the thermodynamic properties and the state of aggregation of the acoustic propagation medium. As a consequence, the experimental determination of the speed of sound may provide an estimate of these properties in a variety of physical conditions over a range of dimensional scales spanning from microscopic to planetary. A number of current applications of such measurements which have a scientific or practical interest is reviewed.

Thu 12:15 Kursaal Plenary lectures Thursday

Low-Frequency Sound - a Special Sound

Detlef Krahé
Bergische Universität Wuppertal

Low-frequency sound is a special issue in different aspects. First of all concerning physics: no absorption by the air, marginal damping by acoustic barriers and even by sound insulation windows leads to very little attenuation during propagation. Only the geometrical damping has an effect. Therefore a protection against low frequency sound is difficult. In addition the number of complaints due to low frequency sound is increasing. The growing number of low frequency sound sources (e.g. plants of renewable energy) may be one reason for this. The question arises, why people are extremely annoyed by low frequency sound? It is remarkable, that this is observable even at levels below the hearing threshold. Research on the physiology of the hearing sense might give an explanation for this reaction. The fact, that most of the suffering people are living in quiet areas, seems to be a key for an explanation, which can help to understand the problems of the suffering people in a better way. However, can this help to solve their problem? Often, an identification of low frequency sound sources is difficult and an elimination impossible. Perhaps the old idea of active noise control offers a solution in some cases. It works efficiently, especially at low frequencies.

Thu 14:10 Kursaal Plenary lectures Thursday

Trends in Binaural Technology

Janina Fels
Inst. of Technical Acoustics, RWTH Aachen University

Auditory displays play a major role when it comes to experiments using acoustic virtual reality. For more realistic conditions in psychoacoustic experiments, however, the natural reproduction of acoustic stimuli in a virtual acoustic scene should include a physically-based simulation of room acoustics. The goal is to create a virtual scene which should not differ from the real scene in terms of the acoustic impression.

In binaural technology static and dynamic acoustic scenes must be discussed separately. In dynamic scenes the benefit of head movements is most significant. In static conditions where head tracking cannot be applied, recent experiments have shown that the individual cues should be maintained in order to achieve the best reproduction result. Hence, there is the need for individually measured or calculated head-related transfer functions as well as individual equalization techniques of the binaural reproduction. Properly created acoustic stimuli can be used in various fields of experiments also in different disciplines. Recent trends in binaural technology will be presented and examples of interdisciplinary experiments will be discussed.

Workshop ”Classroom Acoustics” (Monday)

Mon 14:00 Kursaal Workshop 'Classroom Acoustics'

Opening

Christian Tommasini[a], Robert Pfeifer[a] and Alessandro Peretti[c]
[a] *Assessore Provinciale Edilizia Abitativa, Cultura, Scuola, Formazione in lingua italiana, Bolzano;* [b] *Direttore Provinciale INAIL, Bolzano;* [c] *Presidente Associazione Italiana di Acustica*

Mon 14:20 Kursaal Workshop 'Classroom Acoustics'

Room acoustic regulations for classrooms - a European perspective

Holger Brokmann
Ecophon Germany, Lübeck

It is no matter of course that there are obligatory regulations for classroom acoustics in European countries. And even if there are standards, guidelines or regulations there is quite a range of different figures which are given. The Overview of local regulations in South Tyrol (e. g. Artikel 10 des Landesgesetzes vom 21. Juli 1977, Nr. 21 ”Schulbaurichtlinien”, DIN18041:2004-05) in comparison to European standards and guidelines (e. g. BB93, SS 25268:2007, ÖNORM B 8115-3) show these differences regarding figures and the demand on good speech intelligibility - especially when this is linked to the activity and usage of classrooms. Most people think of classroom as a rectangular room with frontal teaching and most regulations are based on providing good speech intelligibility for this type of activity. Other pedagogic concepts also lead to a different way of usage of the room which includes corridors as learning spaces (DAGA 2012 ”Raumakustische Anforderungen moderner Lernlandschaften” C. Campbell, Holger Brokmann). The need for inclusion (hearing impaired and normal hearing pupils being taught together) in schools also has to be taken into consideration when looking at standards, regulations and guidelines.

Mon 14:40 Kursaal Workshop 'Classroom Acoustics'

Reverberation time in educational environments in South Tyrol

Richard Oberkalmsteiner[a], Giuseppe Canale[a], Luca Verdi[a], Arianna Astolfi[b], Nicola Prodi[c] and Alessandro Peretti[d]
[a] *Agenzia Provinciale per l'Ambiente, Lab. di Chimica Fisica;* [b] *Politecnico di Torino - Dipartimento Energia;* [c] *Università di Ferrara, Dip. di Ingegneria;* [d] *University of Padova, Post-Grad School in Occupational Medicine*

The reverberation time in the educational places influences significantly the ability of learning by pupils. It also has an important effect on the vocal effort required to teachers during lessons. For pupils with hearing impairment, who have consequently a need for greater clarity and speech intelligibility, or in the case of lessons or conversations in a foreign language, this topic is even more delicate. This acoustic quality indicator is particularly strategic for an intrinsically multilingual province. Measurements of reverberation time have been carried out in the last three years in numerous kindergartens, primary schools and high schools of the Province of

Bolzano. The measurements applied to classrooms, gymnasiums, music rooms, dining rooms, recreation rooms and entrances. In some kindergartens and schools, post-operam measurements of reverberation times were also performed in order to verify the effectiveness of the acoustic absorption interventions performed. Additional information was collected by filling in a specific questionnaire distributed to schools and by some direct measurements of the parameter of intelligibility STIPA. The results of the measurements carried out over the last three years in the light of the existing regulations, are presented in this work.

Mon 15:00 Kursaal Workshop 'Classroom Acoustics'

On the influence of acoustics on speech intelligibility and learning inside classrooms

Nicola Prodi
Università di Ferrara, Dip. di Ingegneria

The influence of bad classroom acoustics is primarily manifested by an excess of reverberation, which amplifies the noise and mixes teacher's voice. This occurrence is recognized as a barrier to learning due to a direct interference with the instantaneous communication process between teachers and pupils and due to an cumulative effect of strain on pupils caused by prolonged exposure. Several variables concur in the process such as the classroom preparation which governs the reverberation, the type and level of the interfering noise, the age and condition of the children and finally the teaching style too. Poor communication is described by the subjective and objective ratings of speech intelligibility which are the basis for the evaluation of classroom acoustics. The effects of adverse acoustics are affecting more structured tasks which rely on short-term memory and involve higher-order cognitive functions. All in all a chronic lack of academic achievement was seldom reported for pupils attending unsuitable classrooms, together with an inadequate well-being perception. This work will present results that support the need for a careful planning of acoustics in the primary school classrooms to prevent the noise interference with a special regard to the type of disturbance and the age of pupils.

Mon 15:20 Kursaal Workshop 'Classroom Acoustics'

Influence of classroom acoustics on the vocal load of teachers

Arianna Astolfi
Politecnico di Torino - Dipartimento Energia

Voice disorders, from the functional dysphonia to the vocal fold nodules, are likely to result from voice abuse, erroneous vocal behaviors and poor acoustics in the environments where the voice is used. Teachers of different types and levels are some of the most affected figures as they exhibit a longer phonation time than other workers and typically use their voice in classrooms with bad acoustics. In order to objectively investigate the vocal load some vocal doses and parameters were measured over some working days on 40 primary school teachers in six schools in Italy using the Ambulatory Phonation Monitor 3200 by KayPentax®. The average value over the working days of the mean sound pressure level of the voiced

speech at 1 m from the teacher's mouth was 62.1 dB for the females and 57.7 dB for the males, while the voicing time percentage was 25.9% and 25.1%, respectively. It was found a 0.72 dB increase in the speech level and 1.0 Hz increase in the fundamental frequency per 1 dB increase in background noise level during traditional lessons, and an optimal range of the mid-frequency reverberation time for a talker in a classroom between 0.75 and 0.85 s.

Mon 15:40 Kursaal Workshop 'Classroom Acoustics'

Noise and reverberation effect on vocal effort of primary school teachers

Carlo Giordano[a], Juri Nadalin[a], Luca Raimondo[a], Arianna Astolfi[b], Pasquale Bottalico[c], Giuseppe Riva[a] and Massimiliano Garzaro[a]
[a] *1st ENT Division, Surgical Sciences Department, Univ. of Turin;* [b] *Politecnico di Torino - Dipartimento Energia;* [c] *Studio Progetto Ambiente, Torino*

Aim of the study: evaluate relationships between vocal doses, clinical conditions, acoustic characteristics of classrooms and subjective evaluation of vocal effort in primary school teachers.

Materials and Methods: Study setting: 54 frontal lessons; 39 teachers coming from 6 primary schools of Torino and Beinasco underwent ENT evaluation, videolaryngostroboscopy, speech pathologist evaluation by means of GIRBAS and VHI. APM3200 was used to collect f0 and SPL, moreover 2 ad hoc designed questionnaires were administered to investigate subjective perception of vocal effort, vocal symptoms and acoustic com-fort. A sound level-meter and a digital recorder were used to collect environmental noise and speech levels.

Results: 59% of teachers showed objective or subjective signs of vocal pathologies, SPL at 1mt from mouth and f0 were 66,2dB and 238,7Hz for men and 65,8dB and 150,3Hz for women. Environmental noise levels were 50-55dB(A). A Lombard effect was recorded: for each dB of environmental noise increase we detected an increase of 0,70-0,72dB of voice intensity; f0 increasing rate was 1.2Hz/dB. Subjective perception of noise increased with the square of reverberation time.

Conclusions: Voice disturbances are related to smoking habits, family history and phonation time. Noise and reverberation control are essential to reduce voice pathologies in such sample.

Mon 16:00 Kursaal Workshop 'Classroom Acoustics'

Having a resonant voice in the noise: techniques for assessing the vocal cost and safeguard against professional voice diseases

Franco Fussi
Centro Audiologico Foniatrico, Azienda USL Ravenna

The phoniatric literature investigates for many years the problem of vocal abuse in noisy environments and proxemics in relation to the use of the professional speech, and about diagnosis and measures to prevent and therapies for the injuries, functional and / or organic, that may ensue. There will be shown the techniques useful to obtain a euphonic resonance to improve the audibility of the voice without laryngeal effort, and it will be

suggest a vocal warm-up, including vocal fold hydration, and illustrated a tool for the detection of fatigue voice (vocal dosimetry).

Mon 16:20 Kursaal Workshop 'Classroom Acoustics'

Noise - Stressor for Students and Teachers! Acoustic Ergonomics of School

Gerhart Tiesler
Inst. of interdisciplinary School Research, University of Bremen

This lecture refers to an interdisciplinary research project carried out 2000 to 2006 by the Bremen University, Germany. A mixed team of acousticians, occupational and medical scientists and pedagogues investigated the kind of work and communication behaviour in classrooms in two elementary schools. Using a database of 175 examined lessons an analysis is made of how different kinds of work (frontal lessons vs. differentiated lessons) affect the basic and working sound level in the classroom. Parameters are discussed, which can describe classroom acoustics appropriately. Also discussed are how altered room characteristics (e.g. increased absorption, shortened reverberation time and improved speech intelligibility) affect the sound level in the context of each kind of work. A methodical examination of the database allows an assessment of mean values but also of the detailed teaching phases, as characterised by certain pedagogical factors. The results provide the basis for discussion of stress and work demands of teachers: Based on recordings of teacher's heart rate the effects of noise level on the workload of the teachers as a stress reaction are analysed. Naturally students will show the same reaction in workload by noise as the teachers.

Mon 16:40 Kursaal Workshop 'Classroom Acoustics'

On the possibility to increase the acoustic performance of classrooms with simple and economic projects

Luigi Maffei
Department of Architecture and Industrial Design, Seconda Università di Napoli

The influence that bad acoustic conditions inside schools has on pupils' learning and achievements and on teachers' stress has been widely demonstrated. On the other side there are several obstacles against the solution to the problem: most of the school buildings are dated and they lack materials with sound absorbing or sound insulation characteristics; social, environmental contexts and the way teachers and students experience the school time with their activities (pedagogical approach) determine, now more than in the past, high sound levels inside classrooms; a low sensibility to the phenomena of all school actors (management, teachers, parents, pupils); last but not least, the expected economic impact of acoustic renovation projects. Any acoustic renovation project should take into account the above obstacles and try to remove them globally with material and immaterial actions. In this paper is presented an overview of examples on how the problem can be approached. These pilot studies contemplate awareness campaigns, the involvement of the students and teachers in the design

processes of the acoustic renovation thanks to innovative tools such as the immersive virtual reality, the use of ”green materials” with good acoustic performance.

Mon 17:00 Kursaal Workshop ’Classroom Acoustics’

Discussion

Mon 17:45 Kursaal Workshop ’Classroom Acoustics’

Conclusions

Peter Höllrigl[a] and Nicoletta Minnei[b]

[a] *Intendenza scolastica tedesca, Bolzano;* [b] *Intendenza scolastica italiana, Bolzano*

Pre-colloquium ”Computation, Simulation and Modelling in Acoustics” (Monday)

Introductory Remarks

Although being basically described by a clear and comprehensive "theory of sound"(Rayleigh), theoretical modelling of acoustical phenomena in practice strongly depends on problem specific focussing together with appropriate assumptions and approximations. This is mainly due to the difficulties in generally solving the involved systems of differential wave equations for practical arrangements as well as to the coupling of acoustical wave fields to many other physical mechanisms and to human perception. Also, the large range of perceivable frequencies and corresponding wavelengths covers and involves a broad range of physical concepts and approaches.
As a result, to be useful and applicable, approaches to compute, simulate and model acoustical phenomena need adequate simplifications and assumptions which strongly depend on the characteristics of a specific problem. Therefore, in acoustics, the spectrum of required restrictions and hypothesis is determined by the broad spectrum of practical applications.
The pre-colloquium will demonstrate the resulting multiplicity of methods and approaches in acoustical computation, simulation and modelling by exemplary representative examples from various applicative areas. Apart from giving an overview of the theoretical toolbox to understand and solve practical acoustical problems, this shall encourage mutual exchange of experience between different acoustical disciplines and thus stimulate improvements and new ways to better understand and control particular acoustic phenomena and applications.

Mon 13:00 Puccini Theatre Pre-colloquium ’Computation’

Opening

Wolfgang Kropp[a] and Joachim Scheuren[b]
[a] *Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S);*
[b] *Müller-BBM GmbH, Planegg*

Mon 13:10 Puccini Theatre Pre-colloquium ’Computation’

Vibro-Acoustics Application Specific Requirements: Taking advantage of increased computing power with new or existing approaches to fulfil them

Denis Blanchet
ESI Engineering System International GmbH, München

Nowadays, the increase in computing power and reduction of its cost has driven the vibro-acoustic community to increasingly rely on large FEM (Finite Element Method) and BEM (Boundary Element Method) computation. The emergence of large company and university clusters and more recently of ”cloud computing” has enabled engineers to move beyond the limitations that were the rules only five years ago. For example, where FEM was applicable up to 200 Hz for a full trimmed body automobile simulation using NSM to represent acoustic insulation, now it can be pushed to 500 Hz with

insulation explicitly modelled in 3D FEM. It is not uncommon to see the same FEM structural model used up to 1000 Hz when combined with SEA (Statistical Energy Analysis) for acoustics and insulation. A full diffraction problem around the same vehicle is now possible using FMM-BEM (Fast Multipole BEM) to either simulate pass-by noise or predict effectiveness of pedestrian warning signal for e-vehicles. This paper presents application specific solutions for cases such as: interior vehicles noise predictions, exterior sound field prediction, pass-by/warning noise and wind noise applicable to automotive, aeronautics, marine and railway industries. It also discusses in more details wheel/rail noise radiation and underwater sound radiation.

Mon 13:35 Puccini Theatre Pre-colloquium 'Computation'

Surface and volume propagation methods for broadband sound prediction with synthetic turbulent sound sources

Roland Ewert

Deutsches Zentrum für Luft- und Raumfahrt e.V., Braunschweig

One way to tackle the problem of noise generated aerodynamically at solid surfaces is based on surface integral methods. To capture sound radiation characteristics sufficiently accurate it is necessary to enclose with the surface the entire surface area that affects sound radiation. For airfoil trailing edge noise, for example, this means to wrap-up the entire airfoil to properly capture the multi-lobe radiation pattern. If surface data is not available everywhere, the unknowns of the problem can be obtained with the Boundary Element Method (BEM). High Helmholtz number problems such as aerodynamically generated sound refracted at full-scale aircraft become treatable with fast multi pole BEM. However, surface integral based methods cannot properly tackle refraction effects in non-uniform flow. In recent years different numerical perturbation methods have been developed for simulating the propagation of acoustic perturbations over a given non-uniform mean-flow. The neglect of refraction effects can give rise to significant errors in the prediction of sound pressure levels. The applicability of stochastic methods generating synthetic turbulence for the fast prediction of turbulence related broadband sound has been studied in recent years. The coupling of synthetic turbulence methods to perturbation equations and fast multi pole BEM will be discussed.

Mon 14:00 Puccini Theatre Pre-colloquium 'Computation'

Modelling of acoustical Green's functions above impedance planes by a superposition integral

Martin Ochmann

Beuth Hochschule für Technik Berlin

The sound field caused by a monopole source above an impedance plane can be calculated by using a continuous superposition of point sources (superposition integral). For pure absorbing or mass like impedances, these equivalent sources are located along a line in the mirror space below the plane. For a more general surface impedance, an application of Cauchy's

integral theorem shows that convergence can be achieved by using complex locations for the image point sources. This superposition integral is the starting point for the derivation of two further results:
1. Closed form expressions for Green' functions in time domain, i.e. impulse responses, can be obtained by applying inverse Fourier transform to the superposition integral. Such a result is surprising, since corresponding formulations in frequency domain are not available.
2. Assuming that a monopole source is moving with constant velocity at constant height above the impedance plane, the sound field can be expressed in analytical form by combining a Lorentz transformation with the superposition integral. For an absorbing impedance, the half-space Green's function comprises a line of monopoles and of dipoles. The method of stationary phase leads to an asymptotic solution for the reflection coefficient which agrees with known results from literature.

Mon 14:25 Puccini Theatre Pre-colloquium 'Computation'

Modelling scattering with high orders of edge diffraction
Peter Svensson
Acoustics Group, NTNU, Trondheim (NO)
For the modelling of scattering and propagation in complex geometries, reference numerical methods get computationally unmanageable so instead, geometrical acoustics (GA) based methods are often used. The accuracy of GA-based methods can be improved by adding diffraction components and this presentation will summarize how diffraction can be computed in the GA context, for rigid and soft boundary conditions. The diffraction can be formulated via a recently presented edge source integral equation (ESIE) which can be solved through inversion or iteration. The latter will give individual diffraction orders, which makes the relationship to previous work on edge diffraction clear. For rigid convex scattering objects, accurate results can be computed for all frequencies, as will be shown for cases where reference results are readily available, such as a thin circular disc, and a sphere. The finer the mesh that is used to discretize a smooth surface, the higher orders of diffraction will be needed. For certain symmetrical cases, such as the scattering from an axisymmetric source above a circular disc, extremely efficient computations can be made. Limitations and possibilities for computational and accuracy aspects, of this ESIE approach will be discussed.

Mon 15:10 Puccini Theatre Pre-colloquium 'Computation'

Modelling of the Singing Voice
Malte Kob
Hochschule für Musik Detmold, ETI
The singing voice is probably the oldest and most versatile music instrument. Singing styles range from classic choir, opera, Lied, pop and jazz styles to more recent overtone, metal, and beat boxing. These styles differ in their weighting of voice properties such as breathiness, timbre, resonance quality or diplophony. Various acoustic aspects such as fluid dynamics, resonance theory and wave propagation, as well as neighboured

domains such as biology, phonetics and music contribute to the description and understanding of singing voice generation. Modelling the singing voice implies a thorough understanding of the sound generation principles which underlay the above voice sound aspects. Numerical modelling of these principles requires the adequate implementation and parameterization of algorithms for various generation principles. This talk will introduce basic principles of voice generation and modelling such as multiple-mass models of the larynx or wave-guide approaches for formants. Due to the complexity of the voice organ, modelling can either aim at the simulation of a limited number of aspects in almost real time or a comprehensive approximation with massive computational power. Consequently, the challenge of voice modelling has produced a number of successful approaches for both tasks. Some of these will be detailed in this talk.

Mon 15:35 Puccini Theatre Pre-colloquium 'Computation'

Damping, Dispersion and Classification

Bodo Nolte
WTD71, Forschungsbereich für Wasserschall und Geophysik FWG, Kiel

Common description of the damping behaviour of viscoelastic material is based on the combination of one or more spring and dashpot elements in a specific construction. Such rheological models are widely in use for the description of both, the structural behaviour as well as in the case of fluid dynamics and acoustics. It is also common to describe the stress-strain relationship by an ordinary differential equation and by using the so-called viscoelastic correspondence principle.

Important for the analysis of the mathematical and physical structure of the above mentioned applications are the corresponding partial differential equations in terms of the unknown displacement, which in addition one achieves by means of the Eulerian equation of motion and the kinematic relation between the spatial derivative of the displacement and the strain parameter. On this level dispersion phenomena will be discussed, which leads to a physical classification. A pure mathematical classification will also be performed. The latter one yields to different hyperbolical and mixed parabolic-hyperbolical classes of the partial differential equations.

Mon 16:00 Puccini Theatre Pre-colloquium 'Computation'

On the modelling of wheel/rail noise

Astrid Pieringer
Division of Applied Acoustics, Chalmers Univ. of Technology, Göteborg (S)

The wheel/rail contact is the predominant source of noise emission from railway operations in a wide range of conventional speeds. On the one hand, this wheel/rail noise concerns rolling noise and impact noise caused by the vertical wheel/rail interaction excited by roughness and discrete irregularities of the running surfaces, respectively. On the other hand, it concerns squeal noise generated by the tangential interaction due to frictional instability. The main step in the modelling of wheel/rail noise is the formulation of a wheel/rail interaction model describing the excitation process in

the contact zone between wheel and rail and calculating the resulting contact forces. Wheel/rail interaction models can be formulated either in the frequency or in the time domain. By their nature, frequency-domain models are completely linear models, while time-domain models are suitable to include all kinds of non-linearities. A disadvantage of time-domain models is that they are generally more computationally demanding than frequency-domain models. Besides a short overview of the approaches used in the area, a computationally efficient time-domain model is presented in more detail in this contribution. This model includes wheel and track models represented by Green's functions and a detailed non-linear and transient contact model.

Mon 16:25 Puccini Theatre Pre-colloquium 'Computation'

A mixed physical and statistical approach for the prediction of tyre/road noise

Thomas Beckenbauer[a] and Wolfgang Kropp[b]

[a] *Müller-BBM GmbH;* [b] *Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)*

The hybrid approach is intended to make a tool available for both analysis of tyre/road noise depending on road surface characteristics and synthesis of low noise road surfaces. However, the model does not claim applicability for the development of low noise tyres. Basic physical models for the calculation of non linear contact forces and tyre vibrations as well as an empirical model for the aerodynamic tyre/road noise generation have been implemented in order to feed a multiple regression model with problem specific input quantities. The model is able to predict absolute coast-by noise levels in terms of third octave bands between 315 Hz and 2 kHz within a wide speed range from 50 km/h up to 120 km/h separately for different noise generation mechanisms. Despite the fact that the model does not perform better than +/- 1 dB concerning the difference between calculated and measured overall noise levels and +/- 5 dB for spectral level differences it provides relevant information on the distribution of sound energy due to mechanical and aerodynamic processes within the tyre/road contact. This affords opportunity to characterize and develop road surfaces yielding reduced excitation of rolling noise which is presented by means of practically relevant examples.

Mon 16:50 Puccini Theatre Pre-colloquium 'Computation'

Closing words

Wolfgang Kropp[a] and Joachim Scheuren[b]

[a] *Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S);* [b] *Müller-BBM GmbH, Planegg*

Workshop "The overall quality in buildings: environment, energy, acoustics" (Friday)

Fri 9:00 Kursaal Workshop 'Overall Quality in Buildings'

Opening

Florian Mussner[a], Andrea Casolari[a] and Alessandro Peretti[c]
[a] *Assessore Provinciale ai Lavori Pubblici, Bolzano;* [b] *Assessore Comunale all'Ambiente e all'Energia, Merano;* [c] *Presidente Associazione Italiana di Acustica*

Fri 9:20 Kursaal Workshop 'Overall Quality in Buildings'

Road traffic noise exposure and its effects on health and quality of life

Peter Lercher
Division of Social Medicine, Medical University Innsbruck

Based on established exposure health relationships the supposed health burden of noise in terms of disability adjusted life years (DALY's) is mainly driven by severe sleep disturbance and severe annoyance (WHO 2011). Sleep disturbance impacts directly on health but is also thought to be a major intermediate in the pathway from exposure to traffic noise to impaired health. Established cardiovascular health effects contribute only 3 to 6% to the burden. About 85% of this burden is caused by road traffic noise. Train noise contributes up to 10% and aircraft around 3%. The availability of noise mapping data in Europe, has made it easier to link these noise data to existing large scale studies and further explore the relationship between noise and health. New relationships and susceptible disease groups have been reported recently, including stroke and diabetes. Also sources hitherto considered to exert only mild health effects (train noise) showed up as candidates for more serious effects. The potential combined effects of environmental noise with air pollution and vibrations are still neglected. Eventually, it should be noted that the exposure health relationships can vary widely from region to region and Environmental and Public health agencies should be aware of this fact.

Fri 9:35 Kursaal Workshop 'Overall Quality in Buildings'

The Noise Mapping in South Tyrol

Laura Fedrizzi

Agenzia Provinciale per l'Ambiente, Bolzano

Road traffic noise is considered one of the largest source of noise pollution in modern nations. The Environmental Noise Directive 2002/49/EC (END) prescribes to every member counties the drawing up of noise and strategic mapping, respectively for every specific noise source and for agglomeration according to fixed instructions. The Autonomous Province of Bolzano has drawn up the noise mapping for the roads of its competence as indicated in the Legislative Decree No. 194/2005 which has assimilated the END. The noise mapping represents a picture of an environmental noise situation in a specific territory related to noise descriptors that tell us if the law limit values are respected or not. In this work the data will be supplied on the number of people, dwellings and square kilometres of territory in South Tyrol exposed to the several bands of sound levels, without forgetting the damages exposure to environmental noise can cause.

Fri 9:50 Kursaal Workshop 'Overall Quality in Buildings'

Quality and sustainability in buildings: from design to testing

Ulrich Klammsteiner[a] and Antonino Di Bella[b]

[a] *Agenzia CasaClima, Bolzano;* [b] *University of Padova, Department of Industrial Engineering*

The issue of quality in buildings is often discussed separately from the point of view of energy saving, noise protection, environmental sustainability and urban planning. This approach greatly limits the possibility of a real integration between the different themes, with obvious consequences in cost management and achieving the required performance. The integrated design of the buildings is the solution to combine the best practices currently available in different technical fields, to optimize resources and to provide an adequate outcome to users' expectations. However, this tool requires a thorough understanding of the problems and the ability to effectively manage the different phases of the design and building construction. In this way the testing becomes not only the final verification, but also a method to improve experiences and solutions in buildings design.

Fri 10:20 Kursaal Workshop 'Overall Quality in Buildings'

The acoustic classification in Italy and Germany: perspectives and opportunities

Reinhard Neubauer[a] and Fabio Scamoni[b]
[a] *IBN Bauphysik Consult, München - COST TU0901;* [b] *CNR Istituto per le Tecnologie della Costruzione, Milano - COST TU0901*

In Europe, regulatory requirements concerning acoustic performance of buildings differ widely in performance descriptors and limit values. The comparison between the requirements defined in Italy and Germany has underlined considerable differences both on descriptors and on performance levels as well as on amplitude of the acoustic classes. A very important aspect for a harmonization of descriptors and expected levels of soundproofing classes is the knowledge of the problems and needs that are the basis of these requirements. Similarly, it is important to note that these requirements may affect the architectural and construction systems. From this point of view, the fulfillment of a specific acoustic class constitutes a constraint both technologically and economically.

Fri 10:50 Kursaal Workshop 'Overall Quality in Buildings'

The KlimaHaus Certification for non-residential buildings: acoustic comfort and evaluation protocols

Martina Demattio
Agenzia CasaClima, Bolzano

The KlimaHaus Program has been developed in order to guarantee a high quality level during the whole construction process of low-energy buildings. Since 2002 the KlimaHaus certification system is a widely recognized method. In the last three years the certification program has been upgraded in order to take into account a larger amount of parameters and an innovative sustainability project for non-residential buildings has been established. The KlimaHotel and KlimaHaus Work&Life guidelines represent the result of this applied research. The protocols offer a complete assessment method for hotels and office buildings, which allows to evaluate these complex structures in three fields: environmental impact, comfort aspects and economic factors. In order to consider the whole process the protocol is structured in three successive steps: pre-certification, certification and re-certification. Since acoustic comfort represents a crucial parameter in achieving a high quality level in hospitality and working structures, acoustic parameters control is one of the most significant requirements. In this presentation the requirements of acoustic comfort recommended by the KlimaHotel and KlimaHaus Work&Life certification programs are illustrated and the results of some case studies are presented.

Fri 11:10 Kursaal Workshop 'Overall Quality in Buildings'

Acoustical design and testing issues of multi-storey wooden buildings

Luca Barbaresi and Giovanni Semprini
University of Bologna, Dep. of Industrial Engineering

New buildings constructions with wooden structural panels are nowadays widely used, due to high thermal properties, good structural and seismic properties and for a more use of sustainable materials. Many solutions presents high acoustic performances due to multilayer structure with different thermal-sound insulation layers (coupling of wooden panels, insulating materials, plasterboards). In this paper some acoustic design aspects are analysed for typical prefabricated wooden structures: theoretical expression of sound insulation index for walls and impact sound pressure levels of floors, according to European standard, are analysed compared to some experimental measurements, showing the influence of flanking transmission paths for the in situ performances.

Fri 11:30 Kursaal Workshop 'Overall Quality in Buildings'

Problems of technical equipment integration in buildings

Roberto Zecchin and Valentina Raisa
Comitato Termotecnico Italiano

The increase of comfort level in buildings required by users is increasing and the need to integrate different types of networks makes complex the design and construction of building structures. On the other hand, consider that an increase in needs must be an adequate response in terms of technological solutions. These solutions cannot be separated from the building context and from the functions that take place inside it. The choice of a particular heating system or air conditioning, as well as the use of mechanical ventilation, cannot be independent of how the building will be used. The problems of integration of technological systems in buildings must therefore be addressed together with the definition of architectural choices.

Fri 11:50 Kursaal Workshop 'Overall Quality in Buildings'

Voluntary and mandatory standards in Italy

Giuseppe Elia
Presidente Commissione Acustica e Vibrazioni, UNI

In Italy, according to Framework Law 447/95, a decree, approved in 1997, concerning the acoustical requirements of the buildings, sets the limits for the sound insulation (of the facades and between rooms) , for the impact noise and for the equipment noise. In 2010 and 2012 UNI (Italian Organization for the Standardization) has published two standards, UNI 10367 and UNI 11444, regarding the acoustical classification of the buildings: these standards define the class limits, the methodology of the measurements and the sampling, the assessment criteria, the uncertainty calculation. Based on these UNI standards, the Italian Ministry of Environment has preparing a new decree, that has to substitute the old rule dated 1997. For the design of the acoustical building requirements, in Italy, at the moment,

there are not mandatory rules. UNI, in 2005, has published the technical report UNI TR 11175 , concerning the estimate of the acoustical performances of the buildings, adapting the European standards EN 12345 to the Italian building types. This technical document, fundamental guideline for the acoustical experts, is under revision.

Fri 12:05 Kursaal Workshop 'Overall Quality in Buildings'

Catalogue of structural elements in architectural acoustics

Georg Pichler
Agenzia Provinciale per l'Ambiente, Bolzano

The increasing importance of acoustic comfort for new buildings and the difficulties with which engineers and constructers are faced complying these requests, led to the compilation of a reference book of easy usage and comprehension, containing the main types of structural elements of common use in South Tyrol. The catalogue contains more then 150 solutions, which have been tested in situ in the past 7 years and respected the minimal acoustical requirements prescribed by Italian legislation. The choice of presenting the measured in situ values is due to the experience that certified laboratory results differ often severely from the actual results obtained at finished buildings. The in situ t results include also the lateral transmissions and the errors made during the installation of the elements. Beside the forms containing the satisfactory solutions the catalogue includes for comparative reasons some results influenced by evident mistakes made during planning and construction. The structural elements included in the catalogue are: compartment floors, walls between dwelling units, walls between rooms of different usage, external walls and roofs - in traditional building technique, in timber constructions and dry constructions technique. The catalogue is a work in progress, open to new solutions from engineering and the market.

Fri 12:20 Kursaal Workshop 'Overall Quality in Buildings'

Discussion

Fri 12:50 Kursaal Workshop 'Overall Quality in Buildings'

Conclusions

Ulrich Santa
Agenzia CasaClima, Bolzano

Paper and poster sessions Tuesday 19.03.2013

Session "Speech quality perception and assessment"

Tue 15:30 Kurhaus meeting room 1 Speech quality perception

Speech intelligibility in realistic listening situations for different numbers, azimuths and movement of speech or noise maskers

Martin Hansen, Felix Dollack, Geske Eberlei, Hannah-Lina Grahlmann, Wiebke Lamping and Stefan Raufer
Jade-Hochschule Oldenburg

Speech intelligibility in a noisy environment can be measured with different standardized test methods. However, most of these speech audiometric methods lack a close correspondence to real-life situations. For example, sound signals in everyday life can arrive from different directions, rather than being presented via headphones or by one or a few fixed loudspeakers.

In this study, speech reception thresholds (SRTs) were measured for virtual sound sources generated in a wave field synthesis system. The masker signals were either noise or intelligible speech. For both masker types, a number of n=1,2,3,4, or 8 maskers were placed at positions with semi-random azimuth angles around the test subject in order to simulate a cocktail party situation. The masker(s) could either be fixed in place or could move circularly around the subject, while the target speech signal always came from the front. The results from 22 normal-hearing subjects showed that SRTs for the speech maskers increased significantly with increasing number of maskers. For the noise maskers, however, their number had a much smaller influence on the resulting SRTs. The use of either fixed or moving masker(s) gave only minor differences, with a tendency of slightly elevated SRTs for moving maskers.

Tue 15:50 Kurhaus meeting room 1 Speech quality perception

Comparison of Approaches for Summative and Diagnostic Prediction of Speech Quality

Sebastian Möller[a], Nicolas Côté[b], Timothée Mannoury[c] and Marcel Wältermann[a]
[a] *T-Labs, Quality and Usability Lab, TU Berlin;* [b] *IEMN, UMR CNRS 8520, ISEN department, Lille;* [c] *ENSEIRB-Matmeca, Talence (F)*

In the past years, two types of models have been developed for predicting transmitted speech quality. One type of model predicts the overall quality of the transmission channel, either on the basis of signals or of parameters, in a summative way, taking the transmission channel mouth-to-ear into account. The outcome is an overall quality estimate. The other type of model aims at diagnosing potentially impactful quality characteristics, in terms of perceptual features which may pinpoint to particular aspects of the transmission channel which need special attention. The outcomes are estimators for perceptual dimensions such as coloration, discontinuity,

noisiness or loudness. In this contribution, we will compare different implementation of such models on common databases in order to analyze their prediction power. On the summative side, we will compare the former ITU-T standard P.862.2 (WB-PESQ) and the new standard P.863 (POLQA) which are based on signals, as well as the parametric E-model (G.107.1) which is based on parameters. On the diagnostic side, we present the results of signal-based DIAL (Côté, 2011) and parametric DNC models (Wältermann, 2012). We will put a particular emphasis on transmission characteristics where these models still show limitations, and propose ways for their improvement.

Tue 16:10 Kurhaus meeting room 1 Speech quality perception

Hearing-adequate Assessment of Background Noise Modulation in Conversations

Frank Kettler, Marc Lepage and Simon Stark
HEAD acoustics GmbH

Environmental noise present during telephone conversations is typically transmitted via the terminals to the conversation partner at the far end - a scenario which is very typical when using mobile phones or automotive hand-free implementations. The background noise is processed by noise reduction algorithms but may additionally be modulated by echo suppression in the terminals. This often leads to an audible and annoying noise contrast at the far end side, depending if the user on this side is talking or listening only. Up to now current standards for terminal tests verify this modulation by a rudimentary ”one dimensional dB value”, which often gives room for interpretation by test engineers. This contribution discusses an analytical model for the hearing-adequate analysis of such talking-related modulations in terminals. The method provides MOS-like scores from laboratory test results. It is applicable in narrowband and wideband scenarios and shows a high correlation to the results of listening tests.

Tue 16:30 Kurhaus meeting room 1 Speech quality perception

Noise Intrusiveness Factors in Speech Telecommunications

Raphael Ullmann[a], Hervé Bourlard[a], Jens Berger[b] and Anna Llagostera[b]
[a] *Idiap Research Institute, Martigny (CH);* [b] *SwissQual AG, Zuchwil (CH)*

We present results from three subjective tests following the ITU-T Rec. P.835 test protocol. Short sentences modeling telephone conversations in noisy environments (e.g. informing about a train delay, asking somebody to join a party) were recorded from 4 native french talkers as both regular and lombard speech. The lombard effect was provoked by playing back environmental noise recordings fitting the speech content over closed headphones worn by the talkers. The noises were then added to both types of clean speech recordings, and the noisy mixes transmitted over various live channels, or processed with offline speech coding and noise reduction systems. Subjects were asked to rate speech distortion, noise intrusiveness and overall quality of the such generated samples.
Besides signal-to-noise ratio, noise type and signal bandwidth, we investigate the effect of coding distortions and channel errors on the three quality

scales. One particular focus is on the perceived noise intrusiveness in lombard vs. regular speech recordings for identical distortions, by means of a dedicated test with duplicated conditions. We further compare the effect of synthetic/un-recognizable noises to noises matching the speech content.

Tue 16:50 Kurhaus meeting room 1 Speech quality perception

Towards a new test paradigm for the subjective quality assessment of conversational speech

Friedemann Köster and Sebastian Möller
T-Labs, Quality and Usability Lab, TU Berlin

A conversation between two people is what communication systems are mostly used for. Considering this, research towards the quality assessment of conversational speech is highly relevant, yet a challenging task, since conversations are very complex and multidimensional processes. For the listening situation, perceptual dimensions have already been identified, e.g. Wältermann(2012). For talking and interacting, such perceptual dimensions are mostly unknown. A new approach towards quantifying perceptual dimensions in different phases of a conversation is introduced and linked to the usefulness in quality assessment, concerning the difficulties in collation of reliable results. Subsequently a design for a novel test paradigm with the focus on these different phases is presented. The results of an initial test will be pointed out and analyzed.

Tue 17:10 Kurhaus meeting room 1 Speech quality perception

Experience and insights on the new ITU-T standard on quality assessment of conferencing systems

Janto Skowronek, Katrin Schoenenberg and Alexander Raake
Assessment of IP-based Applications, TU Berlin

Since July 2012, the new ITU-T recommendation P.1301 ”Subjective quality evaluation of audio and audiovisual multiparty telemeetings” is in force. This standard gives recommendations on how quality assessment tests should be conducted for multiparty communication systems; bearing the goal in mind to obtain results that are comparable between studies.
This conference contribution explains the major aspects that play a role when it comes to the quality assessment of multiparty settings. In addition, the contribution will outline how corresponding conversation or listening-only tests should be conducted accordingly to these recommendations.
Furthermore, this contribution touches published work that was used as input to the standard, augmented by providing experiences and insights regarding the development and application of this standard. A final discussion about advantages and room for improvement as well as ideas for future work closes this contribution.

Tue 17:30 Kurhaus meeting room 1 Speech quality perception

Some Results on the Objective Assessment of Speech Quality for Speech Enhancement Algorithms

Michael Buerger[a], Klaus Reindl[a], Sven Nordholm[b] and Walter Kellermann[a]

[a] *Chair of Multimedia Comm. and Signal Proc., FAU Erlangen-Nürnb.;* [b] *Curtin University, Dept. of Electrical and Computer Engineering*

In order to objectively assess the perceptual quality of speech signals processed by speech enhancement algorithms, different perceptually motivated models and evaluation measures have been introduced, such as the *Bark Spectral Distortion (BSD)* measure, the *Perceptual Evaluation of Speech Quality (PESQ)* measure, or the *Perceptual Similarity Measure (PSM)*. The purpose is to provide an instrument, which reliably represents perceptual speech quality without the need for carrying out time-consuming listening tests. A comprehensive analysis of many different evaluation measures was conducted in 2010 by Goetze et al. in the context of listening-room compensation. The authors showed that among all examined measures, PSM achieved the highest correlation with subjectively perceived quality. In the same year, the *Perceptual Evaluation of Audio Source Separation (PEASS)* framework was presented by Emiya et al. In contrast to previous approaches, PEASS provides additional measures which, e.g., explicitly rate the amount of artifacts ntroduced by the algorithms. In this contribution, we compare the performance of PEASS with PSM and show possible limitations, especially for speech enhancement, where various signal characteristics are considered, e.g., different types of interfering sources or reverberation.

Tue 17:50 Kurhaus meeting room 1 Speech quality perception

Long-term impact of varying multimedia service performance on quality ratings in a multiservice scenario

Dennis Guse and Sebastian Möller

T-Labs, Quality and Usability Lab, TU Berlin

For IP-based multimedia service providers service performance is an important factor as the Quality of Experience (QoE) influences user satisfaction, which in turn affects future usage behavior. We propose to complement the current state- of-the-art approach to QoE from short-term, i.e. single service usage scenarios, to cover multiple-interactions over longer periods to determine long-term effects on QoE. In the present study, we focus on Voice-over-IP (VoIP) and audio-visual streaming (IPTV). We conducted a user study with 20 participants over 15 days providing VoIP and IPTV usage each day. The performance of each service could be controlled for each day in terms of available bandwidth for IPTV and packet-loss for VoIP. We found that low performance events immediately influenced the QoE- ratings. However, following QoE ratings were influenced as participants somehow integrate prior experiences into their current QoE rating. It takes at least one day to recover up to the level prior the low performance period after the end of a low performance period.

Tue 18:10 Kurhaus meeting room 1 Speech quality perception

Flow Behaviour of the Glottal Jet in 2D versus 3D CFD modelling

Christoph Brücker, Willy Mattheus and Michael Triep
TU Freiberg, Institut für Mechanik und Fluiddynamik

The vortex dynamics of the flow in three distinct numerical models (2-dimensional (2D), 3D slit-like, 3D lens-like) of the glottal gap is studied and compared. Already through theoretical considerations on the basis of the vorticity equation, which describes the transport of vorticity, there must be a significant difference in the flow field between the 2D and 3D cases.This paper presents the flow results on the jet formation, evolution and disintegration in the aforementioned glottal models. In the simulations the flow and wall motion are prescribed and the open source computational fluid dynamics (CFD) solver OpenFOAM is used. The 3D nature of the glottal jet is shown. Furthermore, a significant deflection of the glottal jet occurs in case of the slit-like geometry, contrary to the 3D lens-like one. The results show the dependency of jet entrainment and vortex dynamics on the glottal orifice geometry. Also, the effect of a tilted glottal orifice on the 3D flow is considered. The different redistribution of the vortex structures in all cases possibly lead to a case specific character of the flow-induced primary acoustic sources in the region downstream the glottis. Effects on the acoustical spectrum are deduced.

Tuesday Speech quality perception (Poster)

Correlations of Reverberant Speech: Parameter of Event-Related-Potentials (ERP) and Subjective Ratings

Jan-Niklas Antons[a], Khalil Ur Rehman Laghari[b], Robert Schleicher[a], Sebastian Arndt[a], Tiago H. Falk[b] and Sebastian Möller[a]
[a] *T-Labs, Quality and Usability Lab, TU Berlin;* [b] *MuSAE Lab, INRS-EMT, University of Quebec*

Speech quality assessment usually depends on subjective judgments after listening to test stimuli. The obtained subjective quality indices are valid and reliable but provide little insight into the underlying perceptual process. Since reverberation is known to influence perceived speech quality and intelligibility, e.g. in conference calls while using a loudspeaker. We analyzed the performance of electroencephalography (EEG) which measures brain activity on cortical level for indicating speech stimuli with a high reverberation time as degradation. We used a database of 22 subjects to test the ability of utilizing EEG-data - especially parameters of event-related-potentials (ERP) - to identify the processing of a stimulus with a high reverberation time. The reported preliminary findings provide promising insights: indirect measurement of perceived stimulus quality - without asking for the subjects' opinion - are sensitive to reverberant stimuli. Correlations between physiological parameters and stimulus features showed that quality degradations can be monitored in conscious stages of stimulus processing. We show that the analysis of ERP is in general a useful and valid tool in quality research. In the case of reverberation, this can actually lead to the indirect measurement of perceived quality with respect to changes of room acoustic.

Tuesday Speech quality perception (Poster)

Evaluation of objective full reference model scores under realistic application constraints

Michal Soloducha, Janto Skowronek and Alexander Raake
Assessment of IP-based Applications, TU Berlin

Two full-reference speech quality assessment models are currently in use for evaluating telephony systems, for example during intrusive service monitoring: PESQ (ITU-T Rec. P.862) and P.OLQA (ITU-T Rec. P.863). Recent studies have shown that, depending on which speech samples are used for testing a system, different results may be obtained. The aim of this paper is to systematically investigate how quality predictions by these models vary for different speech samples of different languages under different real-life network conditions. Several measurements have been conducted using a test network using different VoIP clients. Utterances in 9 different languages such as English, German, Italian and Japanese from ITU-T Rec. P.501 were used for this purpose. The results show that there is a measurable language dependency of the quality scores. The paper analyses the range of prediction-variation resulting from the use of different samples, in comparison with the variation resulting from different network settings. Based on this comparison, implications for network operators and system manufacturers are being discussed.

Session "Uncertainties in the evaluation of environmental noise"

Tue 15:30 Kurhaus meeting room 2 Uncertainties in evaluation

On the Uncertainty according to ISO/IEC Guide 98-3 of the Equivalent Continuous Sound Pressure Level in Presence of Background Noise

Alois Heiß
VDI, Garching

The determination by measurement of an equivalent continuous sound pressure level (SPL) usually requires the elimination of a systematic level shift caused by the superposition of background noise. Additionally the unavoidable uncertainty of the result due to random fluctuations, including the contribution by the background noise, should be taken into account explicitly. If the sound source whose SPL is to be determined can be switched on and off temporarily, the model according to ISO/IEC Guide 98-3 for the dependence of the final result on certain input parameters simply is the difference of the equivalent continuous sound pressure levels between the total and the background noise. By the sensitivity coefficients for the total and the background noise, derived from the model, the combined standard uncertainty of the equivalent continuous SPL of the sound source can be calculated. This uncertainty shows to be strongly dependent on the level difference between total and background noise. By transition into the physical, i. e. antilog variable space a resolution limit in dB, due to uncertainty, can be defined. Examples for the evaluated combined standard uncertainty and the associated resolution limit are presented.

Tue 15:50 Kurhaus meeting room 2 Uncertainties in evaluation

Variations and uncertainties of measurements due to meteorological conditions - Existing guidelines and practical application

Dieter Hohenwarter[a] and Christian Kirisits[b]
[a] *TGM Versuchsanstalt Wien;* [b] *Kirisits Consulting Engineers and Medical University of Vienna*

Sound propagation of railway and road traffic noise varies substantially depending on meteorological conditions. These variations result in major uncertainties for sound measurements and calculations if these effects are not taken into account appropriately. The general knowledge of the variation of the sound level as a result of meteorology is included in guidelines in different ways and can lead to different results. When comparing measurements with calculations they should be performed assuming the same propagation condition, usually favorable or at least neutral conditions. As an example the comparison of different concepts of the guidelines to determine the influence of meteorology to sound propagation is compared with measurements of railway noise. During this noise measurement the meteorology conditions were measured and taken into account in detail. The change of the A-weighted sound level as a result of the meteorology is compared with the classification mentioned in the different guidelines.

Tue 16:10 Kurhaus meeting room 2 Uncertainties in evaluation

Accuracy of Temporal Samplings of Non-urban Road Traffic Noise

Alessandro Bisceglie[a], Giovanni Brambilla[b], Veronica Gallo[b], Fabio Lo Castro[b] and Giovanni Zambon[a]
[a] *Università degli Studi Milano Bicocca;* [b] *CNR-IDASC, Roma*

The legislation on road traffic noise often requires the determination of its acoustic descriptors on medium or long-term. The available instrumentation enables to perform such measurements as they can store and transmit a huge amount of data. However such duration is not feasible for attending monitoring and, therefore, requires the time-consuming post processing validation of the acquired data. On the other hand, use of temporal samplings enables attended monitoring and avoids the data validation, as well as improving the spatial resolution of sampling. However, the estimated values of the noise descriptor are affected by inaccuracy which depends on the ratio between the total measurement time and the long term, as well as on the variability of the noise immission at the receiver. The paper describes the results obtained from the statistical analysis of LAeq data taken from continuous monitoring during weekdays at several sites alongside the network of non-urban roads in the Lombardia region in Italy. The accuracy of the following sampling rates: 1) 5, 10, 15, 20, 30 minutes for the estimate of hourly LAeqh; 2) LAeqh for estimating the LAeqday and LAeqnight; have been determined considering the traffic flow too.

Tue 16:30 Kurhaus meeting room 2 Uncertainties in evaluation

Some outcomes from the Italian round robin tests on road traffic noise measurement

David Casini
ARPAT - AVC - Settore Agenti Fisici

In the last few years two interlaboratory comparisons were carried out to test the Italian method for measuring road traffic noise. An important feature of this environmental source is that its sound emission and its outdoor propagation are not stationary and therefore it is difficult to operate in compliance with the usual technical standards in order to determine the repeatability and the reproducibility of the measurement method. Actually repeated measurements by one laboratory and independent measurements of each participant are not strictly feasible on the same measurand as traffic and meteorological conditions are fluctuating. In spite of such difficulties it was possible to determine the reproducibility and to give a rough estimate of the repeatability, by means of simultaneous measurements of all the participants. The planning and the organization of the two measurement campaigns and the data analysis are discussed, as well as a methodological proposal is provided for interlaboratory comparisons on non-stationary environmental noise sources. Moreover, from the analysis of the results, a first evaluation of the uncertainty associated with road traffic noise measurement is pointed out and a critical review of some aspects of the Italian method is given in the paper.

Tue 16:50 Kurhaus meeting room 2 Uncertainties in evaluation

Overview of Round Robin Tests in Austria

Christoph Lechner
Amt der Tiroler Landesregierung

In Austria there is a long tradition of round-robin-tests opertated within the framework of Forum Schall. The Author has organized and analyzed in situ building acoustic measurement (2001), measurement of various environmental noises (2003), comparison of different measurement methods for road traffic noise (2005), measuring sound insulation of external building components (2007), comparative calculations of environmental noise (2008) and measurement of acoustic emissions (2010). An overview and comparison of the results are given and the consequences for evaluation environmental noise are discussed.

Tue 17:10 Kurhaus meeting room 2 Uncertainties in evaluation

Assessing the Repeatability and Reproducibility of In Situ Measurements of Sound Reflection and Airborne Sound Insulation Index of Noise Barriers

Massimo Garai[a], Paolo Guidorzi[a] and Eric Schoen[b]
[a] *University of Bologna, Dep. of Industrial Engineering - DIN;*
[b] *TNO, Zeist (NL)*

In situ measurements of sound reflection and airborne sound insulation of noise barriers are usually done in Europe according to CEN/TS 1793-5. These methods have been substantially improved during the EU funded QUIESST project. In the frame of the same project, an inter-laboratory test has been carried out in order to assess the repeatability and reproducibility of the newly developed methods when applied to real-life samples. In this paper the main outcomes of the QUIESST inter-laboratory test are presented and discussed. The values of repeatability and reproducibility of sound reflection index and airborne sound insulation index are shown both in one-third octave bands and for the single-number ratings.

Tue 17:30 Kurhaus meeting room 2 Uncertainties in evaluation

Uncertainty in declared sound power emission of household appliances: state-of-the-art and new approaches

Franco Bertellino
MICROBEL s.r.l., Rivoli

EU noise directive 86/594/EEC is a community legislation in force regarding measurement and declaration of noise emissions from household appliances of any kind. Yet, EU exercises its power without any noise limit for this kind of noise sources.Noise data available to typical customer has been frequently limited so far, but the concern for noise at home pushed towards a mandatory declaration of noise emission. Noise has to be declared taking into account the uncertainty of measurement, and this uncertainty is associated to many potential causes. Italy and Germany are the main manufacturers of appliances in Europe and among the main ones throughout the world, and their behavior in declaring noise emission is outstanding in order to fulfill the European approach. This paper intends to investigate the current procedures to be applied by each manufacturer when assessing and declaring noise emissions, taking into account the typical problems associated with noise declarations of such commercial products in Italy. More, the paper would like to investigate which are the new approaches introduced to qualify the human perception of appliances' noise, requiring new rules as well.

Tue 17:50 Kurhaus meeting room 2 Uncertainties in evaluation

Quality Assurance of Calculation Methods implemented in Software
Wolfgang Probst
DataKustik GmbH
Quality assurance of software for the calculation of sound emission and propagation is important if such methods and tools shall be applied to check if calculated results are in accordance with legal requirements. Based on many years of experience with the German DIN 45687 and on some other national activities a new ISO project started in 2011 to come to an International accepted procedure. The main aspects discussed in the frame of the project ISO 17534 are presented and it is shown what consequences arise if new calculation methods are developed or if existing standards are modified. The broad application of software even by persons that are not experts in acoustics produces strong requirements about the architecture and the definition of the range of application of calculation standards. The main aspects are discussed and examples are presented.

Session "Rail/wheel noise 1"

Tue 15:30 Kurhaus conference room Rail/wheel noise 1

The STARDAMP method - Assessment of damping technologies for rail and wheel to reduce railway noise
Helmut Venghaus
Schrey&Veit GmbH
A new railway line is being planned and a consulting office is assigned to formulate a noise abatement plan. To meet the noise emission limiting values, a 3 dB noise reduction is necessary. Several manufacturers of rail dampers are offering a wide range of products claiming to reduce noise. But which, if any, can meet the reduction target for this specific track and its associated traffic? Furthermore, how can a manufacturer prove that their product complies with the specifications?
Scenarios such as the one described above were (partly) the motivation of the French-German cooperation project STARDAMP. After more than two years of research work, the project was successfully concluded at the end of 2012. The main target of STARDAMP was to transfer R&D conducted by damper manufactures, research institutes and end-users to develop an easy-to-use assessment method that is less expensive than field tests. The STARDAMP-method is based on laboratory measurements on a single damped wheel or freely suspended short lengths of rail fitted with dampers. It also includes a specially developed software-tool for predicting rolling noise reduction using the results of the laboratory tests.
This contribution summarizes the results of STARDAMP and provides user examples of the developed methods.

Tue 15:50 Kurhaus conference room Rail/wheel noise 1

The STARDAMP Software: An Assessment Tool for Wheel and Rail Damper Efficiency

Benjamin Betgen[a], David Thompson[b] and Giacomo Squicciarini[b]

[a] *VIBRATEC France;* [b] *Univ. of Southampton, ISVR, Dynamics Group (UK)*

STARDAMP (Standardization of damping technologies for the reduction of railway noise) is a Franco-German research project within the DEUFRAKO framework that unites end users, manufacturers and research institutes. The target of STARDAMP is to support the transfer from R&D of wheel and rail dampers to their regular application. A software tool has been developed within STARDAMP that is dedicated to the prediction of the efficiency of wheel and rail dampers. The necessary input can be produced using relatively simple laboratory measurements. The rail response is assessed by combining track decay rates measured on a real track with decay rates measured in laboratory on a free rail that is equipped with dampers. The wheel response is calculated by using a finite element model of the wheel together with measured damping data. The tool is designed not only for the use by experts within the development of wheel and rail dampers. Indeed, a main goal of STARDAMP was to provide an easy-to-use tool to infrastructure managers and public authorities in order to help the decision making process regarding railway noise mitigation measures.

Tue 16:10 Kurhaus conference room Rail/wheel noise 1

Variation of rolling noise during train pass-bys

Michael Dittrich

TNO Technical Sciences

Pass-by noise measurements on different types of tracks sometimes display a significant difference between the rise and decrease in rolling noise at the front and the back of the train. Whilst this may not necessarily be relevant for the total pass-by noise level, it seems to indicate that the characteristics of the railpads or fastening system vary during the pass-by. This effect has been observed on tracks with soft railpads and is clearly visible in a spectrogram taken over sufficiently long measurement time. One possible explanation would be variation due to the impact loading of railpads, causing internal temperature rise in the railpad material and thereby a change in vibroacoustic behavior. Some examples of this phenomenon are presented and discussed in this paper.

Tue 16:30 Kurhaus conference room Rail/wheel noise 1

Noise Emission Calculation of Rail Vehicles and Railway Tracks

Christian Czolbe[a] and Micha Köpfli[b]
[a] *PROSE AG, Winterthur (CH);* [b] *LCC Consulting AG Software Engineering, Zürich*

Noise emission data are key parameters for environmental noise studies with high accuracy. To determine noise emission of vehicles different methods from type tests over analytical numerical simulations to frequency content calculations are available. For track sections and current transport mixes always a calculation of train configurations is needed. Rolling noise is dominating the noise emission of conventional railways up to 250 km/h speed. Furthermore the rolling noise level is depending on wheel and rail roughness as well as dynamic track parameters. The sonRAIL Emission tool offers different input possibilities for vehicle noise calculation and railway emission calculation depending on rail roughness and dynamic properties of the track section. Vehicles and trains can be chosen from a database or calculated from separate input data of vehicle measurements or simulations. The uncertainty of the result is depending of the quality of input data. Depending on the relevance of sound sources at the entire railway line configuration the uncertainty is presented at the noise emission result. The sonRAIL web application of the Swiss federal office of environment is available for administration, planners, manufacturers and operators.

Tue 16:50 Kurhaus conference room Rail/wheel noise 1

Study on Rail Roughness Embedding the Noise Indicator L(Lambda,CA)

Helmut Venghaus
ACCON Italia Srl.

A main criterion of noise emissions of railtracks is to some extent the rapid and differing growth of rail roughness. Detailed investigations of noise at railway tracks in Dusseldorf and the related track superstructure and rail roughness growth were undertaken. Additional analysis was carried out of the statistical distributions of rail roughness collected using a measurement trolley, based on data over different tracks with various lengths. Utilising this analysis a greater understanding of the roughness growth is possible. As well as the fundamental analysis about roughness growth, by this long distance measuring method, it is possible to quantify the noise emission of the track by the noise indicator LλCA and defining local hot spots with an extreme rapid roughness growth. Doing statistical analysis a new tool for noise management for railway tracks can be established with which the noise emission of rails can be kept to an acceptable level.
This paper explains the approach of the statistical analysis and how LλCA is embedded. Furthermore, some ideas are presented about the implementation of this method within noise calculation software with the aim of simplifying the requirements for government and operating companies by implementing noise mitigation measures and achieving overall noise reduction.

Tue 17:10 Kurhaus conference room Rail/wheel noise 1

Measurements of the Effectiveness of Measures for Reducing Low Frequency Noise of Railway Bridges

Manfred Liepert and Alexander Martens
Möhler + Partner Ingenieure AG

The project "Konjunkturprogramm II" of the federal government was induced to test 13 innovative technologies to reduce sound and vibration emitted by railway lines. One part was the reduction of low frequency noise emitted by bridges. The focus at bridges is on the abatement of vibrations originated by the rails transferring to the structure of the bridge. By this way sound emission and the annoyance because of low frequencies radiated by the construction of the bridge can be reduced. Because of the different types of bridges (i.e. without or with ballast, steel bridges or concrete bridges) there are different types of measures to insulate the vibrations. Other measures, as used on the normal track, can help additionally to reduce the overall sound emitted by the bridge. The effectiveness of some examples of measures is demonstrated at three bridges, where measurements were taken. The results of these measurements will be shown.

Tue 17:30 Kurhaus conference room Rail/wheel noise 1

Experimental Tests on Alternative Methods of Noise Reduction on the Brenner Railway line

Günther Wanker
Agenzie Provinciale per l'Ambiente, Bolzano

The narrow valley with many curbs increases noise exposition and related complaints by the population living on the slopes along the main Brennero railway line. The Environmental Agency of the Province of Bolzano-Bozen in collaboration with Rete Ferroviaria Italiana, Technische Universität Berlin and Studio Pasquali-Rausa Engineering is therefore testing the noise reduction of rail dampers and lubrication devices as an alternative to noise barriers on the main Brennero railway line near Bolzano. Comparison of noise levels depending on train types and speed between three 100 m straight track segments with two different kind of rail dampers and a reference segment are going to be made. In addition roughness and track decay rate on the three segments are going to be compared. In a bend near the city of Chiusa-Klausen two lubrication devices at both entrances of the curb have been installed. Noise level and rail acceleration depending on train types and speed will be compared before and after the installation of the devices. Ante operam measurements and the installation of the rail dampers and the lubrication devices have been made in the last month. Post operam measurements are planned for the coming month of November.

Tue 17:50 Kurhaus conference room Rail/wheel noise 1

Railway Noise Mitigation Measures at the Isarco Valley

Christian Czolbe[a] and Robert Sieglitz[b]
[a] *PROSE AG, Winterthur (CH);* [b] *PROSE Berlin GmbH*

On European transit routes for conventional railways and with a high content of freight transport noise emission is high. At special situations in valleys sound can propagate long distances with low transmission loss and affect large residential areas. The effect of conventional noise barriers in these situations is marginal. To reduce railway noise significantly measures at the source are necessary. Firstly the rolling stock should be treated by retrofitting of freight wagons from cast iron brake blocks to composite blocks and the use of low noise bogie designs. In most cases regional administrations are not able to force operators on vehicle retrofitting. On behalf of the government of the Isarco Valley PROSE was requested to investigate current situations and to present innovative solutions for railway noise mitigation. After local observation rail corrugation was detected at curves with radius below 300m. Rail corrugation leads to high low frequency content on rolling noise and to noise impacts over long distances. PROSE also investigated alternative noise reduction measures at the track as well as on operation. Practical solutions from this study are presented. Currently from this recommendations rail conditioning systems, track maintenance and a prototype test of rail dampers are investigated.

Tue 18:10 Kurhaus conference room Rail/wheel noise 1

AcouTrain - Virtual Testing in the Framework of TSI-Rail Vehicle Certification

Maria Starnberg[a], Estelle Bongini[b], David Thompson[c], Ulf Orrenius[d] and Nathalie Cuny[e]
[a] *DB Systemtechnik GmbH, München;* [b] *SNCF Innovation and Research Department;* [c] *University of Southampton, ISVR, Dynamics Group (UK);* [d] *Bombardier Transportation, Västeras (S);* [e] *ALSTOM Transport, La Rochelle*

The TSI noise came into force in year 2006 and sets limiting values for noise emission of new or upgraded railway rolling stock. The aim is to put pressure on the suppliers and manufacturers to develop quieter products and contribute to a reduction of environmental noise in Europe. Today, the conformity assessment is carried out according to established standards for measurements in field. This can be a very costly and time consuming process, which includes measurements of stationary-, starting- and pass-by noise.

ACOUTRAIN is a FP7 EU founded European research project with the main goal to reduce the expenses of the vehicle certification e.g. by developing virtual testing-methods to complement or even replace some of the required measurements. Virtual testing is already extensively used today by manufacturers during the design phase of new railway vehicles. The concept is to calculate the noise emission by creating a model of the vehicle in a specific software tool. The sound power levels of the single sources

serve as input to the model and by summing these up and taking acoustic propagation rules into account, a pass-by noise measurement can be simulated.
This presentation gives a general introduction to the ACOUTRAIN project.

Session "Modelling outdoor sound propagation"

Tue 15:30 Kurhaus Czerny hall Outdoor sound propagation

An Efficient Method to Calculate the Insertion Loss of a Rigid Barrier
Weigang Wei, Timothy van Renterghem and Dick Botteldooren
Department of Information Technology, Ghent University
An efficient method for calculating the sound insertion loss of thick and thin rigid barriers is presented which is based on a simplification of the Fresnel integral in Pierce's diffraction model. Pierce developed a model to calculate the diffracted sound field using Fresnel integrals. In our new model, the Fresnel integral is replaced by a combination of trigonometric functions and the formula of the barrier insertion-loss can be considerably simplified. This model is verified over a wide frequency range by comparing to the non-simplified Pierce method and finite-difference time-domain simulations with and without ground reflections. The major improvements of the methods are 1)the new method of calculating the barrier insertion-loss is much simpler than the non-simplified theoretical method; 2) performs well for both thin and thick barriers; 3) coincides well with theoretical diffraction formulas and numerical simulations; 4) the calculation time is strongly reduced compared to using Fresnel integrals.

Tue 15:50 Kurhaus Czerny hall Outdoor sound propagation

Area-Wide Time-Domain Simulation of Sound Propagation in Complex Terrain
Dietrich Heimann
DLR Institut für Physik der Atmosphäre, Weßling
Sound propagation in areas with a structured topography is known to be rather complex because it is simultaneously affected by the terrain and the topographically modified meteorological fields. Hence, sound encounters changing topographical and meteorological conditions while it propagates to the receivers. Different parts of these areas are differently influenced by these effects and changing weather conditions lead to a high temporal variability. It is therefore worthwhile to investigate what parts of an area are especially sensitive to changing propagation conditions and what weather situations would cause high local sound impacts. Finite-difference time-domain (FDTD) propagation models are principally suited to consider meteorological and topographical effects. However, they are very demanding and area-wide 3D simulations in the relevant outdoor frequency range are simply not feasible. However, low-frequency simulations ($<$ 10 Hz) would require much less numerical grid cells and would enable larger numerical time steps. This would allow model domains of some kilometers extension. The presentation shows that low-frequency FDTD simulations, coupled to the results of meteorological mesoscale simulations, can be used for

qualitative assessments of the topographical and meteorological influences even on audible sound. Applications refer to railway noise during a six-day observing period in the Middle Rhine valley.

Tue 16:10 Kurhaus Czerny hall Outdoor sound propagation

The influence of the urban flow field modelling approach on computing sound propagation over the urban roof level

Maarten Hornikx, Karin Conen, Twan van Hooff and Bert Blocken
Building Physics and Services, Eindhoven Uni. of Technology

The contribution of distant traffic on noise levels in the urban environment is strongly dependent on atmospheric wind conditions. Under certain downward refracting conditions, distant traffic could be the dominant noise source. Prediction of the effect of atmospheric wind conditions on sound propagation is complicated for urban environments, which in European cities typically consist of multiple street canyons. A prediction based on numerical calculations is therefore needed to quantify the effect of atmospheric wind conditions, both concerning the acoustic propagation method, as well as for obtaining the mean flow field. For the latter, CFD calculations have been carried out by means of steady Reynolds-Averaged Navier- Stokes (RANS) simulations as well as unsteady Large Eddy Simulations (LES). Then, sound propagation over the urban roof level is computed in the presence of the mean flow field as computed from RANS or LES. This is carried out by solving the linearized Euler equations using the PseudoSpectral Time-Domain (PSTD) method. Results show the influence of the used CFD method with respect to quantifying the effect of atmospheric wind conditions on sound propagation over the urban roof level.

Tue 16:30 Kurhaus Czerny hall Outdoor sound propagation

Numerical and experimental validation of the Transmission Line Matrix model under meteorological conditions

Gwenaël Guillaume, Pierre Aumond and Benoit Gauvreau
LUNAM Université - Ifsttar

Since last decade, numerous works have dealt with time-domain modelling in environmental acoustics. Recent developments of the Transmission Line Matrix method allows to model outdoor sound propagation over impedant grounds and complex topography. The present paper treats about the modelling of micrometeorological effects (wind and temperature) through the introduction of the effective sound speed in the TLM model. The necessary wavefront direction is determined through the calculation of the averaged intensity vector direction. The proposed formulation is first validated by comparing TLM simulations with Parabolic Equation method results. Then, the model is compared with experimental (acoustical and meteorological) data issued from in-situ measurements. The numerical simulations of wind and temperature fields are also carried out using the french reference meso-scale meteorological model (Meso-NH - Meteo-France weather agency) at very fine scales (up to 1 m), including new developments (drag force approach), in order to get the input data of the acoustic propagation model. The relevancy of the TLM model is shown under different

propagation conditions through the comparison of simulated and measured sound pressure levels. Satisfactory results are obtained regarding the variability of the observed phenomena. [[english]]

Tue 16:50 Kurhaus Czerny hall Outdoor sound propagation

Modelling meteorological Influences on the Sound Propagation through Forest Areas

Astrid Ziemann[a], Gabi Fischer[b] and Valeri Goldberg[a]

[a] *TU Dresden, Professur für Meteorologie;* [b] *Universität Leipzig, Institut für Meteorologie*

Forest stands significantly influence the properties of the atmospheric boundary layer. To simulate the meteorological regime in forest stands and clearings the coupled vegetation-atmosphere model HIRVAC (HIgh Resolution Vegetation Atmosphere Coupler) is applied. The modification of the atmospheric conditions in forest areas leads also to a changed sound refraction and sound propagation. Therefore, the simulated fields of meteorological quantities are applied as input data for the sound propagation model SMART (Sound propagation Model of the Atmosphere using Ray-Tracing). This meteorological effect of forest areas on the sound propagation is modelled in comparison to grassland regions. Additionally, the simulations are adapted to experiments which were carried out in 2011 and 2012 at the Anchor station Tharandter Wald near Dresden (Germany). Thereby, the sound propagation of artificial signals was measured along sound paths of up to 200 m length through a clearing as well as through an old spruce stand. Beside the acoustic measurements the atmospheric state was investigated using meteorological masts (height: 40 m). The main goal of the study is the description of the atmospheric influence on the sound propagation by means of validated and operationally applicable models under several meteorological and vegetation-specific conditions.

Tue 17:10 Kurhaus Czerny hall Outdoor sound propagation

Measurements on the damping effect of forests

Mattias Trimpop[a] and Peter Mann[b]

[a] *Institut für Lärmschutz GmbH, Düsseldorf;* [b] *Bundesanstalt für Immobilienaufgaben, Berlin*

Around military training areas large forest areas can be found. They shall screen the military shooting positions optically. Moreover, they have a damping effect on the sound propagation. This acoustical effect was investigated during the last years in some measuring campaigns. On the basis of these measurements a technical model concerning the influence of the forest on the propagation has been developed and presented on the DAGA. One of the basic parameters of this model is the damping factor on sound travelling through the forest. This damping factor is calculated in the model by a formula based on a classification of several forestal parameters and their corresponding weighting factors. Due to the small amount of suitable measurements, the actual used weighting factors are only roughly estimated. A measuring method was developed to determine these weighting factors in a higher accuracy and more efficient way. In 2012 this new

method was applied on a forest several times. After each measuring the density of the trees (forestal: stock density - one of the classified parameters) was decreased in three steps. In this paper the measuring method is presented as well as the according measurements. The results of these measurements are discussed.

Tue 17:30 Kurhaus Czerny hall Outdoor sound propagation

Evaluations of vegetation treatments for traffic noise abatements in a 1:10 urban scale model

Ho Jun Kim, Hyung Suk Jang and Jin Yong Jeon
Hanyang University, Seoul

Vegetation as building elements can reduce traffic noise levels in street canyon and courtyard. A 1:10 urban scale model was constructed to evaluate the noise abatement by use of vegetation as sustainable means. The model materials were selected by measuring absorption coefficients and ground impedances in a 1:10 scale. Vegetated facades, shrubs, trees, green roofs were evaluated as vegetation treatments for noise reduction on buildings and street. For the scale model measurements, a line source was constructed and evaluated to simulate the traffic noise with ribbon tweeter. The noise reductions compared with and without vegetation treatments were obtained in street canyon and courtyard.

Tue 17:50 Kurhaus Czerny hall Outdoor sound propagation

A German Prediction Model of the Sound Propagation in and around Tunnels

Sebastian Kluth[a], Christian Schulze[a], Jörn Hübelt[b], Wolfram Bartolomaeus[c] and Michael Chudalla[c]
[a] *Gesellschaft für Akustikforschung Dresden;* [b] *Hochschule Mittweida;* [c] *Federal Highway Research Institute (BASt)*

In Germany, presently, the evaluation of the efficiency of secondary noise control systems is carried out on the basis of the RLS 90. However, the German prediction model does not include engineering formulas to evaluate sound propagation in and around tunnels. Within the present work, such formulas were developed by performing numerical and analytical investigations on the specific sound propagation effects. The formulas were validated by comparing calculation results to present international prediction models and scale model measurements. In this presentation the effect of sound absorbing material near the tunnel mouth with respect to its length will be discussed extensively, since it has a strong influence on the directivity and therefore on the sound emission.

Tue 18:10 Kurhaus Czerny hall Outdoor sound propagation

Modeling of sound propagation for a temperature gradient to measure sound velocity and distance simultaneously with ultrasound

Mario Wolf, Elfgard Kühnicke, Michael Lenz and Martin Bock
TU Dresden, Institut für Festkörperelektronik

A novel technique had been developed to measure sound velocity and distance simultaneously by determining the focal point from the echoes of moving scattering particles. As the focus position depends on the sound velocity, the position can be used as additional information to time of flight. However, high accuracy could be reached for media with constant sound velocity and has to be extended to measure e.g. a temperature gradient. For this problem the focus point has to be predicted in simulation. If sound velocity is a continuous function of location, additional terms appear in the wave equation. By that reason sound velocity depends not only on the material parameters but also on their derivative with respect to position. First attempts to solve the modified wave equation for cylindrical problems in frequency domain and to develop new GREEN's functions are presented. The results are used to calculate sound fields of extended sources. Thus, the simulation can be compared with measurements, where a temperature gradient is generated in water.

Session "Wind turbine noise"

Tue 15:30 Kurhaus Lentner hall Wind turbine noise

Experimental study of noise emission on wind turbine airfoils with trailing edge flaps

Michael Bartelt, Benedikt Ernst and Joerg R Seume
Leibniz Univ. Hannover, Inst of Turbomachinery & Fluid Dynamics

A promising concept for dynamic load control of multi megawatt wind turbines is the application of flaps at the rotor blade trailing edge - the so called smart blades. However, it is expected that this new generation of wind turbine blades tend to increased noise emission due to the strong interaction of generated vortices at the trailing edge flap. Noise emissions are a limiting factor for turbine operation and design. One goal of the present investigations is to obtain a better understanding of the unsteady flow effects and the noise emission arising through the load control by the flaps. Hence, this paper presents the results of an experimental campaign to measure the noise emission and to identify the major source locations at a smart blade for different operating points. The measurements are performed within a low speed wind tunnel with a Re-scaled profile with a segmented trailing edge flap. A microphone array is employed to measure the acoustic signals and standard beamforming algorithms in frequency domain are used for source identification. The results of the acoustical measurements are presented for the most important operating points and flap angles and are discussed in detail.

Tue 15:50 Kurhaus Lentner hall Wind turbine noise

Aeroacoustic Simulation of Airfoils used in Onshore Wind Turbines

Dimitrios Bekiropoulos, Thorsten Lutz and Ewald Krämer
IAG, Universität Stuttgart

In the last years, an increasing number of large-scale onshore wind turbines have been installed. Because of strict environmental regulations, the noise generation is one important parameter and the commercial success of future wind turbines strongly depends on this aspect. There are several sources for flow-induced noise, but earlier investigations have shown, that the main noise contribution stems from the outer part of the wind turbine blade and is caused by an interaction of the turbulent boundary layer with the trailing edge of the blade (TBL-TE noise). At the Institute of Aerodynamics and Gas Dynamics (IAG) several methods have been developed to predict the emitted noise. One method, which will be presented in this work, is based on RANS calculations. The process chain includes a block-structured CFD solver and different aeroacoustic solvers and it can be used for aerodynamic and aeroacoustic design purposes. The methodology will be presented and characteristics of turbulent boundary-layers such as the anisotropy of the flow and its impact on the generated noise will be discussed. Finally, the abilities of the presented aeroacoustic tools will be validated against experimental data and the results will be analysed.

Tue 16:10 Kurhaus Lentner hall Wind turbine noise

Hybrid Aeroacoustic Method for Noise Prediction of Wind Turbines

Stefan Becker[a], Johannes Weber[a], Christoph Scheit[a], Jens Grabinger[b] and Manfred Kaltenbacher[c]
[a] *Inst. für Prozessmaschinen und Anl.-technik, FAU Erlangen-Nürnb.;* [b] *Chair of Sensor Technology, FAU Erlangen-Nürnb.;* [c] *Vienna University of Technology*

The paper present two different numerical scheme, that aims at predicting the sound radiation induced by turbulent flow in rotating machinery, such as fans. Both methods based on a hybrid approach. First, the transient compressible aerodynamic simulation has been performed. The data from aerodynamic simulations have been used as input for in-house code based on classical Ffowcs-Williams Hawkins (FW-H) equation and on a Finite Element method. The Finite Element method has been applied to Lighthill's analogy for predicting noise radiation. Unlike first approach the second proposed method accounts for both the movement of flow-induced sound sources and reflection of sound waves by the casing at the same time. In which we impose a domain decomposition method in order to perform computations partly in a rotating frame of reference and partly in a stationary one. A so-called Mortar method ensures the exchange of sound waves between the subdomains. The method is then validated by comparison with analytical solutions for sound fields generated by a monopole source, a quadrupole source, and a co-rotating vortex pair. The applied both methodologies are computational tools for getting a better physical understanding of flow induced noise source terms inside wind turbines.

Tue 16:30 Kurhaus Lentner hall Wind turbine noise

Robin - A one-man measurement system for standard acoustic emission measurement according to IEC 61400-11

Timo Klaas[a] and Daniel Vaucher De La Croix[b]
[a] *Wölfel Messsysteme, Höchberg;* [b] *ACOEM, Limonest (F)*

Wind turbines are built at more and more locations - which makes their noise emission an important subject. The international standard IEC 61400-11 and the German "Technische Richtlinie für Windenergieanlagen,Teil 1" of the FGW were set up in order to unify the evaluation of noise emission. Measurement of noise emission according to these standards is linked to formidable challenges, especially for the installation of testing equipment and evaluation of data.

After a short reminder on the ISO 61400 standard the proposed paper will discuss the details of operational constraints linked with on-site measurements and how modern communication technologies help in an easy system deployment and most efficient operation for the benefits of its users.

Tue 16:50 Kurhaus Lentner hall Wind turbine noise

Theoretical Analysis and Experimental Test of the Acoustic Impact of a high Power Wind Farm

Paolo Giuseppe Mura, Roberto Baccoli, Roberto Innamorati and Bruno Manca
Università degli studi di Cagliari

After the description of a high power wind farm situated on a wide hilly area in Sardinia, by presenting the building elements, the aerodynamic and noise radiating LwA properties of the three rotor blades wind turbines planned in the project, it is presented the theoretical predictive analysis of the acoustic impact on the environment, through the mathematical model of WinPro, with particular attention to the noise level generated from a single turbine on the ground and to the noise level Leq(A) radiated in the environment of sensible receivers of the area in which the plant has been realised. There are briefly resumed the main acoustic parameters and equations and the technical Italian regulations on this field, with the aim to describe the experimental analysis methods "post operam" to test the real noise radiated by wind plant during its operation. It is fully described the instruments used to measure the local microclimate and the noise level Leq(A) radiated from the wind plants into the sensible receivers.

It is finally presented the critical analysis of the experimental results compared with the theoretical predictive model.

Tue 17:10 Kurhaus Lentner hall Wind turbine noise

Methods of Measurement of The Environmental Noise Generated by a Wind Plant And Critical Analysis of the Current Italian Regulations

Paolo G. Mura, Ubaldo Carlini, Stefano Mariotti and Leonardo Addis
Università degli studi di Cagliari

After a brief presentation of the current italian regulations on the measurement of the environmental noise produced by wind plants, also with a comparison of the regulations on other nations, the authors describe in this paper the methods of experimental measurement of the noise radiated in the environment by a high power wind plant operating in Sardinia; in particular there are presented the technical problems occurred during the measurements, with particular attention to the effects of the wind on the microphones as far as concern the 5 m/s limit of the current regulations. Continuous recordings have been done on conventional periods of 24 or 36 hours TR diurnal and TR nighttime, and a method of calculation has been developed in order to obtain, from the values recorded in continuous, the acoustic elements/parameter necessary to evaluate the noise level Leq(A) radiated in the environment of sensible receivers and to compare it with the absolute limits and with the differential limits admitted. Based on this experience of field testing, it is finally presented the critical analysis of the current italian regulations which appears not satisfactory for the requirements of the measurements of the environmental noises generated by high power wind plants.

Tue 17:30 Kurhaus Lentner hall Wind turbine noise

Experimental evaluation of the propagation conditions for sounds of high wind turbines at night in comparison with calculations according to DIN ISO 9613-2

Justus Engelen
Uppenkamp & Partner GmbH

The purpose of the investigation is to obtain reliable data on the quality of sound-propagation of high WT in order to consequently improve the prediction-quality. Calculation methods of the ISO9613-2 have been developed for ground-near noise-sources thus information on the accuracy are just related up to 30m. Consequently, modern WT are not included. Conservative propagation-calculations with a safetymargin of at least 1,9dB provide a non systematic studies hedged prediction.

Sound pressure level and meteorological parameter measurements were carried out in tail /headwind direction at distances between 500m-1000m. In addition, SODAR-RASS-measurements provided data concerning vertical wind/temperature profile.

Two wind turbines with a capacity of 2MW were used as emission-source, whose sound power levels were determined by parallel emission-measurements according to IEC61400-11. Operating parameter of the WT had been modified to guarantee high sound power levels even at low wind speeds. Therefore - without facing the problem of an inadequate signal-to-noise-ratio - measurements could be performed at low wind speeds.

Beyond wind speed, meteorological conditions have a considerable influence on the propagation of sound caused by wind turbine noise. To meet the requirements of the DIN45645-1 five independent measurements are going to be performed especially to increase the accuracy according to VDI3723-1.

Tue 17:50 Kurhaus Lentner hall Wind turbine noise

Wind turbines - could they be too noisy?

Frank Kameier[a], Michael Köhl[b] and Tobias Pohlmann[a]

[a] *University of Applied Sciences Düsseldorf;* [b] *Müller BBM GmbH*

In public news coverage wind turbines are still reported as annoying. The audible sound and infra-sound can be disturbing for residents. Scientifically based research work on that topic has been done but finds hardly any consideration in that coverage. This can be explained by the political brisance of that subject (change from nuclear to wind power supply) and that manufacturers do not want to be associated with noisy wind turbines. If the following considerations will be followed, there is no reason for noisy wind turbines: - common guidance for the permission under building law, - technical operating conditions, - basic research on the localisation of the physical cause, - current possibilities of noise reduction methods. This contribution exemplarily shows physical causes of annoying sounds and summarises the unused sound reduction capabilities from an aerodynamic point of view. Improved mechanical design has reduced noise from mechanical sources, these approaches will not be considered in the present study. Among other things, CFD calculations of a wind-turbine-demonstrator will be shown. CFD calculations in the rotor area will be carried out for a better understanding of the flow topology. In order to visualise vortices, the Q criterion was used in the CFD post processing.

Tue 18:10 Kurhaus Lentner hall Wind turbine noise

Environmental monitoring of a micro vertical axis wind turbine

Fabio Serpilli[a], Sergio Montelpare[b], Gianni Cesini[a] and Renato Ricci[a]

[a] *Università Politecnica delle Marche, DIISM, Ancona;* [b] *Università degli studi 'G. d'Annunzio', Pescara*

A vertical axis micro wind turbine, mounted in the area of the University of Ancona, has been monitored for a few months. Monitoring sessions focused acoustical and meteorological parameters. Environmental assessment is discussed applying the methods suggest in UNI project U20000947 "Acoustics. Method to evaluate the acoustic impact and environment for different kinds of sources. Part 7: Wind turbines noise".

Tuesday Wind turbine noise (Poster)

Application of IEC 61400-11 on a micro vertical axis wind turbine
Gianni Cesini[a], Fabio Serpilli[a], Sergio Montelpare[b] and Valter Lori[a]
[a] *Università Politecnica delle Marche, DIISM, Ancona;* [b] *Università degli studi 'G. d'Annunzio', Pescara*
THE PAPER SHOWS THE RESULTS OF ACOUSTIC TESTS ACCORDING TO IEC 61400-11 ON A MICRO VERTICAL AXIS WIND TURBINE. THE RESULTS ARE SHOWN ACCORDING TO IEC AND ARE DISCUSSED PROBLEMS OF APPLICATION DUE TO THE TYPE OF SOURCES AND TO THE MOUNTING CONDITIONS.

Tuesday Wind turbine noise (Poster)

Noise and meteorological monitoring of a wind farm
Massimiliano Masullo, Francesco Sorrentino and Giuseppe Ciaburro
Second University of Naples, Dep. of Architecture
Although the contribution of wind farm noise on the overall level is generally quite low in magnitude, resulting in some cases comparable with the existing background noise, the noise generated from wind turbines represents one of the main reasons of opposition by residents against the wind farms' functioning or new installation. Many studies have highlighted how this problem is complex and multifaceted, in fact, besides the noise, many other aspects such as physical, psychological, individual, socio-cultural and economical factors, can play a primary role on the reaction of the population living near the wind farms. In order to identify and assess as objectively as possible the impact of a wind farm on residents, a noise/meteorological monitoring and an accurate analysis of the results should consider both spectral and statistical content as well as their correlation with wind speed and direction. In this paper we present the results of a noise/meteorological monitoring carried out in two outdoor receiver points situated in the yards of two dwellings near the wind farm of Savignano Irpino (Italy) and the analysis of the data.

Tuesday Wind turbine noise (Poster)

Measurements of wind turbine noise in residential areas
Kai Pies, Paul Pies and Dan Pies
Ing. Büro Pies
Measurements of noise in residential areas caused by wind turbines are complex respecting the measurement setup and data analysis. The maximum wind turbine sound power is normally due to meteorological conditions and wind speed at the measuring point that influence the measurement results. Wind also causes noise at the windscreen of the microphone. Therefore, a sole background correction of the wind-induced noise in the periphery (e. g. bushes or trees near the monitoring car) is not sufficient. A further aspect is that usually the measurements are not realized for one wind turbine but for whole wind parks. This presentation illustrates the measurement settings, the data analysis and the results of measurements at different locations with different numbers of wind turbines. One important

aspect is for example that the same sound levels are obtained with Mitwind and headwind.

Session "Building acoustics: Glazing, windows, facades, roofs"

Tue 15:30 Puccini Theatre Building acoustics: Glazing

Sound Insulation of High Performance Thermal Insulating Window Constructions

Joachim Hessinger, Bernd Sass and Norbert Sack
ift Rosenheim GmbH

The thermal insulation of the building envelope is very much discussed in German public because of energy saving efforts in new buildings and for refurbishment. Building regulations in Germany ("Energieeinsparverordnung") are currently adjusted to this demand. Presently the development of new window constructions is driven mainly by the demand of thermal insulation and energy saving. Adjusting window constructions to requirements on sound insulation is often only of secondary importance. However improving the thermal insulation of single windows can have an impact on their sound insulation. Within this paper we discuss the influence of improvement measures for thermal insulation on sound insulation of these windows. The impact on sound insulation is discussed separately for the single components frame and glazing. Comprising the effects on frame and glazing the sound insulation of the complete window element is assessed. For this analysis results from research projects of ift Rosenheim (publicly funded by the German "Forschungsinitiative Zukunft Bau") were evaluated.

Tue 15:50 Puccini Theatre Building acoustics: Glazing

Analysis of the extensibility of Sound Reduction Index measurements of windows

Simone Secchi[a], Elisa Nannipieri[a] and Elena Stoppioni[b]
[a] *Università di Firenze;* [b] *Envircom, Firenze*

The UNI Technical Report on the extensibility of Sound Reduction Index measurement results of windows gives guidelines for the application of EN 14351 series of standards and criteria for the extension of the results of laboratory tests of sound reduction index of windows and doors to others with similar characteristics. Moreover, some indications are provided for the correct application of the laboratory test procedures, in order to make more repeatable test results of Sound Reduction Index of windows. In addition to the requirements of extensibility for different sizes of windows and doors single, already explained the UNI EN 14351-1, conditions are defined based on the characteristics of windows and their components. In the paper, the results of Sound Reduction Index measurements of windows carried out at the Florence laboratory of Envircom will be examined with regard to conditions of extensibility defined by the Technical Report. In particular, some specific criteria of extensibility will be analyzed and the accuracy of the technical report evaluated.

Tue 16:10 Puccini Theatre Building acoustics: Glazing

Noise Abatement of Noise Dampening Shutters in Case of Closed Windows

Rudolf Liegl and Andreas Hackl
Möhler + Partner Ingenieure AG

Measurements confirm noteworthy improvements of outdoor noise abatement by noise dampening shutters in the case of tilted windows. Based on measurements of the sound insulation in buildings according to DIN EN ISO 140-5 the noise abatement of a noise dampening shutter is compared in the case of a closed and a tilted window, holding constant all the other measuring conditions. It becomes apparent that noise abatement is diminishing in the case of a closed windows. Even deteriorations have been observed at frequences above 500 Hz. Measurement results will be presented and conclusions will be discussed.

Tue 16:30 Puccini Theatre Building acoustics: Glazing

Experimental and analytical analysis of the acoustic properties of glazing systems

Paolo Ruggeri[a], Nicola Granzotto[b], Fabio Peron[a] and Paolo Bonfiglio[c]
[a] *Università IUAV di Venezia, Lab. di Fisica Tecnica Ambientale;* [b] *University of Padova, Department of Industrial Engineering;* [c] *MechLav, Tecnopolo dell'Università di Ferrara*

High insulation façade requirement in contemporary buildings needs the development of high performance glazing systems. In this work a combined experimental and analytical approach has been utilized for predicting sound transmission loss of such systems. In particular, firstly, mechanical properties of PVB's layers have been measured using a resonant method characterization for flexural waves on glass bars. Therefore the diffuse field sound transmission loss of glass panels has been predicted through a transfer matrix method for elastic solid layers. The finite size effect of the sample has been accounted for in the analytical scheme. Results from the above-mentioned procedure have been compared with laboratory tests carried out according to UNI EN ISO 10140.

Tue 16:50 Puccini Theatre Building acoustics: Glazing

Sound Insulation of Glazing: Effectiveness of Predictive Formulas

Enrico Manzi
www.enricomanzi.it

The technical literature in acoustics makes available various predictive formulas, with experimental basis or related to the mass law, from which it is possible to calculate the weighted sound reduction index and the behavior in frequency of a glass partition, depending on its configuration as a simple glass, laminated or insulated one. This research relies on a large number of laboratory certificates of airborne sound insulation of glazing for the construction industry, to propose an evaluation of the effectiveness of predictive formulas available to the designer. With the goal of providing

new useful elements in the preliminary steps of the acoustic design of buildings enclosures, and taking into account recent technological results in this specific field, this study carries out a comparison between experimental and predictive values of sound reduction, and also analyzes the correspondence between any resonance and coincidence phenomena noticed in laboratory and the informations provided by the formulas for the determination of frequency critical values. The results obtained can form the basis for a next phase of study aimed at the analysis of correlation between acoustic performance of the glazing and final performance of the window in which it will be installed.

Tue 17:10 Puccini Theatre Building acoustics: Glazing

Strömungsgeräusche an Fassadenelementen

Wolfgang Herget and Peter Brandstätt
Fraunhofer-Institut für Bauphysik, Stuttgart

Einschalige und doppelschalige Fassaden sowie Design-Elemente an Fassaden können eine Entstehungsfläche für windinduzierte Geräusche darstellen. Das Spektrum derartiger Geräusche kann zwischen breitbandigen Strömungsgeräuschen, tonalen Einzelkomponenten und schwingungsbedingter Schallabstrahlung variieren. Alle Formen der Geräuschentstehung bieten Potential für eine kontroverse Auseinandersetzung. Diese muss sich nicht ausschließlich auf das Gebäude selber beziehen, z.B. bei Nutzung als Büro oder Wohnung, sondern kann auch benachbarte Bereiche beeinflussen, wie weitere Gebäude und öffentliche Plätze. Zur Klärung dieses Sachverhaltes ist es hilfreich, akustische Messungen in einem Strömungskanal durchzuführen. Untersuchungen dieser Art wurden an modellhaften Ausschnitten von Fassadenelementen im Aeroakustik-Windkanal am Fraunhofer IBP durchgeführt. Der Bericht präsentiert Praxisbeispiele und zeigt die dabei auftretenden Effekte.

Tue 17:30 Puccini Theatre Building acoustics: Glazing

Acoustic performance of a ventilated roof with skylight in case of traditional intrados and insulated system

Andrea Landini
Z Lab Engineering srl, Pontedera

Ventilation is a key element in the design of wooden roofs for different reasons. This technology, however, entails a number of issues related to the transmission of noise through out the air cavity. The installation of skylights amplifies this problem, due to the use of intrados or matchboarding frames which are generally permeable elements to noise. The performance data reported for the passive elements of the buildings are consequently nullified, and the environmental comfort is affected. Regarding this fact, we studied the performance benefits brought by a technological solution developed for roof windows, that is a one-piece prefabricated frame characterized by a high acoustic performance. At first the study had been carried out through a series of laboratory tests on products type ”traditional intrados” and ”insulated intrados”, then, referring to a case study, we analyzed the acoustic performance provided by a ventilated roof built in Verona before

and after the installation of ”insulated intrados”. The results are presented through the elaboration of intensimetric maps and the testing of the sound transmission loss for each configuration.

Tue 17:50 Puccini Theatre Building acoustics: Glazing

Acoustic isolation of wooden roofs - presentation of nearly 150 measurements

Bernhard Oberrauch
TBZ Building Physics, Bolzano

In this research study we compared nearly 150 misurements of wooden roofs, changing the materials or structur of the wooden roof. So we get good and important informations about what materials are apropiately, what details are important and how build a roof in order to get a good acoustic isolation. It helps also as catalogue of building elements of wooden roofs.

Tue 18:10 Puccini Theatre Building acoustics: Glazing

Acoustics of Bolzano Chamber of Commerce

Christina Niederstaetter
Raum & Akustik, Renon

The new office building of the Bolzano Chamber of Commerce, designed by the architect Wolfgang Simmerle, was completed in 2007. For its architectural conception and the high energy-efficiency the office building is one of the modern examples of its kind in Bolzano. The sound landscape of the urban place is characterized by the traffic noises which come from the major motorway and the nearby railway station. Acoustical consultants have been asked from the beginning of the executive design and acoustics were integrated in the whole process of the construction. The room acoustics of the general offices, executive offices, conference rooms and the main hall with counters and information desks were considered very important, so also the sound insulation of the façades. Because of the satisfying results, employees, clients and visitors highly appreciate the acoustic environment. We hereby report the suggested solutions and describe the materials employed with some results of measurements in situ. The building now has been tone-downed of the existing frenetic nature of urban life.

Session "Ultrasounds"

Tue 15:30 Hotel Terme room 1 Ultrasounds

Improved Signal Processing for an Ultrasonic Distance Sensor with Reduced Blind Zone

Andreas Schröder and Bernd Henning
University of Paderborn, EIM-E, Measurement Engineering Group

Single transducer distance sensors have a blind zone because normally the electrical received signal cannot be detected during transmitting. There are several approaches to realize a simultaneous transmit and receive operation. Digital signal processing is the best solution for narrow band systems (air ultrasound transducer) especially when the transmitted signal is coded. Thereby a mathematical model is used to estimate the electrical received signal. A drawback of the digital signal processing is the required computing time to estimate the model and the time of flight of an echo. In this contribution the computing time is reduced significantly by using base band signals for the signal processing. The signal-processing is subdivided into the following steps: Preprocessing, model identification, estimation of the received signal and echo detection. Beside the model identification the signal-preprocessing is an important part of the system. It depends on the time of flight of an echo (close echo, far echo) and the state of the system (single measurement, averaging). The whole system is evaluated with measurements using a 40 kHz air ultrasound transducer in front of a reflector with varying distances between 0 mm and 1000 mm.

Tue 15:50 Hotel Terme room 1 Ultrasounds

Determination of Ultrasonic Cleaning Efficiency using a Quartz Crystal Microbalance

Christian Koch and Matthias Jüschke
Physikalisch-Technische Bundesanstalt

The evaluation of the cleaning efficiency is an indispensable requirement for quality management and reliability of manufacturing processes. In the industrial practice empirical techniques using various kinds of test artifacts are common which yield, however, no quantitative output.

In this talk a sensor is presented which quantitatively determines the erosion during cavitation activity and allows a direct assessment of cleaning efficiency in a cleaning vessel. The sensor element comprises an AT-cut quartz crystal which is coated by a test layer containing silica microparticles as a representative of removable substances during cleaning. During the cleaning process parts of the layer were removed and the change in resonance frequency of the crystal is a quantitative measure of the ablated mass and, thus, the cleaning efficiency.

The sensor was tested in different cleaning vessels operating in the range from 25 to 45 kHz. The dependence of resonance frequency change on various process parameters as electrical input power, temperature und gas content was investigated. It could be shown that reliable relations between removing of particles, i.e. cleaning efficiency and the resonance frequency

change exists. This shows the high potential of the sensor to be used for a quantitative description of cavitation.

Tue 16:10 Hotel Terme room 1 Ultrasounds

Influence of angular radiated ultrasound waves on the Schlieren tomogram

Sergei Olfert, Leander Claes and Bernd Henning
University of Paderborn, EIM-E, Measurement Engineering Group

The Schlieren technique is a fast and non-invasive method to characterize the spatial and temporal propagation of ultrasound. In this method, the integral phase change of the electromagnetic wave is influenced by the ultrasonic wave. Raman and Nath showed that a correct representation of the ultrasonic wave is ensured only if the electromagnetic wave (optical axis) and the acoustic wave (acoustical axis) are orthogonal to each other [RaNa35]. The influence of non-perpendicular side lobes of an ultrasonic field parallel to the propagation direction of the electromagnetic wave (is equivalent to the optical axis) is not considered. In this article the effect of the angular ultrasonic waves relating to the optical axis on the Schlieren tomogram will be investigated in detail. A model to characterize the interference of sound wave and electromagnetic wave was developed. Using this model the resulting phase change of the electromagnetic wave in dependence on the angular radiated sound beam is calculated numerically. Finally simulation results and experimental results are compared. This knowledge of this relationship is an important requirement for the development of reconstruction algorithms for the three-dimensional sound field visualization.

[RaNa35] Raman, Nath: The diffraction of light by high frequency sound waves: Part II, 1935

Tue 16:30 Hotel Terme room 1 Ultrasounds

Acoustic energy loss in cavitating and non cavitating liquids estimated by acoustic streaming velocities

Till Nowak and Robert Mettin
Georg-August-Univ. Göttingen, 3. Physikalisches Institut

Acoustic streaming is caused by absorption of sound energy in the liquid. When cavitation bubbles are present, the energy loss is dramatically increased, which also can induce enhanced liquid streaming. Additionally, small-scale streaming due to bubble oscillations and translations occur. With a two-camera-PIV-setup liquid streaming and bubble motion can be observed at the same time. Both is investigated in a special setup where cavitation can be essentially suppressed by application of an ambient overpressure. We try to quantify these effects and compare it to numerical streaming simulations.

Tue 16:50 Hotel Terme room 1 Ultrasounds

Sound Films of Acoustic Cavitation

Julian Eisener and Robert Mettin
Georg-August-Univ. Göttingen, 3. Physikalisches Institut

Although there are clear signatures of microscopic cavitation processes in the corresponding acoustic emission spectra, a complete understanding of spectral features is still lacking. Here we try to correlate high-speed recordings of bubble ensembles with simultaneously measured hydrophone time traces and short-term spectra. Preliminary results show that episodes of reasonable coherence exist (”we see what we hear”), but that also apparently uncorrelated periods occur. The findings are discussed with respect to emission spectrum analysis as diagnostic tool of acoustic cavitation.

Tue 17:10 Hotel Terme room 1 Ultrasounds

Stability of translating acoustic cavitation bubbles

Robert Mettin
Georg-August-Univ. Göttingen, 3. Physikalisches Institut

Acoustic cavitation bubbles can develop instabilities that lead to non-spherical shape. One possibility is the build-up of unstable shape modes if sufficiently strong driving and/or resonances of the modes are reached. Another typical case is a liquid jet penetrating the bubble during collapse (”jetting”), which is usually observed when the flow symmetry around the bubble is disturbed, e.g. by adjacent boundaries or other bubbles. Recently it has been theoretically predicted and experimentally confirmed that jetting also takes place for ”free” bubbles if they translate sufficiently fast. This case is discussed with respect to similarities and differences as compared to shape mode excitation of free bubbles.

Tue 17:30 Hotel Terme room 1 Ultrasounds

Sodium line emission in sonoluminescence and bubble dynamics

Carlos Cairos Barreto, Julia Schneider and Robert Mettin
Georg-August-Univ. Göttingen, 3. Physikalisches Institut

The connection of microscopic bubble dynamics and sonoluminescence emission is investigated in multi- and single-bubble systems at various acoustic driving frequencies. Particular interest is put on Na* line emission in aqueous NaCl solutions under noble gas atmospheres. We employ high-speed videography, high-resolution color photography, PMT light emission and spectroscopic measurements. In multi-bubble systems, the spatial distributions of sonoluminescence show a strong dependence on frequency, gas content, and driving amplitude. Sodium line emission could only be obtained with dissolved Ar and tends to vanish for higher driving frequencies. First results in single-bubble systems exhibit a very high sensitivity of the line emission on noble gas content and acoustic driving pressure, which significantly affects the bubble dynamics. Transitions between a ”real” single bubble and few bubble cluster is observed, and the detailed link of bubble collapse dynamics and sodium excitation is investigated.

Tue 17:50 Hotel Terme room 1 Ultrasounds

Size determination of spherical inclusions with ultrasound

Sebastian Kümmritz, Mario Wolf and Elfgard Kühnicke
TU Dresden, Institut für Festkörperelektronik

If no back wall-echo exists, the size of sphere-shaped inclusions is not detectable with ultrasound without further ado. By recording the 6 dB descent of the reflected amplitude with a line scan over the spherical inclusion, nearly independently of its size, the lateral 6 dB width of the sound beam (in the depth of the inclusion) will be measured. In nondestructive testing sphere shaped inclusions would be detected smaller then they are in fact. This would leads in an incorrect evaluation of an inclusion in the test object. In this work two approaches for sphere size determination are presented. The first one uses the time of flight difference between the direct reflected echo and a second echo from the inclusion, caused by the circumferential wave. Since this approach only works for full spherical inclusions, but not for partial spherical shaped structures like bondings or splodges of solder as has to be evaluated in ultrasound microscopy, the use of a special distance-size-gain-diagram for spheres will be discussed.

Session "Ultrasounds (Poster)"

Tuesday Ultrasounds (Poster)

Evaluation of Ultrasound Sources and of the Spatial Spread of Ultrasound Fields

Peter Holstein[a], Joachim Feierabend[b], Andreas Tharandt[c] and Thobias Fritsche[a]
[a] *SONOTEC Ultraschallsensorik Halle GmbH;* [b] *gfai tech GmbH;* [c] *Steinbeis Transferzentrum 'Technische Akustik u. angew. Numerik'*

Ultrasound has been extensively used for medical applications. Furthermore, many applications can be found in the fields of the non-destructive testing. The number of applications is still increasing. Besides the fields mentioned, there are important applications in every day areas such marten defense for motor vehicles or distance warning in automotive which use common air as transport medium of the wave. A very important application is the use of ultrasonic sources for the evaluation of the leak tightness of cabins and booth in different areas such as automotive, railway, aviation and dust-free rooms. Therefore, the quality of the transmitter is of special interest. The acoustic camera is a promising and powerful technique for locating and evaluation of sound sources. The characteristic of several ultrasound sources has been investigated in order to optimize their emission which can be highly anisotropic. The results are compared with the requirements of the specific applications.

Session "Listening and understanding speech in rooms 1"

Tue 15:30 Hotel Terme room 2 Speech in rooms 1

Reverberation time in educational environments in South Tyrol

Richard Oberkalmsteiner[a], Giuseppe Canale[a], Luca Verdi[a], Arianna Astolfi[b], Nicola Prodi[c] and Alessandro Peretti[d]

[a] *Agenzia Provinciale per l'Ambiente, Lab. di Chimica Fisica;* [b] *Politecnico di Torino - Dipartimento Energia;* [c] *Università di Ferrara, Dip. di Ingegneria;* [d] *University of Padova, Post-Grad School in Occupational Medicine*

The reverberation time in the educational places influences significantly the ability of learning by pupils, as well as has an important effect on the vocal effort required to teachers during lessons. For pupils with hearing impairment, who have consequently a need for greater clarity and speech intelligibility, or in the case of lessons or conversations in a foreign language, this topic is even more delicate. Measurements of reverberation time have been carried out in the last three years in numerous kindergartens, primary schools and high schools of the Province of Bolzano. The measurements applied to classrooms, gymnasiums, music rooms, dining rooms, recreation rooms and entrances. In some kindergartens and schools, post-operam measurements of reverberation times were also performed in order to verify the effectiveness of the acoustic absorption interventions performed. Additional information was collected by filling in a specific questionnaire distributed to schools and by some direct measurements of the parameter of intelligibility STIPA. The results of the measurements carried out over the last three years in the light of the existing regulations, are presented in this work.

Tue 15:50 Hotel Terme room 2 Speech in rooms 1

The acoustic correction of classrooms in historical buildings with numerical simulation

Gino Iannace[a], Patrizia Trematerra[a] and Ahmed Qandil[b]

[a] *Second University of Naples, Dep. of Architecture;* [b] *Philadelphia University*

Often the classrooms are located in historical buildings, where for aesthetic and historical reasons is difficult to install sound-absorbing panels for acoustic correction; also the classrooms are not regular in shape and the ceilings irregular. To improve the acoustic characteristics of the classrooms have to enter the sound-absorbing material in an appropriate manner, but with structures not fixed, being historical buildings. The software for the architectural acoustics "Odeon", was used to identify the type of material to be used and to find the geometrical position most effective for the acoustic correction. As a case study were selected the classrooms of the Faculty of Architecture of the SUN. The classrooms were located in an historic building, are irregularly shaped and show vaulted ceilings , e with walls of smooth plaster. For each classroom were measured reverberation times. With the aid of the software Odeon has tried to find the location where to install the panels for reduce reverberation time and improve the acoustics, preservin the aesthetic and following the instructions of historic

preservation. Are Shown the results of the acoustic measurements for the classrooms and the results of relative acoustic correction to the vary of the position of the sound-absorbing panels.

Tue 16:10 Hotel Terme room 2 Speech in rooms 1

On the relationship between speech perception and the psycho-acoustical parameters of background noises in primary school classrooms

Chiara Visentin and Nicola Prodi
Università di Ferrara, Dip. di Ingegneria

It is widely accepted that a bad acoustics negatively affects the pupils performance in primary school classrooms: the presence of background noise forces the pupils to put more resources in the speech recognition process and consequently increase time and effort required to process the information. This work investigates the relationship between the psycho-acoustical characteristics of the background noises and their detrimental effects on pupils performance. Speech intelligibility tests with the presence of ”activity” background noise are proposed to 157 pupils aged 9 to 10. The acoustic conditions are described with the instrumentally measured STI (based on impulse responses and sound-to-noise ratios); in addition, the psycho-acoustical qualification of the background ”activity” noise is performed in order to assess the resulting auditory sensations. The objective quantities are compared with the subjective data collected for each participant, expressed in terms of speech intelligibility and listening efficiency (psychophysical quantity combining accuracy and effort put in the task). The obtained numerical relationships allow then to analyse the disruptive effect on the speech recognition task of a typical classrooms background noise by considering the elicited hearing sensations.

Tue 16:30 Hotel Terme room 2 Speech in rooms 1

The Difference Between CCV and CVC Logatome Form Intelligibility Levels Observed in Two Acoustically Different Spaces

Andrea Andrijašević[a], Hrvoje Domitrović[b] and Juraj Šimunić[a]
[a] *Faculty of Engineering, University of Rijeka;* [b] *University of Zagreb*

Logatome listening tests are a standard method for speech intelligibility level assessment in closed spaces. The main focus of this work is to highlight the difference between CCV (consonant-consonant-vocal) and CVC (consonant-vocal-consonant) logatome form intelligibility levels as a function of speaker-listener distance and room acoustic properties, namely the reverberation time. In accordance with that, two closed spaces with different acoustic properties have been examined using logatome tests. The percentages of correctly heard CCV and CVC types of logatomes for three different source-listener distances are presented for each of the enclosures. Following that, female and male participants' CCV and CVC results are shown separately and compared to each other for each of the six cases. In the end of the paper, the correlation between the percentage of correctly heard logatomes for each of two logatome types, the acoustic parameters of closed space, i.e. the impulse response and reverberation time, and the

masking effects of human hearing system is discussed in detail and the conclusions are drawn.

Tue 16:50 Hotel Terme room 2 Speech in rooms 1

Temporal-spatial processing of a single speech reflection in normal-hearing and hearing-impaired listeners

Jan Rennies[a], Anna Warzybok[b], Thomas Brand[b] and Birger Kollmeier[b]
[a] *Fraunhofer IDMT - HSA, Oldenburg;* [b] *University of Oldenburg, Medical Physics*

Reflections and reverberation considerable affect speech recognition in rooms. Early reflections of the speech signal have mostly been found to enhance speech intelligibility, while late reflections can have detrimental effects. In recent studies, the ability of the normal auditory system to integrate a single speech reflection with frontal direct sound has been investigated with respect to reflection delay (0 to 200 ms), reflection azimuth (0° to 315° in steps of 45°), and type of interferer (frontal, diffuse, or lateral). The main findings were that the benefit of early reflections was independent of reflection azimuth, that the binaural gain in the presence of non-frontal interferers was independent of reflection delay for frontal reflections, and that the detrimental effect of a late reflection depended on the reflection azimuth relative to the spatial position of the interferer. The data could only be predicted when the distinction between early and late reflections was made already in the binaural processing stage of an existing speech intelligibility model. The present study extends the previous experiments by measurements with hearing-impaired listeners. The data are compared to model predictions to investigate to what extent reductions in speech intelligibility can be explained by the pure tone audiogram.

Tue 17:10 Hotel Terme room 2 Speech in rooms 1

Listening and Understanding Speech in a Cafeteria: Effects of Binaural Noise Reduction, Hearing Loss and Cognitive Function

Tobias Neher, Giso Grimm, Christoph Völker, Volker Hohmann and Birger Kollmeier
University of Oldenburg, Medical Physics

Elderly hearing-impaired (EHI) listeners differ widely in terms of their listening abilities in complex environments, even under aided conditions. So far, little progress has been made in terms of finding ways of tailoring hearing aid (HA) signal processing better to such individual differences. Consequently, HA fittings are typically based on the audiogram only. More recently, however, a number of studies have found a link between cognitive function and benefit from amplitude compression, thereby identifying a potential avenue for more individualization.

The present study aims to investigate how hearing loss and cognitive function interact with benefit from a binaural noise reduction (NR) algorithm. Four groups of EHI listeners having either mild or moderate hearing losses and either better or poorer cognitive function are being tested. The algorithm under consideration is a binaural coherence-based NR scheme designed to suppress reverberant signal components as well as diffuse

background noise. The strength of the applied processing is varied from inactive to extreme. Outcome measures include speech recognition, listening effort and preference. All measurements are made using headphone simulations of a busy cafeteria.
The collected data will be presented and discussed.

Tue 17:30 Hotel Terme room 2 Speech in rooms 1

Predicting Speech Intelligibility in Conditions with Nonlinearly Processed Noisy Speech

Søren Jørgensen[a] and Torsten Dau[b]

[a] *Centre for Applied Hearing Research, DTU (DK);* [b] *Centre for Hearing and Speech Sciences, DTU (DK)*

The speech-based envelope power spectrum model (sEPSM; Jørgensen and Dau, 2011; Jørgensen et al., 2013) was proposed in order to overcome the limitations of the classical speech transmission index (STI) and speech intelligibility index (SII). The sEPSM applies the signal-to-noise ratio in the envelope domain (SNR_{env}), which was demonstrated to be essential for successfully predicting speech intelligibility in conditions with nonlinearly processed speech, such as spectral subtraction. Moreover, the sEPSM accounts for speech intelligibility in various conditions with reverberation, stationary and fluctuating interferers. However, the current model fails in the case of phase jitter distortion, in which the spectral structure of speech is destroyed but the temporal envelope is maintained. This suggests that an across audio-frequency mechanism is required to account for this distortion. It is demonstrated that a measure of the across audio-frequency variance at the output of the modulation-frequency selective process in the model is sufficient to account for the phase jitter distortion. Thus, a joint spectro-temporal modulation analysis as proposed in (Elhilali et al., 2003) is not required. The results are consistent with concepts from computational auditory scene analysis and further support the hypothesis that the SNR_{env} is a powerful metric for speech intelligibility prediction.

Tue 17:50 Hotel Terme room 2 Speech in rooms 1

Impact of Reverberation on Speech Perception in Cochlear Implant Users

Tobias Weißgerber and Uwe Baumann

Audiologische Akustik, HNO, Goethe-Univ. Frankfurt am Main

Speech perception in patients fitted with cochlear implants (CI) decreases in listening environments with reverberation compared to free field conditions. This holds even for classrooms with short reverberation times of about 0.6 seconds. In previous studies an exponential decrement in word recognition with increasing reverberation time was found. Another detrimental factor is the direct-to-reverberant ratio (DRR) which describes the logarithmic ratio between direct and reverberant sound. The DRR decreases with increasing distance to the sound source. This work focuses on the influence of the DRR on speech perception of patients with CI. The speech perception in a simulated reverberant room was measured with the Oldenburg Sentence Test (OLSA) in an anechoic chamber. The OLSA was

modified to adaptively determine the DRR, where 50% of the words are understood correctly. The direct sound was presented via loudspeaker in front of the listener (0°) whereas the reverberated signal was generated by 20 equally distributed surrounding plane waves created by wave field synthesis to approximate a diffuse sound field. Users of either unilateral or bilateral cochlear implants participated in the study. In this contribution, we describe the method of wave field synthesis to assess speech perception in reverberation and first results are presented.

Tue 18:10 Hotel Terme room 2 Speech in rooms 1

Psychoacoustic abilities of CI users in relation to speech understanding and localization in a reverberant room

Stefan Kerber and Bernhard Seeber
Audio Information Processing, TU München

Good localization abilities help to find and follow a speaker during group conversation, but in rooms localization depends on the ability to perceptually segregate interfering reverberation from the speech signal. For cochlear implant (CI) users the low-level psychoacoustic cues that foster the segregation process are disrupted by the signal processing in the devices. However, speech understanding as well as localization in a reverberant room is not equally disrupted for all CI users with similar devices. Thus performance differences are likely caused by different perception of degraded segregation cues.

To test this hypothesis we measured localization performance for seven bilateral CI users in our Simulated Open Field Environment. Tests were done in anechoic conditions and in a simulated reverberant room. The same participants then completed a speech test and a battery of tests using direct electric control of their implants to measure forward masking decay and the sensitivity to interaural level differences (ILDs) and interaural time differences (ITDs) in signal envelopes. Results showed that CI users with better sensitivity to ITDs maintained better localization ability in reverberation. However, speech understanding was not well predicted by results from the direct stimulation tests. Further explanations and implications are discussed in the presentation.

Session "Music acoustics 1"

Tue 15:30 Hotel Terme room 3 Music acoustics 1

Modeling resonators of reed organ pipes

Péter Rucz[a], Judit Angster[b], Fülöp Augusztinovicz[a], András Miklós[c] and Tim Preukschat[b]
[a] *Budapest University of Technology;* [b] *Fraunhofer-Institut für Bauphysik, Stuttgart;* [c] *Steinbeis Transfer Centre Applied Acoustics, Stuttgart*

Resonators of reed organ pipes play special role regarding the sound character of the pipe. The pitch is determined by the frequency of the vibrating tongue and the resonator acts as a filter, reinforcing or suppressing harmonic partials in the pipe sound. Measurements show that current design does not exploit fully the capabilities of resonators. Therefore the aim of

this contribution is to establish a methodology for optimal scaling of reed pipe resonators, which allows sound design and leads to cost and effort reduction in practice. The family of resonators is large, however, most of them consist of cylindrical and conical sections. Due to the axisymmetricity, one-dimensional models can be used, providing rapid calculation of eigenfrequencies and applicability inside an optimization algorithm. Radiation impedances play crucial role in these models. Analytical approximations can not predict the radiation impedance of open conical pipe endings correctly, hence finite element techniques were applied to simulate a wide range of cone aperture angles and frequencies. The results are stored in a database, which allows straightforward insertion into the one-dimensional model. This methodology is validated by comparison against measurements. The presented approach can serve as good basis of optimized scaling methods for reed pipe resonators.

Tue 15:50 Hotel Terme room 3 Music acoustics 1

Simulation of Reed Vibration in Lingual Organ Pipes

Tim Preukschat[a], Judit Angster[a] and András Miklós[b]
[a] *Fraunhofer-Institut für Bauphysik, Stuttgart;* [b] *Steinbeis Transfer Centre Applied Acoustics, Stuttgart*

Since the focus of organ research was primarily on flue pipes in the recent past, reed pipes were less investigated so far. Now, the functioning of a beating reed was analyzed by means of state-of-the-art measuring technology, whereby investigations required solutions of mechanical, acoustical, electro-technical as well as software related problems.

For the theoretical consideration of reed organ pipes the reed is first of all treated as a beam fixed at one side and described by means of the Euler-Bernoulli equation. This differential equation comprises the internal reed friction as well as the restoring force, and gives the reed displacement in dependence of the reed position and time by taking into consideration the load on the reed.

It will be demonstrated that a permanent pipe sound will be generated only, if pressure reflections at the shallot or resonator end are added to the model. The results achieved by means of the MATLAB software describe the experimental results very well and allow forecasts with regard to the variation of different pipe parameters besides the reproduction of individual measurements.

Tue 16:10 Hotel Terme room 3 Music acoustics 1

Problems of Organ Building and Physical Backgrounds

Andreas Gloos[a], Judit Angster[a] and András Miklós[b]
[a] *Fraunhofer-Institut für Bauphysik, Stuttgart;* [b] *Steinbeis Transfer Centre Applied Acoustics, Stuttgart*

Until today, traditional organ building is a craft based on experience, which has been passed on for centuries. Therefore, many work processes can only be performed by experienced and skilled organ builders. Nevertheless there are complex problems, which can be hardly solved without physical knowledge. Within the framework of organ research the components

of an organ contributing to the generation of sound are investigated by means of state-of-the-art measuring technology and computer simulation. Based on this fundamental research conclusions are made on the functioning of the individual components of the organ. The knowledge gained serves as a basis to optimize and improve assemblies as well as to develop tools and computer applications, which facilitate the work of organ builders. In previous research projects a new wind system was developed and the sound generation of flue pipes was investigated. Current studies focus on the sound generation by means of beating and free reed organ pipes.

Tue 16:30 Hotel Terme room 3 Music acoustics 1

Research Organ for Pipe Organ Research at the Fraunhofer IBP in Stuttgart

Judit Angster[a], Stephan Pitsch[a], Zlatko Dubovski[a], Philip Leistner[a] and András Miklós[b]

[a] *Fraunhofer-Institut für Bauphysik, Stuttgart;* [b] *Steinbeis Transfer Centre Applied Acoustics, Stuttgart*

At the Fraunhofer IBP in Stuttgart a research organ has been built for scientists. Its transparency and unique design allows the demonstration of research results, the investigation of technical and sound problems in organ building as well as the audible testing of sound ideas. Some of the special design features are: The wind system can be switched from traditional to innovative design. The dimensioning of pipes and wind systems was conducted by means of scaling software developed within the context of European research projects. One wind chest of a division can be exchanged to allow the testing of valves and pipe layouts. Newly developed swell shutters which allow a better dynamic of the sound are mounted in the swell organ. In order to test newly designed stops a blind slider is available. There are several blind grooves to analyze the effect of wind flow, of resonances in the grooves and of different outlet holes on the pipe sound. The blowers are driven by a frequency converter for continuous adjustment of wind pressures. The motion of a beating and a free reed can be visualized by means of a stroboscope installed. Some of the research results will be demonstrated.

Tue 16:50 Hotel Terme room 3 Music acoustics 1

Scaling software for labial organ pipes

Stephan Pitsch[a], Péter Rucz[b], Judit Angster[a], András Miklós[c] and Johannes Kirschmann[d]

[a] *Fraunhofer-Institut für Bauphysik, Stuttgart;* [b] *Budapest University of Technology;* [c] *Steinbeis Transfer Centre Applied Acoustics, Stuttgart;* [d] *Mühleisen Organ Building, Leonberg*

In organ building, pipe scaling is a complicated process. All geometrical dimensions of a labial pipe, e.g. diameter, flue width, cutup etc., have to be determined so that its sound fulfills the requirements defined by the organ builder. Every pipe stop has a characteristic sound that should be clearly recognizable over the whole rank from low to high notes. Scaling is done

based on a standard sequence of pipe diameters and deviations from it. Then all other dimensions are derived from diameters and fundamental frequencies. In practice however, the resulting pipe sound is not always as it is supposed to be, especially at transitions between different pipe types within a stop. In order to facilitate the traditional scaling process, a software was developed at the Fraunhofer-Institute for Building Physics (Stuttgart). Here the user can easily define scaling lines and calculate pipe dimensions for all labial stops in the organ. In addition, new calculation methods were developed for transitions, wooden pipe stops and chimney pipe stops, and implemented in the software. The software development was part of a project supported by the European Community (FP7-SME-2007-1, INNOSOUND - 222104).

Tue 17:10 Hotel Terme room 3 Music acoustics 1

Klangliche Charakterisierung von Klangschalen

Johanna Stever, Christina Imbery, Julia Habicht and Reinhard Weber
University of Oldenburg

Aufgrund eines komplexen Fertigungsprozesses bei der manuellen Herstellung von Klangschalen ergeben sich von Schale zu Schale sehr unterschiedliche klangliche Eigenschaften. Generell setzen sich die Klänge aus einer Vielzahl von Teiltönen zusammen, die Schwebungen, Schwankungen und psychoakustisch raue Empfindungen hervorrufen können. Bei impulsartiger Anregung der Schalen ändern sich die unverwechselbaren, klangschalenspezifischen Klänge darüber hinaus noch während der Zeit des Ausklingens. Um die klangschalentypischen Klangcharakteristika verstehen und beschreiben zu können, wurden Aufnahmen von verschiedenen Klangschalenklängen spektral analysiert. Eine frequenzmäßig hochaufgelöste Analyse zeigt, dass ”Einzeltöne” oft aus zwei dicht benachbarten Einzelkomponenten bestehen, die je nach ihrem Amplitudenverhältnis, für mehr oder weniger starke Schwebungen im Klang verantwortlich sind. Die Analyse zeigt auch, wie sich die Teiltöne in ihrem Abklingverhalten unterscheiden. Mit einer Analyse-durch-Synthese-Methode wurden charakteristische Soundbestandteile identifiziert. Zur Untersuchung der reichhaltigen klanglichen Aspekte in den Klangschalenschallen wurde ein semantisches Differential entwickelt und in einem Jurytest zur Beurteilung verschiedenster Klangschalen- und klangschalenähnlicher Klänge eingesetzt. Die Ergebnisse des Jurytests und der Analyse der Soundcharakteristika von Klangschalen werden vorgestellt.

Tue 17:30 Hotel Terme room 3 Music acoustics 1

Acoustics of experimental violins in the Hanneforth collection

Robert Mores
HAW Hamburg

In 2011, the collection of Prof. Wolfgang Hanneforth was donated to the Museum of Decorative and Industrial Arts in Hamburg (MKG), comprising some 250 string and wind instruments. The focus of Hanneforth’s 30 years collecting activity was on experimental constructions and innovations in the

19th and 20th century. Since the foundation of the patent office ("Kaiserliches Patentamt") in 1877 more than 300 patents have been granted on innovative violin constructions in Germany alone. Some of the unusual violins, their constructions and acoustics are discussed here: a violin with a fold in the top, or with extremely round ribs, or with the strings attached to a bridge on the top, or a relatively flat violin without a waist, or with a cornet replacing the wooden body. How will these instruments sound? In the light of some of the basic principles of violin acoustics these experimental instruments are investigated with reference to a valuable Stradivari violin and a student level instrument, both not part of the collection.

Tue 17:50 Hotel Terme room 3 Music acoustics 1

Analysis of saxophone attack transients by auto-regressive modelling

Johann-Markus Batke[a] and Karsten Gloger[b]
[a] *Technicolor, Hannover;* [b] *Gloger-Handkraft, Groningen (NL)*

The identification and discrimination of musical instruments depends largely on the attack transient of the sound. For wind instruments like the saxophone moreover the controllability of the transient determines the playing properties of the instrument. To investigate the transient, often a short-time Discrete Fourier Transform (DFT) is applied to the recorded sound. The short-time DFT is limited in time or frequency resolution. This is an issue for transients that occur over a time of a few milliseconds only. The auto-regressive (AR) modelling overcomes this problem and was successfully applied for transient analysis of many musical instruments. In this study we compare the transients of two similar soprano saxophones that mainly differ in the corpus material - one is commercially available and made from brass, the other one custom made from high density copper. Measurement results are set into relation to the comments of the players comparing the instruments.

Tue 18:10 Hotel Terme room 3 Music acoustics 1

Bassoon and Bassoforte - an acoustical comparison

Timo Grothe[a], Peter Wolf[b] and Stefan Pantzier[c]
[a] *Hochschule für Musik Detmold, ETI;* [b] *Guntram Wolf Holzblasinstrumente GmbH, Kronach;* [c] *Atelier Pantzier, Leipzig*

The generic design of the bassoon has barely changed in the past 80 years. A new prototypical instrument is now presented, for bassoonists in wind orchestras who require more sound power: the "Bassoforte".

Several construction peculiarities of the bassoon are more or less remains of its historical predecessors. Among these are long and narrow finger-holes, obliquely to the main axis, as well as many local variations in taper of the bore. Being a fully developed orchestral instrument, today's modern German bassoon has a limited dynamic range due to its specific design.

With partial contribution of the authors, a new prototypical instrument has been built recently, which comprises a drastically re-designed air column. Compared to the bassoon, it has a larger taper which is constant along

the main bore, as well as wider tone holes, which are entirely operated by keys.
We present an acoustical comparison of bassoon and the new instrument with respect to input impedance curves and sound spectra. Although the first prototype still needs refinement, due to its largely increased dynamic potential and enriched overtone spectrum the Bassoforte might become a promising development for bassoonists playing along with brasses in symphonic wind ensembles, jazz and big bands.

Tuesday Music acoustics (Poster)

Effects of Auditory Feedback on Instrumentalists' Timbre Production
Madeline Huberth
University of Cambridge
Previous work has shown that the presence or absence of auditory feedback in musicians has little effect on performance factors such as note accuracy, timing, and dynamics. This study explored the extent to which an instrumentalists' timbre is affected by various feedback conditions. Nine cellists were recorded playing excerpts from the orchestral literature with their hearing completely unimpeded, masked by pink noise, and masked by orchestral recordings of the excerpts requested for the experiment, simulating orchestral playing. Changes in relative harmonic strengths across the three conditions were focused on in analysis. Overall, the results show that auditory feedback condition has minimal effect on timbre production.

Tuesday Music acoustics (Poster)

Accessible Haptic Force Feedback for Virtual Instruments
Edgar Berdahl
Audio Communication Group, TU Berlin
Haptic force feedback can enable a musician to exchange energy with and feel the vibrations of virtual musical instruments while playing them. Prior work in force feedback for virtual instruments has been based primarily on expensive proprietary hardware and software and has not been widely accessible. In contrast, the author aims to make force-feedback technology accessible to the wider community, empowering them to study force feedback and incorporate it into practical new musical instrument designs. The FireFader is a haptic force-feedback device based on open-source hardware, which allows community members to reconfigure and extend the FireFader in a variety of ways. The design is based on the currently least expensive mass-produced and widely obtainable motor with collocated sensor–the motorized fader from mixing consoles.
Via feedback control, the dynamical behavior of the FireFader can be programmed using physical models designed with the Synth-A-Modeler framework. This framework integrates digital waveguide, mass- interaction, and modal synthesis modeling techniques, allowing a wide variety of dynamic behaviors to be achieved subject to fine-tuning of a minimal number of model parameters. Example models of traditional acoustic musical instruments as well as hypothetical acoustic instruments are demonstrated on the FireFader.

Tuesday Music acoustics (Poster)

Hybrid reverberation algorithm: a practical approach

Andrea Primavera, Michele Gasparini, Stefania Cecchi, Laura Romoli and Francesco Piazza
Università Politecnica delle Marche

Reverberation is a well known effect that has an important role in our listening experience. Reverb changes positively the perception of the sound, adding fullness and sense of space. Generally, two approaches are employed for artificial reverberation: the desired signal can be obtained by convolving the input signal with a measured impulse response (IR) or by synthetic techniques based on recursive filter structures. Taking into account the advantages of both approaches, a hybrid artificial reverberation algorithm is presented aiming to reproduce the acoustic behaviour of real environment with a low computational load. More in detail, the early reflections are derived from a real impulse response, truncated considering the calculated mixing time, and the reverberation tail is obtained using an IIR filter network. The parameters defining this structure are automatically derived from the analyzed impulse response, using a minimization criteria based on Simultaneous Perturbation Stochastic Approximation (SPSA). The effectiveness of the proposed approach has been proved taking into account a real Italian theatre impulse response providing comparison with the existing state-of-art techniques in terms of objective and subjective measures.

Session "Virtual acoustics 1"

Tue 15:30 Civic room Virtual acoustics 1

A Spherical Far Field HRIR Compilation of the Neumann KU100

Benjamin Bernschütz
Fachhochschule Köln

A full sphere far field HRIR (head related impulse response) compilation of a Neumann KU 100 dummy head is presented. The compilation is primarily intended and optimized for applications in the field of spherical acoustics. Several sampling configurations like simple circular horizontal grids, Lebedev quadratures (2454 and 2702 nodes) and a full two-degree Gauss quadrature have been captured. The compilation on the whole involves around 22.000 post-processed high quality stereo impulse responses. The data is organized and stored in MATLAB objects offering different processing features and including a gateway to the SOFiA sound field analysis toolbox for spherical harmonics processing. Associated headphone compensation filters for around 20 common headphones have been created. Additionally, a new method to optimize and extend the low frequency response of measured HRIR datasets employing an adaptive low frequency extension (Adaptive LFE) is presented; this overcomes the typical problems like room modes in the anechoic chamber and the surge of group delay in non-linear phase speaker systems at low frequencies. The method is applied to the presented HRIRs; hence these offer an excellent low frequency response without any high-pass characteristics or excessive surge of group delay.

Tue 15:50 Civic room Virtual acoustics 1

A high resolution head-related transfer function database including different orientations of head above the torso

Fabian Brinkmann[a], Alexander Lindau[a], Stefan Weinzierl[a], Gunnar Geissler[b] and Steven van de Par[c]

[a] *Audio Communication Group, TU Berlin;* [b] *Deutsches HörZentrum Hannover;* [c] *University of Oldenburg*

To facilitate the comparison of virtual acoustical environments (VAEs) based on room acoustic modeling with binaurally measured sound fields, head-related transfer functions (HRTFs) were measured for a head and torso simulator suitable for the fast acquisition of complete datasets of binaural impulse responses in natural environments. In total, 124,795 HRTFs were measured with high spatial resolution, for 11 different azimuthal orientations of head above torso, and covering elevations from -64° to 90°. Special care has been taken to ensure the accuracy of the measurements, verification procedures are described in detail.

Tue 16:10 Civic room Virtual acoustics 1

Effect of element size and microphone model on the numerically calculated head-related transfer functions

Harald Ziegelwanger, Wolfgang Kreuzer and Piotr Majdak

Austrian Academy of Sciences, Acoustics Research Institute

Listener-specific head-related transfer functions (HRTFs) are required for accurate sound localization in binaural reproduction systems. The boundary-element method coupled with the fast-multipole method can be used for free-field simulation of the HRTFs for the whole audible frequency range. The simulation results are determined by the numeric parameters (boundary conditions; choice of receiver elements) and the representation of the listener's geometry. The requirements on the geometric accuracy and resolution of the mesh in order to obtain HRTFs similar to acoustically measured HRTFs are not clear yet.

In this study, we used a high-accuracy geometrical model representing listener-specific head and pinnae (ground-truth mesh, 120,000 elements) to investigate some of those requirements. First, the effect of various representations of the microphone in the mesh on the simulated HRTFs will be presented. We show that selected elements in the mesh with a velocity-boundary condition may yield HRTFs equivalent to the acoustically measured HRTFs. Further, the number of elements in the mesh has been investigated by remeshing the high-accuracy geometry, i.e., increasing the average edge-length of the elements from 1 (ground-truth mesh) to 5 mm (coarse mesh). The results will be discussed in the light of further optimizations required for perceptually-valid numerically calculated HRTFs.

Tue 16:30 Civic room Virtual acoustics 1

Subjective importance of individual HRTF phase

Eugen Rasumow[a], Matthias Blau[a], Steven van de Par[b], Martin Hansen[a], Simon Doclo[c], Dirk Püschel[d] and Volker Mellert[b]
[a] *Jade-Hochschule Oldenburg;* [b] *University of Oldenburg;* [c] *University of Oldenburg, Signal Processing Group;* [d] *Akustik Technologie Göttingen*

Spatial perception of sounds is determined by so-called head related transfer functions (HRTFs), which are known to be highly individual. However, the individual HRTF-phase is typically assumed to be irrelevant and/or even replaceable by a suitable linear or minimal phase (cf. Kulkarni et al., 1999). In this study, the direction-dependent discrimination of gradually fading the individual HRTF-phase into a suitable linear phase was investigated using three-AFC listening tests with eight normal-hearing subjects. The first listening test revealed that broadband-linearization of the HRTF-phase is discriminable for many directions/subjects. In addition, it could be shown that a binaural discrimination model based on interaural phase differences correlates well with the observed individual judgments. In a second listening test it could be shown that phase-linearization is by far less discriminable if the original HRTF-phase is maintained at lower frequencies. The experimental results revealed that the original HRTF-phase for frequencies larger than 1 kHz may be substituted by a suitable linear phase without yielding any discriminable artifacts compared to the original phase. These results imply that, for many listeners, the original HRTF-phase must be retained at low frequencies in order to be perceptually undistinguishable from the original HRTFs.

Tue 16:50 Civic room Virtual acoustics 1

Application of localization models for vertical phantom sources

Florian Wendt[a], Matthias Frank[b] and Franz Zotter[b]
[a] *TU Graz;* [b] *IEM, KU Graz*

Localization of real sound sources in the horizontal plane is well studied, and the use of inter-aural differences (ILD and ITD) as localization cue is proved. For localization in vertical planes and especially in the median plane, such cues are lacking or completely absent. Nevertheless, sound source localization is possible and other cues such as spectral differences are more important than inter-aural differences.

A single phantom source is typically created by two simultaneously active real sources. For the horizontal plane, well-known studies explain the phantom source localization in terms of ILD and ITD. For vertical planes, spectral models need to be employed. In fact, there are already some existing spectral localization models for the vertical localization that have been verified with real sources. In this contribution, these models are applied to vertical phantom sources and compared to existing listening test results.

Tue 17:10 Civic room Virtual acoustics 1

Spherical Harmonics based HRTF datasets: Design, Implementation and Evaluation for real-time Auralization

Jan-Gerrit Richter, Martin Pollow, Frank Wefers, Michael Vorländer and Janina Fels

Inst. of Technical Acoustics, RWTH Aachen University

It is widespread practice to use the head-related transfer function (HRTF) in binaural synthesis to simulate sound events from arbitrary directions. These HRTFs are usually either measured or simulated with a discrete angular resolution in the far-field. This approach has several drawbacks, mainly due to the necessary interpolation between these discrete sampling points as well as the difficulty to auralize sources in vicinity of the listener. These drawbacks can be rectified if the HRTF data is processed using spherical harmonics. If sampled on a sufficient dense spherical grid a physical correct interpolation is possible, whereas the proximity of the sound source up to close distances can be accounted for by the use of the wave propagation term for spherical waves. During the spherical harmonic transformation, the selected focal point has a high influence on the reconstruction quality and can be used to reduce transformation errors. This paper presents a compact and efficient representation of HRTFs using spherical harmonics. Conceptual aspects and suitable data structures are discussed. The feasibility and performance of this approach in a real-time auralization application is studied. Critical parts are identified and optimized to obtain the best compromise between physical accuracy and performance.

Tue 17:30 Civic room Virtual acoustics 1

On the Use of Continuous-Azimuth HRIR in Higher-Order Ambisonics Rendering

Johann-Markus Batke[a], Stefan Abeling[a], Peter Jax[a], Michael Weinert[b] and Gerald Enzner[a]

[a] *Technicolor, Hannover;* [b] *Ruhr-Universität Bochum, Inst. of Communication Acoustics*

Headphone rendering of soundfields represented by Higher Order Ambisonics (HOA) is greatly facilitated by the binaural synthesis of virtual loudspeakers. Individualized head-related impulse responses (HRIR) corresponding to the spatial positions of the virtual loudspeakers are used in conjunction with head-tracking to achieve the externalization of the sound event. Two different systems for binaural synthesis are investigated in this work, one using HRIR at static positions in combination with soundfield rotation, and another system employing 3D-continuous-azimuth HRIR functions obtained with a recently proposed dynamic measurement apparatus. The continuous HRIR representation provides us with high flexibility regarding the selection of virtual loudspeaker positions and overcomes any issues related to approximation known from conventional HRIR interpolation. Listening tests using both system options were performed to figure out the perceived differences in spatial resolution and accuracy of the spatial playback. It turns out that both options perform similar for the given experimentation setup based on speech and pink noise stimulus.

Tue 17:50 Civic room Virtual acoustics 1

Perceptually Motivated Binaural Rendering of Higher Order Ambisonic Sound Scenes

Craig Jin, Nicolas Epain and David Sun
The University of Sydney

The Higher Order Ambisonics (HOA) framework for the recording and playback of three-dimensional sound scenes has become increasingly popular over the past decade. One of the reasons for HOA's popularity is that it offers a generic format for broadcasting sound scenes: HOA signals can be played back over any loudspeaker setup or over headphones. In this paper, we focus on the problem of decoding HOA sound scenes binaurally for a particular set of Head Related Impulse Responses (HRIRs). Two methods are classically used for calculating HOA binaural rendering filters: the virtual speaker method, and the least-square method. Similar to HOA-decoding over loudspeakers, both of these methods are inaccurate at high frequencies. We present a method for calculating binaural rendering filters based on the idea that, at high frequencies, only the magnitude of the Head Related Transfer Functions is perceptually relevant. Results show that this method greatly improves the fidelity of the decoded signal magnitude spectrums at high frequencies.

Tue 18:10 Civic room Virtual acoustics 1

Simple technical prediction of phantom source widening

Matthias Frank and Franz Zotter
IEM, KU Graz

In a concert hall, the perceived width of an instrument increases with the amount of reflections from the ceiling and the walls. Inter-aural cross correlation coefficient (IACC) and lateral energy fraction (LF) are common technical estimators for this perceived source width. These estimators are determined by measurements with a dummy head or a specific coincident microphone pair, respectively.

Recent research showed for phantom sources that the width perception depends on the aperture of a loudspeaker pair. For this case, the IACC predicts the listening test results at a fair level. A much better prediction is achieved by a modified LF, and the energy vector (r_E) that solely involves the loudspeaker gains and positions.

By contrast, the IACC is an excellent predictor of phantom source widening using phase- or amplitude-based decorrelators. The article investigates how to extend the simpler LF and r_E predictors, which do not require dummy head measurements or measurements at all, to offer similarly good predictions.

Tuesday Virtual acoustics (Poster)

Effects of the Direct-to-Reverberant-Ratio and Divergence Between Synthesized and Listening Room on Perception of Virtual Acoustic Environment

Stephan Werner and Anett Zabel
Ilmenau University of Technology

Three listening tests are presented to evaluate the influence of different direct-to-reverberant-ratios (DRR) on the perception of a binaural synthesized acoustical scene via headphones. The effect is evaluated for divergence and congruence between the synthesized scene and room and the listening room. The first test measured the perceived externalization of a hearing event by a forced-choice method. A strong influence of the DRR on externalization is visible. Furthermore, a clear effect of congruence or divergence between synthesized and listening room is measured. This effect is independent from the DRR conditions. The second test measured the consensus in perception between the virtual acoustic environments and the real environment for different DRR and rooms by a method of adjustment. The third test contains a repertory-grid technique to assess the individual constructs and elements of the perceived virtual environment. The test reveals distinct differences between the attributes and groups ”room acoustic characteristics”, ”listener envelopment”, and ”subjective quality”.

Tuesday Virtual acoustics (Poster)

A Software Tool for the Synthetic Auralization of Gearbox Failures

Karsten Moritz, Joachim Bös and Holger Hanselka
TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

The influences of worn bearings and gearbox failures on the sound emission of machines are well known and used in machine diagnosis tools to detect failures at an early state, e.g., by means of spectrum analyses. In the present study this knowledge was used to create a simulation tool that generates synthetic sound files depending on a chosen failure. The general waveform is built on the fundamental frequency, given by the rotation frequency, and is superposed by an individual tooth engagement frequency. In addition, various failures, e.g., tooth damage, worn gears, and damaged roller elements can be simulated and added to the waveform. An FFT of the sound file is performed so that the effect of the failure can be seen both in the time and in the frequency domain. This way the tool helps to demonstrate the principles of failure diagnostics in classes and allows an estimation how the sound of a gearbox would change if one or several of the abovementioned failures occurred. It can also be used to evaluate the psychoacoustic influence of various gearbox failures to the human perception without the effort of recording the acoustic emissions of faulty gearboxes.

Tuesday Virtual acoustics (Poster)

Synthesis of Binaural Room Impulse Responses

Stephan Werner and Rebecca Sass
Ilmenau University of Technology

An algorithm is developed which synthesizes binaural room impulse responses (BRIRs) by interpolation between measured data sets. Emphasis is put on the interpolation between distances as well as between different rooms. A linear interpolation in time domain and an time adjustment of the two BRIRs by dynamic time warping prior to interpolation to generate new data sets are used. BRIRs are measured in two rooms for different distances as raw data for the synthesis. For each room an interpolation between data sets of different distances is carried out. Additionally, there is an interpolation between the two rooms, also using both synthesis methods.
The results of the synthesis are evaluated in a listening test. On the basis of perceived distance and externalization the general applicability of the synthesized impulse responses for binaural reproduction is investigated. We can show that there is no significant difference in distance perception between synthesized and measured BRIRs. Furthermore, the test shows that perceived externalization benefits from the amount of reverberation and from congruence between the synthesized and listening room. The positive influence of the congruence between the rooms is minor if the synthesized signals are reverberant but it becomes more dominant if there is less reverberation.

Tuesday Virtual acoustics (Poster)

openMat - Management of Acoustic Material (Meta-)Properties Using an Open Source Database Format

Dirk Schröder[a], Alexander Pohl[b], Stefan Drechsler[b], Peter Svensson[c], Michael Vorländer[d] and Uwe M. Stephenson[b]
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While most acoustic material properties are standardized today, the way of digitally storing such data is not. Commercial applications, internal developments and open-source solutions usually use their own proprietary file formats that make a data exchange practically impossible. This circumstance led to the foundation of openMat. This cooperative project aims at defining a standard for the storage of both standardized acoustic material properties and supplemental meta-information. In the current conceptual design, openMat supports the following material properties: absorption-, scattering- and diffusion coefficients as well as bidirectional transfer functions and complex impedances. In addition, meta properties are assignable to each material, e.g., multilingual material description, information on pricing and data acquisition, and additional files such as textures and 3D models. Using such meta-information makes the database already applicable during the early and graphical design stage of a room.

The project proposes an Extensible Markup Language (XML) database format since XML is human- readable, machine-processable, and a de-facto standard today. However, the openMat project provides not only the database specification, but also a huge example library, plug-ins and an open-source, platform- independent database editor with convenient graphical user interface and comprehensive manual. All content is freely available on the project site www.openMat.info.

Tuesday Virtual acoustics (Poster)

Spatial Sound Rendering of a Playing Xylophone for the Telepresence Application

Miloš Marković, Esben Madsen, Pablo F. Hoffmann, Søren K. Olesen and Dorte Hammershøi
Aalborg University, DK

BEAMING is a telepresence research project aiming at providing a multimodal experience between two or more participants located at different locations. One of the BEAMING applications allows a distant teacher to give a xylophone playing lecture to the students. Therefore, rendering of the xylophone played at the student's location is required at the teacher's site. This paper presents a comparison of different recording techniques for a spatial xylophone sound rendering, focusing on the horizontal width of the xylophone auditory image. The directivity pattern of the xylophone was measured and spatial properties of the sound field created by a xylophone as a distributed sound source were analyzed. Xylophone recordings were performed using different microphone configurations: one and two-channel recording setups are implemented. One-channel recording technique with binaural synthesis for spatial xylophone sound rendering is proposed. The recorded signal is processed in order to define multiple virtual sources which are spatially distributed for the auditory width representation of the virtual xylophone. The results of the analyzed recording and rendering techniques are compared in terms of the cross-correlation coefficient and subjectively by the listening test. The results show that the proposed method improves horizontal width perception of the xylophone auditory image.

Tuesday Virtual acoustics (Poster)

HRTF adaption under decreased immersive conditions

Florian Klein and Stephan Werner
Ilmenau University of Technology

About 14 years ago, Hofman et al. have shown that the human hearing system is able to adapt to the listeners head related transfer function (HRTF). Hofman et al. used ear molds to modify the HRTF. They were able to show the adaption effect by conducting localization test after different amounts of training periods. In the last years more researchers have investigated this topic and found similar results. Majdak et al., Parsehian et al. and several others used virtual auditory environments to train the listeners. One degree of freedom in HRTF adaption tests is the type of feedback which is used to present the listener the correct spatial direction of the stimulus to which the

auditory listening system should adapt. Researchers have shown that visual and acoustical responses work well to gain an adaption effect. An open question is how the level of immersion of the adaption test influences the expectable training effect. Is a fully immersive environment needed or can the auditory system also be trained under less immersive conditions? The aim of this publication is to investigate this issue by conducting listening tests under decreased immersive conditions and to compare the results to the work of other researchers.

Tuesday Virtual acoustics (Poster)

Measurements auralization of quality

Pawel Malecki, Jerzy Wiciak and Jacek Wierzbicki
AGH University of Science and Technology, Krakow (PL)

This paper presents the set of partial factors meant to establish how accurate the room acoustic auralization is. Most of the proposed factors are based on sound intensity vector estimated by first-order ambisonic microphone. Sound intensity vector is described in spherical coordinates furthermore psychoacoustic properties of sound perception are taken into account. Also results of the experiment designed to provide proposed factors variance are shown. Finally comparison of different auralization stands is provided using proposed AQF (Auralizatation Quality Factor).

Tuesday Virtual acoustics (Poster)

Comparison of Geometrical Acoustic Simulation Methods

André Siegel and Hans-Peter Schade
Ilmenau University of Technology, Audiovisuelle Technik

Acoustic simulation algorithms are widely used and are subject of continuous development. Two different trends can be observed. On the one hand room acoustical simulation software becomes more complex and accurate and it is computational expensive to calculate exact reverberation and acoustical parameters. On the other hand libraries and plug-ins are used in game audio programming and music production to create a satisfying acoustical environment to impress gamers and music listeners.

In this work is examined, how the complexity of simulation algorithms effects the plausibility of auditory environments. The basis for this work are geometrical methods such as ray tracing and mirror image source method. Two dimensional, three dimensional and hybrid methods are compared. There are two possibilities for the hybrid method, the combination of 2D-raytracing and 3D mirror image source method of very low order or the combination of 2D-raytracing with simulations of the first strong reflections of floor and ceiling.

The simulation programs are used to produce dynamic scenes with moving listener and multiple sources. The synthesized audio material is presented binaurally in a listening test.

The paper will give an overview of the simulation parameters and the results of the listening test.

Tuesday Virtual acoustics (Poster)

A multichannel loudspeaker array for WFS/HOA sound spatialization at IRCAM's concert hall

Markus Noisternig, Thibaut Carpentier and Olivier Warusfel
Acoustic & Cogn. Spaces Res. Group, UMR STMS IRCAM-CNRS-UPMC, Paris

This poster presents the design and implementation of the newly constructed surrounding multichannel loudspeaker array in IRCAM's concert hall (Espace de projection). Building on the variable acoustics already existing in this hall it aims at extending the space's capabilities by adding a system for holophonic sound reproduction. The horizontal array is constructed of 280 equal-distant loudspeakers surrounding the audience, complimented by a hemisphere of 75 loudspeakers. In its current implementation the hemisphere has been optimized for 3D Higher-order Ambisonics (HOA) with reproduction orders up to N=9. The horizontal array provides a dense grid of speakers for 2D sound field reproduction with Wave Field Synthesis (WFS), and HOA up to N=120. A signal-processing library developed for this purpose handles all spatial rendering in real-time.

Tuesday Virtual acoustics (Poster)

Time-frequency-domain parametric spatial audio for virtual acoustics

Ville Pulkki
Aalto University

Directional audio coding (DirAC) is a parametric time-frequency domain method for processing spatial audio based on psychophysical assumptions and on energetic analysis of sound field. Methods to use DirAC in spatial sound synthesis for virtual worlds are reviewed in this paper. It is shown that DirAC can be used to position, and to control the spatial extent of virtual sound sources with good audio quality. It is also shown that DirAC can be used to generate reverberation for N-channel horizontal listening with only two monophonic reverberators without a prominent loss in quality when compared with quality obtained with N-channel reverberators. The auralization of reflections and other phenomena in virtual acoustics are also discussed.

Tuesday Virtual acoustics (Poster)

Modelling of the 3D absorbers in ray-based algorithms

Monika Rychtáriková[a], Julia Zrnekova[b] and Vojtech Chmelik[b]
[a] *KU Leuven, Lab. of Acoustics and Thermal Physics;* [b] *STU Bratislava*

The article deals with acoustic simulations of rooms in ray-based algorithms, that contain sound absorption of one of the interior surfaces higher than 100%, due to presence of acoustic elements such as 3D absorbers, clouds and baffles. It is well known, that in the ray-based simulations it is not possible to assign sound absorption coefficient of a surface higher than 1, which means other solutions need to be used in model preparation. In our study we deal with several alternatives of 3D absorbers modelling in

software CATT Acoustic and Odeon. The result of simulations are compared with the measured values before and after the installation of absorbers in situ.

Session "Auralisation of environmental noise"

Tue 15:30 Civic exhibition room Auralisation of noise

Real Time Auralization of Non-Stationary Traffic Noise - Quantitative and Perceptual Validation in an Urban Street

Julien Maillard
CSTB, Saint Martin d'Hères (F)

This paper presents a validation study of a recently developed auralization technique for non-stationary traffic noise in urban areas. The approach implements a real time sample-based synthesis of engine and tire noise components allowing the restitution of moving vehicles with varying speed and engine regime. The acoustic propagation between sources and the listener location is modeled using standard engineering methods where the most important propagation paths are rendered individually. Results from an urban test site comparing recorded and auralized sequences of road traffic noise are discussed. The site features two types of road surfaces. Statistical pass-by analysis and binaural recordings were carried out for both road surface types. Auralized sequences using equivalent traffic flow conditions were then simulated. Different noise abatement approaches including low barriers and additional road surface types were also simulated. Pass-by sound pressure level indicators obtained on recorded and auralized sequences are compared. Results from listening tests conducted on both recorded and auralized sequences are then discussed. The listening tests were designed to evaluate the ability of the proposed auralization technique to yield similar annoyance levels than those obtained on real recorded signals.

Tue 15:50 Civic exhibition room Auralisation of noise

Auralization of tyre/road noise based on the SPERoN prediction tool.

Alice Hoffmann, Jens Forssen and Wolfgang Kropp
Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)

The SPERoN prediction tool allows to simulate pass-by spectra for different tyre/road combinations. The goal of this work is to use such a prediction for auralising pass-by sounds, which later on can be used in listening tests.
For this a previously developed methodology is applied where recorded sounds of pass-by situations have been recorded monaurally. The recoded signals are then converted to a source signal for the engine and the tyre/road interaction. By this it is possible to shape the tyre/road source term by calculated spectra and synthesize the signal again to a pass-by signal.
With the help of psychoacoustic judgments, the modelled signals were compared with recorded signals on a test field with the same tires, roads and distances in order to see how well the auralised signal matches the real signals in perception.

Tue 16:10 Civic exhibition room Auralisation of noise

Auralization of road traffic noise and its value for environmental noise assessment

André Fiebig, Roland Sottek and Elisabeth Kuczmarski
HEAD acoustics GmbH

In order to obtain a deeper understanding of the relationship between predicted environmental noise and actual noise annoyance and complaints, current research projects address this issue in detail. One approach for a reliable prediction of annoyed people in cities is to work with auralization techniques, which would allow for calculating psychoacoustic parameters and even experiencing the ”real” noise exposure. For example, by means of auralized road traffic scenarios it could be possible to include psychoacoustic evaluation metrics in noise maps. In the European research project CityHush, auralization tools were developed over the last three years. The objective was to auralize road traffic composed of hybrid and electric vehicles as well as vehicles with internal combustion engines. For the synthesis of pass-by noise of different passenger car types as well as of complete traffic scenarios with complex traffic compositions, a traffic noise synthesizer was developed. Measurement data, simulations of road traffic scenarios as well as resulting psychoacoustic noise maps will be presented and discussed with respect to their explanatory power. Further, the benefits and limitations of the developed traffic noise synthesizer with regard to noise mapping and urban planning will be discussed.

Tue 16:30 Civic exhibition room Auralisation of noise

Auralization of truck engine sound – preliminary results using a granular approach

Jens Forssen, Patrik Andersson and Penny Bergman
Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)

It is of interest to auralize engine sounds of heavy-duty vehicles since this part of road traffic auralizations previously has gained less interest compared to that of light vehicles. The current project focuses on urban environments and the sound indoors due to delivery vehicles. Using auralizations of different scenarios, it shall later be possible to propose improvements to an investigated Volvo truck as well as to compare the use of different vehicle types for delivery, e.g. medium-duty and heavy-duty vehicles. For light vehicles in normal driving conditions at constant speed, it has previously been shown that the engine sound can be well modelled using a small number of tonal components at relatively low frequencies. However, heavy-duty vehicles with diesel engines usually display a richer sound also up to mid frequencies. Therefore, a granular approach is used to capture the characteristics of a Volvo truck diesel engine. In this approach, short time pieces of a recorded pressure signal are stored and later combined to synthesize an engine sound that shall function as a source signal to simulate drive-by and other scenarios. Initial listening tests are performed to evaluate the qualities of the granular approach using continuously recorded signals as reference.

Tue 16:50 Civic exhibition room Auralisation of noise

Nuisance comparison in measured and simulated auralizations of noise insulation in building acoustics

Jaume Segura Garcia[a], Maximo Cobos Serrano[a], Martin Guski[b], Michael Vorländer[b] and Santiago Felici Castell[a]

[a] *University of Valencia, Computer Science Dpt (E);* [b] *Inst. of Technical Acoustics, RWTH Aachen University*

Indoor insulation is an important issue in building and room acoustics. EN12354 norm is addressed to estimate a set of insulation parameters. Auralization of noise insulation allows audio rendering of any source in the neighborhood, filtering with the sound abatement parameters of the flanking walls, doors, windows, etc.

In this work, a study of the auralized sound received in two rooms has been made. The measurement of the impulse response has allowed the calculation of the noise reduction, and the simulation of the noise insulation (using a commercial software) has confirmed the results of the measured auralization. Finally, a comparison of the nuisance of the measured and simulated signals has been made by using the Zwicker model.

Tue 17:10 Civic exhibition room Auralisation of noise

The influence of vision on the perception of auralized sounds

Francesco Aletta[a], Massimiliano Masullo[a], Vincenzo Paolo Senese[b] and Francesco Ruotolo[b]

[a] *Second University of Naples, Dep. of Architecture;* [b] *Second University of Naples, Dep. of Psychology*

During the last decades the progresses in the computing power and data storage have allowed to manage and process a large amount of information, improving significantly the possibility to ”renderize” both video and audio cues, re- creating virtual environments that simulate real scenarios. Today virtual environments can be experienced by means of Immersive Virtual Reality (IVR) tools, which provide to the users a full immersion into the simulated environment. While the auralization techniques are well developed and diffused for the applications in indoor environments, for outdoor environments the use of these techniques has only recently gained attention of experts thanks to the even more frequents attempts of its usage in combination with visual or virtual scenarios. Considering the general complexity of the outdoor environments and in order to reduce the computation load needed for their auralization, the efforts of experts are aimed to reach a perceptually correct or plausible auralization rather than a physically correct auralization. However, the sound perception can be also influenced by non-auditory factors. In the present study it was investigated the influence of the vision on the perception of auralized sounds. The main results are presented and discussed.

Tue 17:30 Civic exhibition room Auralisation of noise

A Hybrid-Internet-Auralization Program for Environmental Sounds

Klaus Naßhan and Philip Leistner
Fraunhofer-Institut für Bauphysik, Stuttgart

In the joint research project ”Simulation and rating of total noise with respect to its impact” a hybrid-internet-real-time auralization program was developed. Aim is to give non-specialists a hearing impression of the future sounds at a certain place after a development project is completed nearby or a new railroad line is built etc. For this purpose an internet browser and a real-time auralization is coupled. General information and original sounds are provided via internet, building virtual situations and auralizing is done with the local computer. All steps except the downloads are in real-time. Each sound source is embedded in a ”sound path” which may include the effects of noise barriers, windows, distance, direction and - if indoor - reverberation. Road traffic noise is synthesized from single car passings. Several thousand sounds can be auralized simultaneously. These elements allow to generate a fairly complete mapping of noise at a place, to make changes, to include background noise and rate the situations by one’s own ears. When a few remaining tasks have been finished the program can be downloaded and used cost-free for non-commercial purposes.

Tue 17:50 Civic exhibition room Auralisation of noise

Auralization of Wind Turbines

Kurt Heutschi and Reto Pieren
Empa, Swiss Fed. Labs for Materials Science & Technology

The Swiss project VisAsim implements a tool to synthetically visualize and auralize wind turbines in arbitrary environments. Here the auralization module is described with special emphasis on the emission synthesizer and the propagation filtering. As detailed analysis of several turbines has shown, the emitted signal is composed of broad-band noise with periodic and random amplitude modulations and possible tones. The propagation filtering considers geometrical spreading, air absorption, ground effect and shielding by obstacles. In addition, frequency dependent amplitude variations caused by turbulences are simulated. As measurements have revealed, the source needs to be modeled with a vertical extension that spans over the diameter of the rotor in order to correctly simulate the ground effect and the effect of turbulences.

Session "Vehicle acoustics"

Tue 15:30 Cult. centre movie theatre Vehicle acoustics

Simulation and Measurement of High Frequency Vibration Excitation during Vehicle Crash

Marco Pawlowski[a] and Martin Meywerk[b]
[a] *Volkswagen AG;* [b] *Helmut-Schmidt-Univ. Hamburg, Fahrzeugtechnik*

In the field of car safety the main requirement of sensor systems is the activation of passive safety systems as quickly as necessary with robust distinction between different crash configurations. Commonly applied crash detecting algorithms are based on deceleration signals up to 400Hz. However, discrimination of crash configurations at low-speed with high relative stiffness and high-speed with low relative stiffness between crash partners is challenging. In order to assure robust discrimination between these cases additional sensor information is provided by up-front-sensors placed directly in the frontal crumble zones and Crash-Impact-Sound-Sensing (CISS) technology. CISS exploits high frequency vibration up to 20kHz and contributes to a better crash severity classification. This work presents explicit FEM simulation of a frontal bumper system allowing to estimate CISS-signals excited by a plastic deformation process. It is shown, that the dominating source of high frequency vibration are colliding and deforming components. The CISS signal intensity is directly related to contact parameters and surrounding structural stiffness. Single impact events with well known parameters are discussed as well as complex crash tests involving a body in white car structure. FEM simulation results are validated by experimental data and lie within measuring accuracy.

Tue 15:50 Cult. centre movie theatre Vehicle acoustics

Creating a Method to make the Excitation of a Cars Roof by Rain more objective - Creating an Artificial Rain Sound on the Basis of a Defined Single Excitation -

Christian Triebel[a], Marc Mändl[a] and Jörg Bienert[b]
[a] *Bertrandt Ing.-Büro GmbH;* [b] *HAW Ingolstadt*

In developing cars topics of convenience like acoustics grow more and more important. This article deals with the question whether the acoustical result of rain on the roof of a vehicle can be reproduced.
According to the findings of previous studies, that you can reproduce raindrops in a test bench this article shows another element for making the sounds of rain objective and comparable.
After building and starting a test bench for raindrops the roof of the vehicle is systematically divided into several smaller areas, which are given raindrops one by one. Then the sound which is heard inside the vehicle is measured. With help of different algorithms the recorded raindrops will be transformed into a synthetical rainsound which is very similar to the natural sound. First you judge subjectively if there is a difference between the artificial sound and the real rainsound. But there is also a statistical procedure for this comparison.

Through reproducible raindrops and a certain ”rain algorithm” you can make exact statements about different insulation agents against sound and vibration for the roof of a vehicle. So the stochastical character of the rain doesn't have an effect on the comparability of the results.

Tue 16:10 Cult. centre movie theatre Vehicle acoustics

Modeling of Gearbox Whining Noise

Matthias Stangl and Brice Nelain
VIBRATEC France

The main source of excitation in gearboxes is generated by the meshing process, which generates vibration transmitted to the casings through shafts and bearing. Casing vibration generates in turn acoustic radiation (whining noise). For real cases, the prediction of whining noise remains a difficult problem.

In this work, an original calculation procedure is implemented by combining a finite element method with efficient algorithms for contact resolutions and parametric excitation (Spectral Iterative Method, developed by the Ecole Centrale de Lyon). The procedure is based on a modal approach with development in the frequency domain, being very effective in analyzing system having many degrees of freedom.

First, the excitations (static transmission error and tooth stiffness) are calculated from the knowledge of the teeth macro and micro geometry. Then, these data are used to calculate the vibration response of the gearbox, via a modal reduction.

The calculation chain is validated at each stage by confrontation with measurements performed on a specific gearbox test bench with complex instrumentation. The correlations prove the relevance of the approaches.

The work is carried in the French research program MABCA, funded by the ANR (National Research Agency).

Tue 16:30 Cult. centre movie theatre Vehicle acoustics

Development of a Vehicle Interior Diesel Knocking Metric

Dirk Hunken[a], Oliver Jung[b], Volker Grützmacher[b] and Jan Rennies[c]
[a] *Fraunhofer IDMT;* [b] *Adam Opel AG;* [c] *Fraunhofer IDMT - HSA, Oldenburg*

The audible noise of combustion engines has been significantly decreased over the past years. Due to reduced masking by other engine noise components, however, impulsive noise phenomena such as the ”knocking” in diesel engines become more audible and annoying for customers. Previous studies were concerned with the assessment of impulsive noises based on acoustical parameters. The Diesel Knocking Index (DKI), for example, was developed as a combination of loudness and modulation parameters to objectively quantify the airborne knocking of diesel engines for different engine operating conditions, either on a dynamometer or outside of a vehicle.

In contrast to the exterior noise, the perceived knocking in the passenger compartment is a combination of airborne and structure-borne transmission paths. Therefore, the original weighting factors in the DKI calculation are not suitable for the assessment of interior noise. The present study aimed

at extending the applicability of the DKI to diesel knocking inside vehicle interiors.
Listening tests were conducted to evaluate interior diesel noise. Exterior noise ratings were also used to check the comparability to previous DKI-related studies. Based on the ratings of the interior noise samples a new interior diesel knocking metric was developed and further validated with a control data set.

Tue 16:50 Cult. centre movie theatre Vehicle acoustics

Measurements and model predicts of detection thresholds for a conventional and electric vehicle in traffic and pink noise.
Julian Grosse[a], Steven van de Par[b] and Reinhard Weber[b]
[a] *University of Oldenburg, AG Akustik;* [b] *University of Oldenburg*
This study deals with the perception of vehicles passing by using binaural recordings. More specifically the detectability of a Mitsubushi Colt 1.1 (internal combustion engine) was compared with the Mitsubishi I-MiEV (electric power train) in street noise and pink noise. The detection thresholds and reaction times of seven subjects have been measured for vehicles passing at 10, 20, 30 and 50 km/h using a 3-AFC-measurement. Furthermore, the detection thresholds have been modeled using a psychoacoustic masking model [Dau et. al. (1996), J. Acoust. Soc. Am. 99, 3615 - 3622]. The detection thresholds of the AFC-measurement showed that especially at low velocitys the electric vehicle is more difficult to detect in comparison with the conventional vehicle. It also showed that the decrement of reaction times as a function of SNR was halved when traffic noise was used instead of pink noise. The combination of the AFC-measurements and the reaction times allows for a prediction of the moment in time that vehicles can be first perceived. In addition, the sound level necessary to avoid collisions can be estimated.

Tue 17:10 Cult. centre movie theatre Vehicle acoustics

Sound Quality Improvement using Low Weight Reinforced Thermoplastics (LWRT) in Automotive Air Conditioning Systems
James William Browne[a], Frank Uhl[b], Jakob Putner[a], Hugo Fastl[a] and Klaus Pfaffelhuber[b]
[a] *AG Technische Akustik, MMK, TU München;* [b] *Röchling Automotive AG & Co. KG*
Since air conditioning systems are often the largest source of noise in vehicles at low driving speeds, there is the potential for improvement of the overall vehicle interior noise. The noise reduction achieved by using Low Weight Reinforced Thermoplastics (LWRT) in automotive air conditioning systems was evaluated in psychoacoustic experiments with a magnitude estimation procedure. The vehicle interior noise was studied at various vehicle driving speeds and air condition air flow rates and evaluated using algorithmic methods and listening tests. Both methods showed reductions in loudness for noises emitted by LWRT equipped air conditioning systems. In addition, comparisons of the results showed that the calculated loudness

according to Zwicker (DIN 45631) gives suitable predictions for the perceived annoyance.

Tue 17:30 Cult. centre movie theatre Vehicle acoustics

Periodic Impulsiveness - Perception and metric

Ralf Heinrichs[b], Markus Bodden[a], Martin Rüth[b] and Jörg Müller[b]
[a] *Product Sound, Essen;* [b] *Ford Werke GmbH*

A process and metric to tackle Diesel Impulsiveness (Diesel knocking) has been developed and presented in former publications (e.g., Bodden & Heinrichts, DAGA 2008, Internoise 2007). While vehicles with gasoline engines did not show any similar behavior in the past, the introduction of direct injection engines let to the fact that nowadays also these engines produce a typical periodic impulsiveness (tick). The aim of the work presented here was to develop a unique and global process and metric to quantify general periodic impulsiveness. Extensive listening clinics have been performed an all levels, vehicle interior, exterior, and powertrain cell level to get insight into the perception of periodic impulsive signals. A corresponding metric has been developed which can be used on all levels for engineering purposes and for target setting on vehicle and system level.

Tue 17:50 Cult. centre movie theatre Vehicle acoustics

Source localization in real and simulated ISO - pass by for the determination of partial sound sources

Clemens Nau and Werner Moll
Daimler AG

Einer Verschärfung der Grenzwertregelungen für die Geräuschpegel von Kraftfahrzeugen muss insbesondere bei der ISO-Vorbeifahrt durch die Anwendung moderner Entwicklungsund Messwerkzeuge begegnet werden. Da sich das Beamforming bei der Kartierung von Schallquellen bereits in Teilbereichen als besonders leistungsfähig erwiesen hat, sollte im Rahmen der Untersuchungen das Potential dieser Methode bei der Bestimmung von Teilschallquellen bei der realen ISO-Vorbeifahrt und statischen Messungen unter den Randbedingungen der simulierten Vorbeifahrt evaluiert werden. Zur Beurteilung ihres Einflusses auf die Teilschallquellenkartierung wurden verschiedene Array-Geometrien eingesetzt. Dieser Vergleich sollte die Frage beantworten, welcher Mehrwert bei der Kartierung von Schallquellen durch die Verwendung eines 120 Kanal Spiral Array im Vergleich zu einem 48 Kanal Ring-Array erzielt werden kann. Zusätzlich wurden verschiedene Berechnungsalgorithmen untersucht. Bei diesen Untersuchungen sollte das ”Classical Beamforming” (CBF) erweiterten Beamforming Algorithmen (”AkustischerRadiergummi”, HDR) gegenübergestellt und die Eigenschaften bezüglich der Verbesserung von Dynamik und Auflösung verglichen werden. Schließlich sollte herausgestellt werden, ob die realen Vorbeifahrtmessungen, auch bei Variation der genannten Parameter, vollständig durch die statischen Messungen unter den Randbedingungen der simulierten Vorbeifahrt ersetzt werden konnten. Ziel der Arbeit war es,

durch die Kenntnisse der Schalldruckpegel der einzelnen Teilschallquellen und denen Anteil am Summenpegel, gezielt wirksame Maßnahmen zur Reduktion der Pegel der einzelnen Teilschallquellen generieren zu können.

Tuesday Vehicle acoustics (Poster)

Noise emission analysis in sliding friction

Dzmitry Savitski[a], Christian Probst[b], Klaus Augsburg[a], Peter Holstein[b] and Andreas Tharandt[c]

[a] *Ilmenau University of Technology;* [b] *SONOTEC Ultraschallsensorik Halle GmbH;* [c] *HTWK Leipzig*

The paper introduces a new approach to evaluate noise emission in sliding friction by means of ultrasonic analysis. This approach provides investigation of ultrasonic oscillations in frequencies up to 500 kHz. Proposed research represents the investigation of noise emission for different materials and conditions of brake pads in disk brake systems. Thus the developed approach can find a proper application in automotive testing area, in particular for noise emission analysis in brake systems.

Tuesday Vehicle acoustics (Poster)

Sound field characteristics of low frequency modes in cavities with leakages using the example of the interior of a car

Katja Stampka[a], Michael Möser[a] and Michael Brandstätter[b]

[a] *TU Berlin, Institut für Strömungsmechanik und Techn. Akustik;* [b] *BMW AG*

The sound pressure level of the low frequency noise in cars is particularly high. If the car occupants are exposed to noise below 100 Hz signs of fatigue and an impaired concentration can occur whereby the risk of an accident is increased. To understand the sound propagation of low frequencies in the cabin better, and to enhance it positively, a detailed knowledge of the sound field is needed. In reality a car could not be considered as a closed cavity due to air conditioning or open windows. The influence of these leakages on the first modes was investigated. For the characterisation of the low frequency modes in a vehicle and to illustrate the fundamental mechanism involved, the cabin was simulated as a rectangular enclosure. The sound field of that two-dimensional model was calculated. Results of numerical studies for systems with one and two leakages will be presented and compared to experimental results.

Session "Micro loudspeaker: Characterization, simulation and measurement"

Tue 15:30 Cult. centre music room Micro loudspeaker

Dominant Nonlinearities in Microspeakers

Wolfgang Klippel
KLIPPEL GmbH

The nonlinearities inherent in micro-speakers are modelled by a lumped parameter equivalent circuit considering the displacement varying force factor Bl(x), stiffness of the mechanical suspension Kms(x), voice coil inductance L(x) and velocity depending mechanical resistance Rms(v). The curve shapes of the nonlinearities are measured by nonlinear system identification based on voltage and current monitoring at the terminals of the transducer. The nonlinear model and the identified parameters of the particular transducer are the basis for predicting the transfer behaviour in the large signal domain and explaining nonlinear symptoms like amplitude compression, bifurcation, instability and the generation of additional signal components (e.g. harmonic and intermodulation distortion). This information is crucial for designing small micro-speakers for personal audio devices such as cellular phones, laptops and other portable applications generating sufficient sound pressure output at high efficiency and sufficient sound quality.

Tue 15:50 Cult. centre music room Micro loudspeaker

Estimating Linear Parameters and Identifying Acoustical Loads of Micro-Loudspeakers

Gregor Höhne
KLIPPEL GmbH

Micro-loudspeakers introduce various new challenges on the corresponding modeling and measurement techniques. Their composition often leads to a high resonance frequency and due to the creep-effect to a strong frequency-dependence of the mechanical compliance. Since they are usually driven over the whole audible frequency-band it becomes necessary to apply well-suitable models describing the creep of the suspension. Additionally, it is preferable to be able to separate the purely mechanical creep-effect from other effects, like air leakage, which have a similar impact. The acoustical load introduced by mounting micro-loudspeakers in enclosures of modern multimedia devices like smart-phones or tablet-computers, can often not be described by classical models in a sufficient manner. The presented techniques combine measurements in vacuum, free air and with an attached load, making it possible to differentiate between mechanical and acoustical effects, as well as to separate the connected acoustical load. Further, methods are introduced allowing to model the separated load as a transfer-function of arbitrary order and to estimate the corresponding parameters.

Tue 16:10 Cult. centre music room Micro loudspeaker

Inverse determination of membrane properties in small dynamic transducers

Meike Wukau
Sennheiser electronic GmbH & Co. KG

Mobile applications demand more and more small transducers also in earphone products. Especially the design of included membranes is a challenge with a lot of goal functions. To provide a good dynamic performance over the whole audible frequency range it is essential to investigate details about the radiation phenomena. Because of complex behavior especially in high frequency range the Finite Element Method becomes more and more an important tool to reduce costly series of measurements.
A detailed knowledge of the elastic membrane parameters is essential for efficient simulations. The data of the raw material is relatively easy to measure. But due to the complex membrane shape it is it impossible to determine the changed properties after the embossing process by conventional methods. Therefore an inverse determination of the material parameters with the help of FE-simulations is developed. A model of the membrane is created and missing properties are determined by fitting the simulation results to measurements.

Tue 16:30 Cult. centre music room Micro loudspeaker

On the Influence of Flat Enclosures on Electrodynamic Driver Properties

Daniel Beer, Lutz Ehrig and Lorenz Betz
Fraunhofer Inst. for Digital Media Technology IDMT, Ilmenau

Neglecting the issue of standing waves loudspeaker enclosure design is usually considered independently of the geometry of the enclosure volume. Based on a given set of Thiele-Small-Parameters only the size of the volume is derived for a desired alignment. However it has been observed that for enclosures having the same net volume but different geometries the mechanical properties of an electrodynamic driver built in that volumes changed. Especially decreasing one dimension of an enclosure, i.e. resulting in a flat shape, the resonance frequency of the driver built in that enclosure decreased significantly.
Based on measurement results we would like to present our findings and give explanations about possible causes. Considering the acoustic effect the question whether special considerations are necessary for the design of enclosures having extreme flat geometries will be discussed.

Session "Electroacoustics and sound reinforcement 1"

Tue 16:50 Cult. centre music room Electroacoustics 1

High-Frequency Loudspeakers using Air Motion Transformer Technology in High-Power Sound Reinforcement Systems

Dieter Leckschat and Arne Muscheites
University of Applied Sciences Düsseldorf

High-Frequency loudspeakers according to the 'Air Motion Transformer' (AMT) technology are in use in studio monitoring for some years now and have yielded a good reputation due to their clear, low-distortion treble sound. Now, improved technology for example in magnetic and glue materials, allow for the use of AMT drivers within high-power sound systems. Being line-shaped by nature, the use in line-array sound reinforcement systems is possible without any compressing wave guides. In Duesseldorf university, a prototype sound system was built consisting of 16 line-array elements resulting in a performance competitive to industry standards. The thermal control of the drivers is of special interest because the AMT's can be driven with high short-term power (more than 1000 Watt per tweeter). This power is converted into acoustic energy in a quite linear manner but would destroy the drivers if applied as a continuous signal. Thus we report about the significant electroacoustic parameters as well as about the measurement and control of the thermal behavior.

Tue 17:10 Cult. centre music room Electroacoustics 1

The Influence of Subwoofer Directivity on the Modal Field of a Small Room

Elena Shabalina[a] and Rob Opdam[b]
[a] *d&b audiotechnik GmbH, Backnang;* [b] *Inst. of Technical Acoustics, RWTH Aachen University*

Subwoofers(<200 Hz) are usually modelled as a point source in acoustical simulations, which is a good approximation and easy to implement. Some applications can benefit, however, by a low frequency source with a certain directivity pattern, for instance more public directed sound and less towards the stage for pop concerts. To investigate the influence of source directivity at low frequencies in a small room, measurements have been carried out and compared with FEM simulations. The measurements were carried out in a room of dimensions 12,2 x 12,5 x 4m with both an ordinary omnidirectional subwoofer and a directional subwoofer.

Tue 17:30 Cult. centre music room Electroacoustics 1

Optimization of Speech Intelligibility for Fire Fighters' Full Face Masks

Achim Volmer, Marcus Romba, Christoph Schmidt and Mohamed Houssem Harbi
Dräger Safety, Lübeck

Breathing protection is essential to protect fire fighters in their daily challenges. Self-contained breathing apparatuses supply clean air form backworn gas cylinder to a full face mask worn on the head. Within an incident it is moreover fundamental to ensure voice-communication within a team. However, full face masks tend to damp a lot of sound pressure especially of higher frequencies and intelligibility thus is degraded. Electro-acoustic amplification systems are therefore added to the mask to compensate the higher frequency losses.
This paper deals with the application of recently introduced objectified assessment of speech intelligibility for fire fighter full face masks. The optimization of the sound direction inside the mask as well as of an amplification system is presented. The potential enhancement depending on component tolerances is analysed.

Tue 17:50 Cult. centre music room Electroacoustics 1

Understanding with Hearing Aids and Audio Hearing Systems - Status and Prospects

Hannes Seidler
TU Dresden, Department of Medicine

Hearing impaired people require not only particular effort for the speech understanding but also a special technology. Hearing aids, Cochlear implants and wireless audio hearing systems have made qualitatively big progress and are used by a importend part of the persons concerned. Every device contains a complex signal processing and is fitted individually to the personal hearing problems. This permits a good communication in quiet surroundings in most cases.
However, under acoustically difficult surroundings the understanding becomes considerably more difficult. What do perform the hearing aids and implants? What do offer modern communication platforms of the hearing aid industry? How does the interconnection of hearing aids and audio hearing systems work? What do expect the hearing impaired users?
The pesentation shows a survey of the present technology. With the help of scientific knowledge, technical developments and the general tendency it is tried to show a perspective.

Tue 18:10 Cult. centre music room Electroacoustics 1

New sound reinforcement system for St. Paul cathedral Münster
Gottfried Behler and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University
One of the most renowned cathedrals in Germany, the Dom St. Paul in Münster was completely closed for renovation for almost one year. During this time the entire electro acoustical sound reinforcement system has been renewed. As for most buildings of this type the acoustical situation is far away from optimal. This mainly is due to a huge reverberation time which makes the understanding of spoken words almost impossible. Moreover, the old concept of sound reinforcement by using distributed loudspeaker systems all over the church is not satisfying anymore with respect to nowadays demands for quality and speech intelligibility. Due to the situation that the number of people in the cathedral during service times is varying from only some hundreds to over 2500 a more flexible PA system is required, that takes into account that only occupied areas inside of the cathedral should be supplied with amplified sound. To achieve the target an entirely new concept for the sound reinforcement based on digital signal distribution and modern digitally operated array loudspeakers was developed. The requirement for the speech intelligibility was to reach at least an STI of more than 0.5. The system will be discussed and results will be shown.

Tuesday Electroacoustics (Poster)

A Stochastic Approach for Robust Listening Room Compensation
Jan Ole Jungmann, Radoslaw Mazur and Alfred Mertins
University of Lübeck, Institute for Signal Processing
The purpose of room impulse response reshaping is to reduce reverberation and thus to improve the perceived quality of the received signal by prefiltering the source signal before it is played with a loudspeaker. The optimization of an infinity- and/or p-norm based objective function in the time domain has shown to be quite effective compared to least-squares methods. There are, in general, two possibilities to improve the robustness of the equalizers against small movements of the listener and/or receiver; namely multi-position approaches or the utilization of a regularization term. Multi-position approaches suffer from the extensive effort of measuring multiple room impulse responses. The perturbations introduced by small movements can be described by a stochastic error term. However, only quadratic penalty terms have been considered so far. In this contribution we propose a third method to improve the robustness against spatial misalignment. We combine the two approaches by feeding multiple realizations of the distorted RIR into the multi-position algorithm. We propose a simple, yet effective model to capture the perturbations and give comparative results against other state of the art methods.

Tuesday Electroacoustics (Poster)

A Curtosis Based Criterion for Solving the Permutation Ambiguity in Convolutive Blind Source Separation

Radoslaw Mazur, Jan Ole Jungmann and Alfred Mertins
University of Lübeck, Institute for Signal Processing

In this paper, we present a modification of an algorithm for solving the permutation ambiguity in convolutive blind source separation. An well known approach for separation of convolutive mixtures is the transformation to the time-frequency domain, where the convolution becomes a multiplication. With this approach it is possible to use well-known instantaneous ICA algorithms independently in each frequency bin. This simplification leads to reduced computational costs and better separation in each frequency bin. However, this simplification has the major drawback of arbitrary permutation in each frequency bin. Without a correction of this permutation the restored time domain signals remain still mixed. An often used approach for solving this permutation problem is the dyadic sorting, where groups of bins are consecutively depermuted. By recursively joining growing groups all bins gets sorted. In recent works we presented a criterion for the depermutation, which was based on sparsity in the time domain of the restored subband signals. In this work we modify this approach to use a curtosis based criterion which is an alternative measurement for the non-gaussianity of speech signals. [[english]]

Tuesday Electroacoustics (Poster)

Home theatre design according to EBU Tech. 3276

Andrea Farnetani
Materiacustica s.r.l., Ferrara

Small rooms dedicated to music listening or movie watching are very critical sound spaces. Their dimensions cause room modes to interfere with low frequency reproduction and the impulse response is usually affected by very strong reflections and lack of diffusion. The acoustical design of the room was done to achieve the reference conditions reported in the EBU Tech. 3276 for professional listening rooms involving direct sound, early reflection, reverberant field and room frequency response. For the simulation of the sound field two different model were used: a FEM model at low frequencies (Comsol multiphysics) and a ray-tracing model for mid and high frequencies (Odeon). Acoustical measurements ante operam were taken also for model calibration. Custom low frequency absorbers were specifically designed and tuned at room modes besides mid-high frequency absorbers and diffusers. All absorbers and diffusers were included into the models in order to optimize their positioning and to achieve the best results at the listening position. After the installation of the acoustical devices test measurements were done. Acoustic data show very good agreement both with simulations and EBU Tech. 3276 requirements.

Session "Noise and vibration at the working place 1"

Tue 15:30 Cult. centre exhib. room Noise at working place 1

Application of measurement uncertainties for comparing measuring results with the action values of European Directive 2003/10/EC

Jürgen Maue
IFA - Institut für Arbeitsschutz der DGUV, St. Augustin

In accordance with European Directive 2003/10/EC governing protection against workplace noise, employers are required to investigate whether "workers are or are likely to be exposed to risks from noise as a result of their work" (Article 1(2)). The directive specifies different action values in the form of daily noise exposure levels LEX,8h and peak sound pressure levels LCpeak as a basis for the evaluation of the noise situation and for the decision concerning the necessary protective measures. The measurement methods and apparatus used shall make it possible to decide whether the fixed action values have been exceeded (Article 4(2)). Since the measurements are to be performed in accordance with the relevant technical metrological standards, the revised international standard EN ISO 9612 forms the basis for determining noise exposure at the workplaces. This standard also describes the procedure for determining the measurement uncertainty. However, neither the EU directive nor the standards indicate how this uncertainty is to be considered comparing measuring results with the action values. In order to solve this problem in Germany two alternative methods for the comparison with fixed values were created. This procedure for comparison with the specified action values is explained.

Tue 15:50 Cult. centre exhib. room Noise at working place 1

Round Robin Test Occupational Noise Exposure

Wilhelm Wahler and Mark Telsnig
AUVA, Vienna, Austria

In case of changing the standard for calculating the noise exposure level from ÖAL-guideline 3 part 2 to ÖNORM EN ISO 9612 it is necessary to specify the uncertainty of measurement. This can be solved in different ways, also by round-robin-tests. Therefore two test series have been done in the AUVA (Austrian Workers' Compen-sation Board). These two test groups varied in skill of measurement experience. To guarantee the comparability between the tests, loudspeakers were used. The used signals are recordings from real life situations. Further aspects have been the uncertainty in determination of exposure time and handling of alarm signals. The results are evaluated and use for quality management.

Tue 16:10 Cult. centre exhib. room Noise at working place 1

Noise Exposure of Teachers in Elementary Schools

Eva Ruppert-Pils, Raimund Kleinhagauer and Andreas Kyrian
AUVA, Vienna, Austria

During measurements at nine different primary schools, the respective noise levels to which teachers were exposed were investigated. For the study, personal dosimeters were used to determine the effective noise level at the ear of the teacher. For additional control and to assess the influence of their own speech to the noise level, microphones were also installed in the classroom. Other factors, such as the reverbation time in the room, the content of carbon dioxide in the room, the subject and additionally notes by the teachers, such as the method of instruction, were also taken into account for the outcome of the study. Measurements were performed for each school in one first and one fourth grade class (6-7 years and 9-10 year old children), spread over several days. First results show that during a lecture, continous sound pressure levels LAeq of over 80 dB can be reached at the ear of the teacher, especially during lessons of physical education.

Tue 16:30 Cult. centre exhib. room Noise at working place 1

Sound exposure within orchestra: contribution of the own instrument

Heinz Waldmann
Suva Luzern, Bereich Physik

Measurement of sound exposure in symphony orchestras showed that the musicians' exposure is very high. In order to reduce this, it is essential to know the main source of sound for the different instrumentalists. Is it the own instrument that produces the main sound exposure or is it rather the combined sound of the instrumentalists next to him?

For the measurement in a symphony orchestra, 12 musicians were equipped with a microphone that was set up at approximately 7 cm from their ear canal. Signals were recorded on an 8 channel sound analyzer and a multichannel recording system respectively; all analysis were made on the 8-channel analyzer.

In a specifically planned rehearsal, an excerpt of approximately 45 seconds of Peter Tchaikovsky's symphony no 5 was played and recorded in different "instrumentations" (whole orchestra, only flutes, only oboes, only first violins, only trumpets...). Different arrangements of the height of the podium were also studied.

Tue 16:50 Cult. centre exhib. room Noise at working place 1

Workplace hospital: noise as a strain for the medical staff

Gert Notbohm and Silvester Siegmann
Universität Düsseldorf, Institut für Arbeitsmedizin

Noise research in hospitals focuses mainly on the harmful effects on patients. But at least in intensive care units and operation theatres, also the staff is exposed to high levels of noise during considerable portions of working time. Evidence from literature is summarized here. During operation sessions lasting from 30 min. to several hours, reported average Leq values range from 58 to 72 dB(A) with maximum levels above 105 dB(A). Similar noise levels are reported from emergency departments. As concentration, precise communication and fast decisions are necessary in these situations, the acoustical environment has to be considered an enormous strain for the staff and a potential risk with regard to faults at work. But also during normal day and night shifts in intensive care units, noise is mentioned as an important disturbance by the medical staff. Most disturbing are noises from telephones and other communication tools and the signals and sounds from medical devices. Questionnaire surveys result in 80 to 91 % of the staff reporting negative effects of noise in their daily work. A variety of measures for noise reduction and prevention in hospitals is suggested in literature emphasizing that the staff plays a decisive role in such projects.

Tue 17:10 Cult. centre exhib. room Noise at working place 1

Survey of Noise Emission Declarations of Machines in the European Market

Georg Brockt
Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)

In a common project shared by partners from 14 European member states the noise-related content of instructions supplied with machinery offered for purchase in the European Economic Area were examined by a market survey. The information in these instructions was analysed to determine compliance with the requirements of the European Machinery Directive and to assess the quality of information. The project collected more than 1500 sets of instructions from machines covering 40 broad machine-families. The general state of compliance of machinery instructions with the noise-related requirements of the Machinery Directive was found to be very poor: 80% of instructions did not meet legal requirements. The main causes of failure to meet legal requirements were: some or all required numerical values relating to noise emissions were missing or not traceable to machine operating conditions or measurement methods. As a consequence, it is considered highly likely that, in making a machinery procurement decision, employers are prevented from taking noise emissions into account, and are prevented in managing the risks from noise related to equipment that is procured.

Tue 17:30 Cult. centre exhib. room Noise at working place 1

Industrial Noise Reduction by Room Acoustic Measures

Daniel F. Förster
IFA - Institut für Arbeitsschutz der DGUV, St. Augustin

Room acoustic treatments are often suitable to reduce industrial noise. Depending on the initial conditions, noise reductions of 1 to 6 dB(A) can be achieved in proximity to the sound source, and more than 10 dB(A) farther away.

In Germany, the Noise and Vibration Occupational Safety and Health Ordinance demands that workrooms have to be designed such that the sound propagation conditions are conform to the state of technology. This is considered to be fulfilled if either the mean sound absorption coefficient of the room or the reduction of the sound level per distance doubling meet requirements which are given by corresponding technical rules.

As the possible noise reduction by room acoustic measures strongly depends on the given conditions, a significant lowering of the sound level is not guaranteed by just meeting these requirements. Furthermore, room acoustic treatments can be quite expensive. Hence, the given conditions should be carefully analysed and the amount of noise reduction should be estimated for different distributions of sound absorbers to find the most effective configuration. Such estimations can be performed by indoor sound propagation calculations which yield sufficiently accurate results due to improvements to the corresponding programs in recent years.

Tue 17:50 Cult. centre exhib. room Noise at working place 1

Noise Reduction in Working Areas by the Application of absorbing Baffle-Systems

Fabian Probst
DataKustik GmbH

Baffle systems are arrangements of absorbing panels that allow free flow of air and therefore don't disturb the acoustic climate. This is one of the reasons why they are often used in industrial environments because there is no need to take into account aspects of thermal isolation that may be a problem with closed suspended ceilings. A method to determine the absorption coefficient of baffle systems was derived and published in 2088 (Probst W.: "Sound absorption of baffle systems", Lärmbekämpfung Nr.2, 2008). A method is now presented how such systems can be taken into account if the acoustic behavior of even complex rooms is determined by computer modeling. For simple cases the mentioned analytical method can be applied and it is shown that the results are in good agreement with the detailed simulation. But this detailed simulation allows to determine the acoustic influence of partially covered areas with different heights and otherwise complex layouts with absorbing appliances.

Tue 18:10 Cult. centre exhib. room Noise at working place 1

Field report - evaluation of open plan offices according to ISO 3382-3

Mark Telsnig and Wolfgang Posseth
AUVA, Vienna, Austria

Many new offices are planed as open plan spaces. Up to now the acoustical situation was described by the mean sound absorption coefficient of the room according to ÖNORM B 8115-3 and the sound pressure levels of background noise and of normal office operation.
2012 a new standard was published to evaluate the acoustical conditions in open plan offices in an objective and repeatable way - ÖNORM EN ISO 3382-3. This article describes the used parameters, the first experiences by using the standard and possible improvements derived from the measured parameters.

Tuesday Noise at working place (Poster)

The Risk of Noise in the Bottling Alcoholic and Non-Alcoholic Drinks into Glass Bottles

Dennis Ramus, Alessandro Cervo and Markus Malfèr
Azienda Sanitaria dell'Alto Adige, Bolzano

In the present investigation nine of the leading beverage companies in South Tyrol, Italy, have been analysed, with particular attention to filling glass bottles. The areas examined were those related to the production of mineral water, soft drinks, wine, beer and grappa (a local spirit). After analyzing the technological cycle for beverage filling and the organization of work, the noise was measured, the sources of noise risk were highlighted and the moments of the strongest acoustic pollution were noted. The following components were measured: the noise levels emitted by individual machines (Leq dB (A)) and the measurement of reverberation times in order to define the work environments under the acoustic profile. The noise levels measured were related to the number of bottles produced. In the factories of fast bottling of mineral water, soft drinks and beer (more than 20.000 bottles/hour) high noise levels were found. The levels were higher than 85 dB (A) and sometimes reaching Leq of 94 dB (A) in areas where the workers were controlling washing and filling of the bottles.

Tuesday Noise at working place (Poster)

Exposure to noise and vibrations during the olive harvest in small farms

Valter Lori and Giorgia Nardini
Università Politecnica delle Marche, DIISM, Ancona

The aim of the study is to assess the noise and vibrations exposure for farmers during the olive harvest with electrical and pneumatic olive harvesters. Eight different commercial models of hand-held olive harvesters were tested. The models tested represent a sample of machines used in small farms for the olive harvest. Noise and vibrations samplings were carried out during the regular working activity with all the harvesters operated by the same worker expert in the use of this machines. The measured data are compared with the prevention values for the safety requirements fixed by the law in force.

Tuesday Noise at working place (Poster)

Vibration level generated by a rotary pick-up for the harvest of table olives

Christian Preti[a], Filippo Gambella[b], Roberto Deboli[a], Angela Calvo[c], Marco Inserillo[a] and Riccardo Dau[b]
[a] *IMAMOTER-CNR, Torino;* [b] *University of Sassari, Department of Agricultural Engineering;* [c] *University of Turin, DEIAFA, Mechanics Section*

The purpose of this study was to measure the level of vibration transmitted to the operator's hand while using electric machine used in the harvest of table olives. The tests were conducted measuring the level of vibration generated by three different types of plastic coating material, such as natural rubber, silicon and vulcanized rubber, used as coating of the teeth in order to minimize the damage to the drupes. The teeth coated were tested at three different rotation speed: 2000, 3000 and 4000 rev/min. The rotation speed of the teeth was controlled through the use of a mechanical revolution counter with a measuring range of the number of revolution between 400 and 50.000 rev/min and three different protection coatings, with a thickness of 7, 14 and 19 mm were tested. The data of all tests were statistically analyzed, by the simple analysis of variance. The hand-arm vibration from the different rake models tested depend mainly from kinematics of the rake used, varying in the different trials from a minimum of 6.3 m/s^2 to a maximum of 22.4 m/s^2. Probably this aspect is the main element to be taken into account by the ergonomic point of view.

Pneumatic Screwdrivers: Exposure to Hand-Transmitted Vibration when Changing Tyres at the Car Mechanic

Markus Malfèr, Dennis Ramus and Alessandro Cervo
Azienda Sanitaria dell'Alto Adige, Bolzano

This survey was carried out after having discovered soft-tissues disorders of the upper limb in workers exposed to hand-trasmitted vibration. The aim was to assess the extent and quality of the vibration in the arms of the workers specialized in replacing the tyres on cars. A total of thirtyfive measurements, made according to the recommendations of the International Standard ISO 5349:1-2, were taken from seven car mechanic shops in South Tyrol, Italy. The workers exposure to hand arm vibration resulted below the "action value" of 2.5 m/s^2. This finding seems to support the view that there might be an evidence for a positive association between exposure to a combination of risk factors (segmental vibration, forcefulness, awkward posture, manual handling of car wheels and tyres) and the occurrence of musculoskeletal disorders of the upper limb (WMSDs) in car mechanic.

Session "Numerical acoustics 1"

The Acoustic Power Radiated from Aluminum Foam Sandwich Panels

Vincenzo D'Alessandro, Giuseppe Petrone, Francesco Franco and Sergio De Rosa
Univ. of Naples 'Federico II', Dep. of Aerospace Engineering

Aluminium Foam Sandwich panels are becoming always more attractive in transportation applications thanks to their excellent combination of properties. These are due to the metallic nature of the matrix and porosity behaviour of the foam core: high strength and stiffness, low density, capability to absorb crash energy, thermal/acoustic insulation, vibration damping and recyclability. These properties depend on the morphology of the pores, the cell types, the size and the density of the gas bubbles. In this work, experimental investigation of acoustic characteristics of AFS panels is performed and the radiated acoustic power of two types of Alulight™ sandwich panels is carried out. Two types of specimens, made of the same material but with different thickness and percentage of foam density are tested. A simple experimental test bench is set-up with the panels suspended in free-free condition and excited by a shaker with a white noise signal in the frequency range 0-10kHz. The radiated acoustic power intensity is recorded by scanning the panels with an intensity probe. Results are post processed using sound intensity standard tools. Experimental results are compared with numerical ones: these ones are evaluated by using the Finite Element Method through the discretised Rayleigh integral for plane radiators.

Tue 15:50 Urania Alton Numerical acoustics 1

Structural-acoustic design of Hydraulic Pump Housings using Topology Optimization

Ulrich Bittner[a] and Peter Clausen[b]
[a] *Bosch Rexroth;* [b] *FE-Design, Karlsruhe*

Increasing demands on sound design require new methods to analyze and improve the acoustic properties in the early design process by appropriate simulation and optimization methods.

This presentation will show results of a housing of an axial-piston-pump which was modified by topology optimization. The method is based on the adjoint solution and uses a commercial tool chain consisting of ANSYS (FEM) and TOSCA (Optimization). Like other parameter-free methods, topology optimization method allows an easy setup of design variables and covers a large variety of possible solutions.

At first, the method will be shown on a simple box to demonstrate the challenges of the structural-acoustic topology optimization when verifying the design proposals. An improved strategy to overcome these limits will be presented. While other objectives which are traditionally available in topology optimization like maximizing static/ dyn. stiffness or Eigenfrequencies may hardly improve the sound power level, it can be shown that the surface-velocity objective is able to reduce the sound emission over a wide frequency band.

Finally the possibilities of the NVH optimization will be presented on a housing of an axial-piston-pump. The optimization leads to a realizable structure with innovative design features and improved acoustic properties.

Tue 16:10 Urania Alton Numerical acoustics 1

Energy-Finite-Element-Method for Acoustic Simulation of Large-Scale Structures

Marius Karger, Olgierd Zaleski and Otto V. Estorff
Novicos GmbH

Numerical simulations of vibrating structures, sound propagation and radiation may lead to enormous numerical cost depending on the frequency range and size of the structures. In the low and mid-frequency range the Finite-Element-Method is established and provides satisfactory results. The applicability of the Energy-Finite-Element-Method in the high-frequency range especially for large-scale structures of vessels is analyzed within the research project EPES, sponsored by the federal ministry of economy and technology.

The Energy-Finite-Element-Method (EFEM) based on energy and power densities and not on pressure and velocities as common Finite- Element-Methods, which simplifies the numerical models dramatically. In this paper focus is put on plate-like structures, for which the mesh must be separated in different parts at specific changes of geometrical and material properties. The EFEM also requires an analysis of transmission coefficients simulating the energy interactions between these separated parts.

This contribution presents the EFEM approach, calculations of transmission coefficients and energy distributions for structures of several geometric proportions. Based on those calculations, the applicability of the EFEM is discussed.

Tue 16:30 Urania Alton Numerical acoustics 1

On boundary conditions of absorbers for the intensity potential approach

Patrik Andersson
Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)

Noise emission of acoustical sources is commonly controlled by encapsulations that have large apertures to allow for cooling airflow. The intensity potential approach has been developed to predict sound power flow through partial enclosures. The approach is based on the Helmholtz decomposition of the vector field of the time-averaged sound intensity into its irrotational and rotational components. The local power balance in a lossless medium and the Helmholtz decomposition gives a Poisson equation for the scalar intensity potential of the irrotational component only. The approach has been evaluated by comparison to canonical examples and measured data. Previous investigations use a boundary condition of absorbers that assumes that the incident power is uniformly distributed over angle of incidence. The paper presents the intensity potential approach and a preliminary investigation on the use of a boundary condition of absorbers that assumes the incident power at a certain angle. The angle of incidence is given by the direction to a source close to the absorber. It is shown that this type of boundary condition may yield results closer to experimental results for certain cases.

Tue 16:50 Urania Alton Numerical acoustics 1

Quantum Mechanics_Acoustics Analogy and Inverse Scattering

Graziano Genuini
ISTI-CNR, Pisa

In the work sent is identified an analogy between the equations which describe acoustic phenomena and those which describe quantum phenomena. In fact, if we transform the wave equation, we see that the equation (in the frequency space) are similar (to less than a term related to the electrical potential) to the Schroedinger equation in ordinary physical space. However, even Acoustics possess a potential, whose physical meaning is not very physically transparent (a pseudo-meaning, defined as the impulsive force per unit mass of fluid that would generate the motion from the quiet). We can then conjecture, making an 'ad hoc' assumption that even our transformed equation, yet incomplete, may be written as the Shroedinger equation. In virtue of the suppository analogy, we can therefore mutuate the methods (tested) of quantum mechanics, known as 'inverse scattering'. The equation is then solved by applying an impulsive potential, and it is applied to it the technique of 'inverse scattering' with success. Then

we pass, through, inverse Fourier transform, to the solution in the physical space; it shows interesting aspects related to the shape of the ”new” functions found.

Tue 17:10 Urania Alton Numerical acoustics 1

TD-BEM - An Open Source MATLAB Toolbox

Michael Stütz[a] and Martin Ochmann[b]
[a] *Institut für Technische Akustik;* [b] *Beuth Hochschule für Technik Berlin*

Within the framework of a PhD thesis a Time Domain Boundary Element Method (TD-BEM) has been developed. 3D scattering as well as radiation problems can be solved in time domain. Transient processes like moving sources, engine acceleration, tire road interactions and squeal noise must be dealt with in time domain. The TD-BEM is a promising tool to handle such problems. The often discussed instable behavior of the method is treated by the use of the CHIEF method as already published in previous publications by the authors. The basic functionality of the TD-BEM-Toolbox will be shown and future extensions of the method will be discussed. It is freely available for download under GNU General Public License. This is a copyleft license for general use, which means that derived works can only be distributed under the same license terms.

Tue 17:30 Urania Alton Numerical acoustics 1

Objective Functions for Structural-Acoustic Optimization in Interior Acoustics

Gesche Diekmann[a], Steffen Marburg[b] and Fabian Duddeck[a]
[a] *FG Computational Mechanics, TU München;* [b] *Universität der Bundeswehr München*

In every optimization task, a good choice of the objective function is essential for obtaining meaningful results. Here, different objective functions related to energy-based and other physical quantities are compared regarding their performance in optimization of interior acoustics. Most common objective functions used in this field can be assigned to one of the two groups of either structural objective functions, e.g. equivalent radiated power, or acoustic objective functions, e.g. pressure or energy density, often taken at certain points inside the cavity. In this study, simple examples are developed in order to quantify the applicability of several objective functions to problems of interior acoustics dependent on design stages, knowledge or lack of knowledge, restrictions in computational effort, possible design variables and other general conditions of the optimization task. This should enable appropriate a priori choices of objective functions for more complex optimization problems.

Tue 17:50 Urania Alton Numerical acoustics 1

Efficient analysis of trimmed cavities with a hybrid (u,p) - Finite Element - Wave Based Method

Stijn Jonckheere, Dirk Vandepitte and Wim Desmet
KU Leuven

With the current state of the art, it is very challenging to solve a full FE-model of an undamped vibro-acoustic system into the mid-frequency domain, let alone a locally damped one. The Wave Based Method (WBM) is well suited for this full- system modelling, since it has a very good convergence rate as compared to the FEM and BEM. The application of the WBM is, however, limited to convex domains. To overcome this limitation, hybrid Finite Element - Wave Based approaches have been developed. This contribution extends the family of hybrid FE-WB methods towards coupling WB models for acoustics with FE models for poro-elastics. The method benefits from the computational efficiency of the WBM for the acoustic calculations, without losing the FEM's ability to model the layered and complex poro-elastic material in detail.

As previous work focused on the (u,U)-formulation of the poro-elastic problem, containing 6 DOFs per node, the current approach further reduces the computational cost by using a (u,p)-formulation with only 4 DOFs per node. The presented method is validated with a numerical example. This study considers the interior acoustics of a rigid-walled cavity where one of the walls is covered with trim layer.

Tue 18:10 Urania Alton Numerical acoustics 1

Two-dimensional Interaction of Pressure Pulses governed by a Modified Lighthill-Westervelt Equation

Enrique Nava[a] and J. I. Ramos[b]

[a] *Universidad de Malaga, ETSI Telecomunicacion (E);* [b] *Universidad de Malaga, Escuela de Ingenierias (E)*

A modified Lighthill-Westervelt equation that includes a damping term whose coefficient is a function of the pressure, is used to study numerically the two-dimensional interactions of compact pressure pulses generated at two adjacent edges of a rectangular domain. The numerical method is a time-linearized, second-order accurate finite difference scheme in both space and time that provides an explicit expression for the pressure. For Dirichlet's boundary conditions at the edges facing those where the pressure pulses are generated, it has been found that the pressure in the triangular zone determined by the edges where the pressure pulses are generated and their corner, exhibits a breathing behavior characterized by an oscillatory pressure that increases and decreases as the pressure of the pulses is positive, and increases and decreases, respectively. A similar behavior is observed when the amplitude of the pressure pulses is negative. It has also been observed that the pressure field is a periodic function of time after an initial transient that depends on the constants that appear in the nonlinear damping term, the lengths of the domain, the magnitude of the nonlinearity,

and the amplitude, location, width and frequency of the pressure pulses at the two adjacent edges.

Tuesday Numerical acoustics 1 (Poster)

A SEA-like Model for the Sound Insulation of Absorbing Materials

Cristina Díaz-Cereceda, Jordi Poblet-Puig and Antonio Rodríguez-Ferran
Universitat Politècnica de Catalunya, Barcelona

Modelling absorbing materials with statistical energy analysis (SEA) is an open issue. They are neither reverberant subsystems nor conservative couplings. In this work, a SEA-like model is presented for studying the sound insulation provided by absorbing materials. This model consists on extending the SEA approach for dealing with non-conservative connections.

The presented approach allows solving sound transmission problems in large domains (typical of building acoustics) in an efficient way, for the whole frequency range required by the regulations (50-5000 Hz). To do so, the SEA-like model is combined with detailed numerical computations in order to obtain the loss factors associated to the coupling. With these factors, a global system may be stated for computing the sound transmission between different subsystems, with both conservative and non-conservative couplings.

In this work, the model is applied to analyse the insulating effect of a layer of absorbing material (mineral wool) located between two thin plates. This layer is considered as a non-conservative coupling between the plates. Results of the computations show that the absorbing layer may be modelled as a non-conservative coupling and considered in an SEA-like system for studying the sound transmission in building acoustics.

Tuesday Numerical acoustics 1 (Poster)

Multidisciplinary Characterization and Optimization of Multi-Layered Sound Insulating Natural-Fibre-Reinforced-Plastic Components

Dina Al-Kharabsheh and Sabine Langer
Institut für Angewandte Mechanik, TU Braunschweig

Developing multi-layered sound insulating components, made of fiber-reinforced plastics, should start with the characterization of the mechanical and acoustical properties of the plastics. Here, various disciplines merge together; namely, mechanics, acoustics, materials science, and the production and manufacturing technology. This multidisciplinary characterization and then optimization requires understanding the dependencies between optimization objectives, acoustical and mechanical properties of the used materials, and the production process. As an example, a multi-layered component developed for the use in building acoustics is shown. A sensitivity analysis reveals the most important parameters for developing this component. Predicting the optimum range is supported by simulating the optimization objectives with the Transfer Matrix Method (TMM) and numerical methods, like the Finite Element Method (FEM). These predictions support the manufacturers during the development phase and are necessary for the future to enable rational design. Hence, a reduction in the amount of

costly experimental measurement effort is achieved. This saves enormous time and cost expenditures in future component designs.

Tuesday Numerical acoustics 1 (Poster)

Comparison of simulations and measurements for a simplified acoustic enclosure

Stephan Paul[a], Jéssica Lins De Souza[a], Eric Brandão[a] and Pascal Dietrich[b]

[a] *Undergr. program in Acoustical Eng., University of Santa Maria;* [b] *Inst. of Technical Acoustics, RWTH Aachen University*

Some years ago the Institute of Technical Acoustics of Aachen RWTH University started a project on measurement and simulation of transfer functions. A small rectangular room was chosen as device under test for acoustic and structural transfer paths. Several participants, four of them from Brazil, build their ITA Auralization Box according to the original specifications. In the current paper the most recent copy of the box should be evaluated regarding the results of measurements between 200 Hz and 20 kHz, simulations with FEM within 200 Hz to 2 kHz and simulations with BEM within 0 Hz to 6 kHz. Beside the results of measurement and simulation the measurement setup, material properties, discretization and geometry used for the FEM and BEM will be compared between the different boxes and discussed.

Session "Acoustic measurements and instrumentation (Poster)"

Tuesday Acoustic measurements (Poster)

Preliminary Acoustic Test on Densified Swine Solid Fraction

Christian Preti, Niccolo' Pampuro, Alessio Facello and Eugenio Cavallo
IMAMOTER-CNR, Torino

The aim of this study was to evaluate the acoustic characteristics of the solid fraction resulting from the solid-liquid separation of pig slurry in order to use this material during realization of facilities. In this study two different types of material have been investigated: swine solid fraction and swine solid fraction mixed with sawdust. These substrates were composted for a period of three months in order to stabilize them. The tests were conducted using different levels of pressure on the two materials for 60 seconds each. In order to verify the acoustic absorption coefficient, cylinders with different densities were made by using a hydraulic press (Pampuro et al., 2011). The method under normal sound incidence was used and the tests were performed with the Impedance tube device (also known as Kundt's tube device). Two different diameters for each cylinder (29 mm and 100 mm) were required to run the tests in order to cover the frequency range from 100 Hz to 5000 Hz. The tests carried out showed that the analyzed materials have good acoustic performances. More detailed analysis is undergoing to confirm the positive initial test results obtained with the sound at normal incidence method.

Tuesday Acoustic measurements (Poster)

Nonlinear Behavior of Piezoelectric Accelerometers

Jakob Putner, Philipp Bernhard Grams and Hugo Fastl
AG Technische Akustik, MMK, TU München

Piezoelectric accelerometers are widely used for vibration measurements, because of their robustness and reliability, which lead to stable transfer characteristics. Typical piezoelectric accelerometers show good linearity over wide frequency and dynamic ranges. While the linear behavior is understood and documented, specifications of the nonlinear behavior are scarce and, if present, state generally low distortions.

Since the limitations of the transducer have to be considered in the analysis of the measured vibrations, the nonlinear behavior of a typical piezoelectric accelerometer was further investigated. For the measurements a setup for vibration calibration by comparison to a reference transducer, according to ISO 16063, was enhanced by laser doppler vibrometry, to resolve limitations of the vibration exciter. In order to calculate the vibration amplitudes, methods for vibration calibration by comparison to a reference transducer, and primary vibration calibration by laser interferometry, from ISO 16063, were combined. Since current standards for vibration transducers do not regard nonlinear behavior, further analysis was done according to IEC 60268 for sound system equipment. In the frequency range, limited by the setup, distortions, added to the measurements by the piezoelectric accelerometer, were typically below 0.1 %, which leads to the conclusion that these can be neglected for typical applications.

Tuesday Acoustic measurements (Poster)

Exposure to noise in the headphones

Federica Presciutti
VERAM SRL, Roma

The present data, collected over the last 2 years, refers to the levels of exposure to noise experienced by call center workers. The estimation, was conducted using the standards set down by UNI EN ISO 11904-2 ”Estimation of noise exposure from sound sources in the proximity of the ear”. The research was carried out by connecting the font of the noise to two identical ear pieces. One of these was worn by the call center worker and the other was placed on the head of a dummy previously equipped with two mini microphone receivers. Overall, the daily (8 h by law) exposure levels of 274 call centre workers were checked, 163 of which wore headphones and 111 a single ear plug. All findings were corrected for uncertainty ”U” associated with this type of exposure. The findings reveal that an unexpectedly large number of subjects were exposed to daily levels of more than 80 dB(A), which is 14% of the analyzed sample. There were more call centre workers wearing a single ear plug among the most exposed subjects, this was probably due to the increased disturbance caused by background noise. The present data offer important observations on this particular phenomenon.

Tuesday Acoustic measurements (Poster)

Acoustic travel-time tomography for simultaneous detection of 3D distributions of temperature and flow fields

Manuela Barth, Armin Raabe and Michael Wilsdorf
Universität Leipzig, Institut für Meteorologie

Acoustic travel-time tomography is a method that allows for detection of spatial distributions of temperature and flow fields in an investigation area. The technique bases on the fact that the speed of acoustic sound propagation in air mainly depends on temperature and flow properties along the propagation path. Thus, average values of these properties along a defined propagation path (distance between sound source and receiver has to be known a priori) can be deduced from travel-time measurements along this path. A combination of travel-time measurements along different propagation paths through a defined volume permits to calculate spatial distributions of temperature and flow properties using tomographic techniques. The measurement method is described, and example measurements are presented which demonstrate the capability of the method to detect three-dimensional distributions of temperature and flow properties under different (well defined) conditions in comparison to established measurement methods.

Tuesday Acoustic measurements (Poster)

Misura delle prime riflessioni laterali con metodo intensimetrico

Laura Peruzzi, Massimo Coppi and Andrea Venditti
Università degli Studi 'Sapienza' di Roma - DIAEE

Listening to the musical performances, impression of space is extremely important. Studies have identified two effects of this space: the Apparent Source Width , which explain the enlarged perception of the sound source, and the Listener Envelopment, which gives an account of how the viewer feels surrounded by music. So it is appropriate that the first reflections come from directions different from that of the source, so that the simultaneous perception of the direct sound and the reflection causes different stimuli to the two ears. The contribution of the lateral reflections with a slight delay compared to the wave front is determining . Traditionally, the study of the spatial characteristics of the acoustic field requires the use of directional microphones with a figure eight, or measurement data type with Binaural microphone probe anthropomorphic. This memory illustrates the possibility to evaluate the contribution of the first lateral reflections through a methodology of measuring sound intensity probe. The intensimetric technique allows the relief of the acoustic field, and then the detection and measurement of the lateral energy. The proposed methodology allows to obtain a closer approximation for the determination of the indices of spatiality compared to techniques previously proposed in the literature.

Tuesday Acoustic measurements (Poster)

Noise emission management in heavy duty industry by mean of live & smart noise monitoring systems

Germano Dealessandri[a], Andrea Cerniglia[b] and Mauro Bellagente[c]
[a] *ICOSTECH srl, Pinerolo;* [b] *ACCON Italia Srl.;* [c] *Ori Martin S.p.A., Brescia*

This paper show a case study of noise emission management performed by mean of a LIVE & SMART multi point noise monitoring system. The system interface with the main control area for a heavy duty industry with arc furnace. A real time information is available to manager of the furnace control cabin to take decision about the process based on the projected Leq measured along the fence and inside the furnace shed. Over the live real time records an automated report is sent to the relevant people in the company by email each day and other analysis are prepared for the community and the city hall.

Tuesday Acoustic measurements (Poster)

Overview of Acoustic Holography and Beamforming techniques for Noise Sources recognition in open/closed environments: choosing the correct theory to apply for sound field reconstruction

Giovanni Amadasi[a] and Tim Dannat[b]
[a] *SCS & Partners VIBRO-ACOUSTIC;* [b] *CAE Software und Systems GmbH*

It is presented an Overview of existing Sound Images techniques like Acoustic- Holography or Beamforming and associated calculation methods like Music, Damas, Capon, orthogonal Beamforming, Sonah, with additional user defined alghoritms, in association with the use of 2 types of transducers: microphones (P) or Intensity probe (P-P or P-U). Full-digital front-end I2S, MEMS transducers and Open software architecture are also explained to allows most precise analysis of each of the different sound situation which requires full flexibility to perform right choices and improve results both in Near-field and Far-field Acoustic Imaging. Applications examples include indoor sound images inside vehicles and leaving spaces as well as noise sources identification on heavy machines and distant sources recognition in outdoor environments.

Session "Acoustic urban planning (Poster)"

Tuesday Acoustic urban planning (Poster)

Urban quality evaluation by means of acoustic indicators and indexes: validation of an acoustic quality index

Anna Magrini[a], Sergio Luzzi[b] and Francesco Borchi[c]

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Quality of Life (QoL) in Urban Areas is becoming a strategic issue for city planners. In Europe, the rapidly increasing urban population amplifies the need of more attention on good quality urban areas creation and preservation. QoL assessment is a multidisciplinary concept involving environmental, social, urban planning features and subjective estimation. The general objective of the research is to provide a procedure for standardizing the evaluation of urban QoL levels and to perform its optimisation. The method is based on definition of indicators and indexes that, by means of relative weights (RW) and weighting factors (WF), can take into account an association of a large number of playing factors. The Noise Quality Index (NQI) has been obtained considering noise pollution, traffic intensity, population involved etc. RWs and WFs have been defined and calibrated to reach a significant objective judgment, taking into account the national/international legislation and displeasure levels. In this way the NQI contributes to weigh up QoL levels of different urban areas. The methodology has been applied on case studies referred to urban areas and City Plans where noise and soundscapes are involved, aiming to a more accurate definition of the relative weights and the weighting factors

Tuesday Acoustic urban planning (Poster)

Noise awareness as key resource for acoustic design

Rossella Natale and Sergio Luzzi

Vie En.Ro.Se. Ingegneria, Firenze

Noise awareness is considered the first step in participatory acoustic design methods. Authors have coordinated the past three edition of "Noise Awareness Day" initiatives in Italy and various noise awareness campaigns, as actions of Urban Noise Reduction Plans and Strategic Action Plans. They have experimented soundscapes based approaches for information and education in schools of different levels and the participatory method in the design of solution for noise mitigation. Students and teachers have been involved, during the preparation of noise awareness campaigns and on the annual "Noise awareness day" the experiences of acoustic design in school spaces (classrooms, gyms, canteens, courtyards, gardens) have been shared with students of other countries. Users have participated to acoustic design carried out in the spaces that they usually attend, getting a better environmental education and awareness about noise effects on health and the direct involvement in a validated tool for acoustic design. In this paper the main results of this experience are shown, together with a possible program for future development of Noise Awareness campaigns as a key resource for acoustic planning of urban spaces in smart cities.

Tuesday Acoustic urban planning (Poster)

Lärmkartierung und Lärmaktionsplanung in Deutschland

Matthias Hintzsche

Umweltbundesamt, Dessau-Roßlau

Die Lärmaktionsplanung der erste Stufe der Umgebungslärmrichtlinie ist weitestgehend abgeschlossen. Die Ergebnisse der Lärmkartierung der zweiten Stufe liegen vor und zeigen, dass große Teile der Bevölkerung hohen Belastungen durch Umgebungslärm ausgesetzt sind. Es werden die wesentliche Ergebnisse der Lärmaktionsplanung der ersten Stufe analysiert und Empfehlungen für die zweite Stufe zusammengefasst. Die Lärmkartierung der beiden Stufen wird vergleichend gegenübergestellt.

Tuesday Acoustic urban planning (Poster)

HARMONICA project (HARMOnised Noise Information for Citizens and Authorities)

Fanny Mietlicki[a], Piotr Gaudibert[a] and Bruno Vincent[b]

[a] *Bruitparif, Paris;* [b] *Acoucité, Lyon (F)*

The HARMONICA project comes from the following observation: the general public and public authorities are insufficiently aware of noise pollution and its consequences. In order to increase awareness and therefore the efficiency of noise prevention and reduction policies, the project will aim to prove the usefulness of a new noise index. Based upon measured and estimated data, this index will be easier to understand for populations than the usual noise indicators, in a similar way to the ones used for air quality. The project will be implemented and evaluated by the two observatories involved in the project, Bruitparif and Acoucité, in their respective regions, the Ile de France region and the Greater Lyon agglomeration. This wide experimentation territory will cover a total surface area of more than 12,500 km2 and a population of 13 million people. The access to noise information will also be facilitated through the creation of a platform displaying the index and a database of noise abatement actions, available on the portal www.noiseineu.com. Started in October 2011, this 3-year project will provide a new index and new tools, freely usable by any agglomeration in Europe. The HARMONICA project is cofinanced by the European programme LIFE + 2010.

Tuesday Acoustic urban planning (Poster)

HUSH project results: definition of a platform for an integrated and harmonized noise Action Plan and proposals for revision of Italian legislation and END Directive

Rosalba Silvaggio[a], Salvatore Curcuruto[a] and Francesco Borchi[b]

[a] *ISPRA, Roma;* [b] *Università di Firenze*

H.U.S.H. "Harmonization of Urban Noise reduction Strategies for Homogeneous action plans" is a project co-funded by Life+2008 Program, aimed to give a contribution to the harmonization of the Italian National and European legislations, regarding urban noise management tools, allowing a definition of coherent procedures able to comply the commitments introduced by National laws and by the END Directive. The results of the project, concerning the definition of a platform for an integrated and harmonized noise Action Plan, considering methodological, technical, administrative and legal aspects, will be presented. Starting from the methodology defined and the interventions realized in two pilot areas in Florence, proposals for revision of National legislation and END Directive, for supporting competent authorities and policy makers, will be suggested.

Tuesday Acoustic urban planning (Poster)

Acoustic Requalification for Territorial Structures by INAIL following partial change of purpose for residential use

Augusto Papa[a], Pasquale Addonizio[a] and Paolo Meschino[b]

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Following selling of INAIL's offices, the upper floors apartments reserved to the employees have become a private ownership, involving promiscuity issue. The tenant's quiet needs have to coexist with a correct carrying out of INAIL's office working activities in the ground floor. For example, there is a issue with the Siracusa offices renovation, where the installation of a VRV air- conditioned has been assumed to replace all individual air conditioning system, installed in the past, in order to cooling the different locations of INAIL's office. This INAIL's building is near the Ortigia inner city. In according to the superintendence constraint, the external new air-condition units will be place on an internal building terrace, this is like a courtyard and it is critical for noise diffusion. Therefore, it is necessary to evaluate this noise diffusion, modeling many scenarios and their acoustic impact. This model is calibrated with ante opera acoustic climate characterization measures, searching for the best condition that fulfill the acoustic restriction provided for by law, with referring to exposed receptors.

Session "Application of ultrasound in medicine (Poster)"

Tuesday Ultrasound in medicine (Poster)

Nonlinear Simulations of Therapeutic Ultrasound Transducers using Equation Of State Material Model

Abtin Jamshidi Rad and Friedrich Ueberle
HAW Hamburg

Simulating therapeutic ultrasound is a challenging task. While low amplitude ultrasound relies on linear wave propagation, the pressure amplitudes in therapeutic ultrasound frequently generate nonlinear effects which may distort the wave into a Shockwave. For many applications it is sufficient to neglect these effects and confine the wave-equation to a linear approach. High-pressure amplitudes of therapeutic transducers create strong non-linear effects in the medium which must be included into the modeling equations. The Finite element method (FEM) models the acoustic equilibrium-equations with nodal pressures on an acoustic element mesh. With standard acoustic elements in most FEM programs nonlinear effects cannot be modeled easily with reasonable mesh densities. But for certain nonlinear effects, the equation of state (EOS) material model can be used. We investigate simulations using acoustic and EOS materials in Abaqus® and compare the simulations with done by an optical hydrophone measurements.

Tuesday Ultrasound in medicine (Poster)

New therapy for hypoxia-related damage of superficial tissues by ultrasonic activation of oxygen nanobubbles

Chiara Magnetto[a], Caterina Guiot[b], Mauro Prato[b] and Adriano Troia[a]
[a] *INRIM, Torino;* [b] *Università degli Studi di Torino, Dip. Neuroscienze*

Tissue hypoxia occurring in degenerative, ischemic or infectious diseases seriously undermines the processes of tissue repair associated with wound healing. For instance, it was previously shown that hypoxia strongly reduces secretion of human monocytic Matrix Metalloproteinase-9 (MMP-9), a proteolytic enzyme playing a crucial role in extracellular matrix turn-over. Thankfully, hypoxic regions are often located superficially; thus, topic administration of exogenous oxygen, encapsulated in suitable formulations of nanobubble solutions and provided through ultrasonic sonophoresis, might help to counteract hypoxia effects during wound healing. Oxygen-loaded nanobubbles (OLNs) are constituted by a shell of biocompatible material (chitosan or dextran) and an oxygen-storing decafluoropentane core, showing good capacity of oxygen delivery. In the present work the possible role of OLNs as therapeutical tools favouring tissue repair mechanisms during hypoxia-associated diseases was evaluated by studying OLN sonophoresis throughout natural membranes and OLN effects on MMP-9 secretion from human monocytes in vitro. Results showed that OLNs trespassed significantly pig skin membranes increasing oxygen levels in the underlying compartment; on the other hand, OLNs abrogated hypoxia-dependent reduction of levels of human monocytic MMP-9. In conclusion, OLN sonication, being a non-invasive and low-cost nanotechnological device, appears

to be a good candidate to treat hypoxia-related damage of superficial tissues.

Session "Demands on room acoustic criteria (Poster)"

Tuesday Room acoustic criteria (Poster)

Preferred Values of Room Acoustics Criteria for Turkish Melodic Music

Zerhan Yuksel Can[a], Asli Ozcevik[a], Sevda Erdogan[b], Korkutalp Bilgin[c] and Ruhi Ayangil[c]

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There is an important lack of information on the room acoustics criteria for the rooms used for Turkish melodic music, which is completely different from western music. A Research Project, titled "Evaluation of the Room Acoustic Parameters for the Rooms Used for Turkish Melodic Music", is implemented to research the subjective and objective acoustical parameters and the preferred values for Turkish melodic music. Three rooms; Dolmabahce Palace Music Room, Serifler Sea Mansion Hall and Galata Mawlawi House Main Hall are modeled in Odeon room acoustics program, and room acoustics measurements are made according to ISO 3382. Music pieces selected depending on the room types are recorded in anechoic room and auralisations are held from the computer simulation to be used for the psycho-acoustical evaluation of the sounds in these traditional spaces.
Psyhco-acustical evaluation is realized in laboratory environment by a jury of 30 subjects. A set of preferred values are determined by the cross evaluation of the data held from the jury test and the objective data. Jury test is repeated for two new halls of different volume to control the reliability of the preferred values.

Session "Digital signal processing in audiology (Poster)"

Tuesday Signal proc. in audiology (Poster)

Ohr-Modell zur Analyse der Pegeldynamik

Oskar Bschorr

Aeroakustik Stuttgart

Mit 120 dB hat das menschliche Ohr eine unvergleichlich große Dynamik. Bei technischen Stellgliedern verschlechtern sich im Randbereich Stellsicherheit und Prägnanz, auch sind redundante und sich überlappende Stellglieder robuster und zweckmäßiger. Diese Kriterien gelten nicht nur für technische sondern auch für biologische Systeme. Deshalb soll hier das reflektorische und das instantane Verstellpotential der im Ohr wirksamen Schwingelemente - Feder, Dämpfung, Masse, Impaktfläche - thematisiert werden. Besonders interessant erscheinen nichtlineare, passive Effekte, die zum Überlastschutz des Hörnervs eine selbsttätige, spontane Anpassung an hohe und impulshaltige Schallpegel gewährleisten. Dazu wird ein vereinfachtes Ohr-Modell aufgestellt, um die Pegelreduzierung als Folge von degressiven Kennlinien abzuschätzen, ebenso deren funktionsbedingte, nichtlineare Frequenzverzerrung.

Comparison Calibration of a pressure-velocity (p-v) Tympanometric Probe Prototype

Martina Buiat[a], Davide Bonsi[b], Paolo Bruschi[c], Massimo Piotto[d], Giorgio Sacchi[e] and Domenico Stanzial[e]

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Wide band p-v tympanometry can be defined as the measurement of the acoustic immittance of the ear, possibly in normal air pressure condition of the ear canal, and in the full audio frequency range. The most important innovation pioneered by the p-v tympanometry regards the introduction of a different principle of measurement based on the direct acquisition of both pressure and velocity (p-v) signals at the ear canal entrance. To this aim a p-v tympanometric probe prototype has been developed by modifying a traditional one in order to host a standard miniature microphone (Knowles Electronics mod.EK-23133-C36) and a CMOS compatible- MEMS technology based acoustic velocimeter. The CMOS prototype has been then calibrated by comparison with a similar prototype holding a commercially avalilable Microflown(R) match size sound intensity probe, used as reference. Calibration methodology and obtained results are here reported.

Session "Effects of noise (Poster)"

Noise and sleep in hospitals - a review of literature

Silvester Siegmann and Gert Notbohm

Universität Düsseldorf, Institut für Arbeitsmedizin

Sleep disturbances are the most common complaints of patients in hospitals, and they might have harmful effects on the outcome of the medical treatment. In a first step of analysing the extent of this problem, a review of international literature was performed. General conclusions cannot be drawn as studies differ considerably with regard to the objectives and methods chosen, to the particular medical facilities, and to the general framework of health care in the respective country. Sleep quality in terms of falling asleep and sleeping through is reduced in many patients of ICUs as assessed subjectively by questionnaires or objectively by EEG records. Laboratory studies suggest that these alterations are accompanied by physiological responses especially of the cardiovascular system. Also hormonal stress responses are reported. Sleep disturbance might influence the duration of recovery and stay in the hospital and the need for sedative medication. To sum up, noise is one important stress factor for patients in hospitals strongly influencing the quality of sleep. Other important factors have been identified such as perception of pain, personal worries, and discomfort with the situation and the surroundings. Thus, the interaction of noise and other stress with regard to sleep disturbance needs further research.

Potential hearing loss from non occupational noise exposure in headphones and hearphones

Raffaele Mariconte[a] and Diego Annesi[b]
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The Italian Law T. U. 81/08 obliges the noise exposure assessment in the sector of entertainment, music and call centers with specific standards (art. 198). Often, in this sectors we have occupational noise exposure in headphones and headset. Recently, have been published guidelines for the music industry and recreational activities and the technical report UNI / TR 11450, which provide all the technical indications for the measurement and assessment of occupational noise exposure, including workers using headset. Listening music in headphones and hearphones with portable devices is a widespread phenomenon, born with the advent of the "Walkman" and increased exponentially with the spread of digital devices. This practice concerns mostly teenagers, which are a pre-employment category and which is usual listen to high volume music. Young people who listen to personal music players for several hours a day at high volume could risk their hearing. For these cases it is difficult to set limitations, if not in regulations for player's sound power, so it is important the training and information about the risks involved. This work aims to give an overview of the problem and propose methods for risk prevention through information campaigns.

Session "In vivo acoustic measurements in musicians and music instruments (Poster)"

Study of the acoustical properties of hearing protector devices for musicians

Esther Merz
Universität für Musik und darstellende Kunst Wien

For a musician's career it is important to protect own hearing. A product therefore is the custom-made hearing protector device ER-15TM of the company Etymotic, USA. It shall damp the whole frequency range in a regular way, so that sound quality can be preserved while hearing is protected. In the first part of the thesis several validating tests for hearing protector devices will be presented and referenced to the belonging standards. Every validation test has its pros and cons. For the second part a procedure will be chosen by which some of the disadvantages will be eliminated. For the validating test, which was built up for this thesis, the damping of so-called musician's earplugs will be measured in the ear channel of eight individual ears by means of a miniature microphone. The results are some aspects of the impact of the damping with regard to music, which can now be heard because of the recording by the microphone in the ear channel. The final chapter talks about further development in the prevention of hearing loss for musicians.

Musicians' Subjective Perception and Objective Acoustic Descriptors in the Stages

Valentina Silingardi, Dario D'Orazio, Simona De Cesaris, Massimo Garai
University of Bologna, Dep. of Industrial Engineering - DIN

In this work three medium-sized theaters of the Romagna region are studied and all the three are historic theaters, designed in the shape of a horseshoe, never previously studied with regard to the stage acoustics. The theaters under study are: Masini Theatre of Faenza, Rossini Theatre of Lugo and Bonci Theatre of Cesena. The investigation was divided into a two phases. At first, in situ measurement were carried out; two configurations have been considered: a trio and chamber orchestra of about 30 elements. Following technical standard and literature, descriptors extracted from the impulse responses measured on stage have been used. Then a numerical models of the theaters with different software configuration have been studied in order to attempt a tuning between sources and receivers on the stage. Finally, a survey was carried out among musicians and conductors from the territory, through the distribution of a questionnaire on their perceived in these theaters. Then the results obtained from the measurements and questionnaires were crossed.

Session "Medical acoustics (Poster)"

Modeling Sound Localization for Binaural Cochlear Implant Users

Christian Wirtz[a], Michele Nicoletti[b], Werner Hemmert[b], Peter Schleich[c] and Peter Nopp[c]
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Although modern cochlear implants (CI) provide good speech intelligibility, their performance in a "cocktail party" situation with multiple simultaneous sound sources is not satisfactory. It is well known that sound localization provides important cues to separate sources which enhance speech intelligibility in noisy environments. Since CIs were initially designed for monaural implantation only, there is room to optimize coding of binaural information.

Within a simulated listening setup a binaural model can provide a metric to predict source localization abilities. After reviewing the model's basic setup, the metric was extended to work with action potentials, which are generated by physiologically inspired models of sound coding for both the intact ear and the implanted ear.

To improve sound localization of CI-listeners, coding strategies must convey ILDs and especially ITDs. We applied our model and evaluated binaural cues in the electrically excited spike trains of the auditory nerve for different CI coding strategies. We found that the CIS strategy did not provide useful fine-structure ITD cues. However, todays latest coding strategies as the FS4 by MED-EL are potentially able to convey viable fine-structure cues with sufficient precision to enable sound source localization.

Tuesday Medical acoustics (Poster)

Performance in speech perception and directional hearing for patients with active implantable bone conduction implants

Tobias Rader[a], Tobias Weißgerber[a], Timo Stöver[b] and Uwe Baumann[a]
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The Bonebridge system (Med-El, Innsbruck) is a recently introduced semi-implantable hearing prothesis which enables sound transmission directly to the inner ear by means of bone conduction. It is developed for patients with a sound conduction disorders and an optional mild inner ear hearing loss up to max. 45 dB HL. The system contains a bone conduction implant (BCI) equipped a floating mass transducer which is screwed into the temporal bone and completely covered by skin. An external processor delivers energy to power the implant and converts the sound/speech into electrical signals which are transcutaneously delivered to the implant where vibrations are generated accordingly. Directional hearing was investigated since simultaneous bone conduction to the contralateral ear might appear which may cause a detrimental effect. Speech perception in noise was assessed by means of the German OLSA sentence test and directional hearing was measured in the azimuth plane ($\pm 60^\circ$) by using a loudspeaker array (resolution 1.5°-5°) arranged in an unechoic chamber. The direction judgments of the subjects were collected by adjusting a LED light of a LED chain (resoluteion $<1.8^\circ$). The performance data of five patients implanted with Bonebridge are shown in this study.

Tuesday Medical acoustics (Poster)

Feedback on Prosodic Features in an Assistive System for Speech Treatment

Rainer Jäckel
TU Dresden, Institut für Akustik und Sprachkommunikation

This study is part of a project aiming at the development of a data driven assistive system for speech treatment designed for patients with Parkinson's disease (PD) and patients with brain stem infarct. The database includes recordings of 50 patients with PD, 50 speakers with brain stem infarct, and reference recordings of 50 normal geriatric speakers. All subjects are German native speakers with normal language ability. The alternation of speech in PD is known as hypokinetic dysarthria. Patients with brain stem infarct are affected by flaccid dysarthria. Both types of dysarthria are characterized by disorders in speech prosody. The narrow issue of the study is detecting prosodic patterns of impaired speech and to perform an automatic classification of speakers with regard to different types and degrees of speech impairment. Patients and controls were recorded with a diagnostic test including sustained phonation, oral diadochokinesis, and variable reading tasks, representing exclamations, questions and statements, as well as longer text passages and Speech recordings are semi-automatically segmented and stress and pitch marked in a multilayer

Praat TextGrid format. Prosodic analysis is performed both parametrically and statistically. The classification task is solved using SVM.

Session "Models of the hearing system and psych. quant. (Poster)"

Tuesday Models of hearing system (Poster)

Robust fundamental frequency estimation in an auditory model

Stephan D. Ewert, Carolin Iben and Volker Hohmann
University of Oldenburg, Medical Physics

Voiced parts of speech utterances can be considered as harmonic tone complexes that elicit a pitch percept. Yet remarkably robust against noise, pitch (fundamental frequency) extraction in humans has to cope with several signal distortions introduced by non-linear auditory processing, such as the half-wave rectifying property of inner hair cell transduction. Successful solutions for fundamental frequency (F0) extraction, however, often disregard auditory pre-processing details. In this study we propose a method of deriving harmonicity information from the output of a peripheral auditory model to investigate how the human hearing system might achieve robustness of pitch perception in noise despite of the peripheral nonlinearities. Inspired by the strobed integration stage of the auditory image model [AIM; Patterson et al. (1995), J. Acoust. Soc. Am. 98, 1890-1894] a strobed averaging method based on a number of possible pitch candidates was used to extract a spectro-temporal display (referred to as synchrogram) serving as basis for F0 extraction. F0 extraction from the synchrogram combines temporal fine-structure and temporal-envelope information in different auditory channels as well as spectral pattern analysis. Results show that the proposed model achieves better accuracy of pitch estimation in noise maskers than a reference method (YIN after A. De Cheveigné).

Session "Robust speech recognition (Poster)"

Tuesday Robust speech recognition (Poster)

Evaluation of Noise Robust ASR Features on a Subset of TIDigits Database

Branislav Gerazov and Zoran Ivanovski
FEEIT, Skopje, Macedonia

Automatic Speech Recognition Systems of today are intensely deployed in real world application scenarios which are often characterized by suboptimal operating conditions. Thus their noise robustness has become a crucial parameter when assessing ASR in-field performance. The paper examines the noise robustness of various ASR features as applied to a subset of the TIDigits database. The analysis focused on noise robust features such as: Relative Spectral Perceptual Linear Prediction (RASTA PLP), Teager Energy Cepstrum , Amplitude and Frequency Modulation, Zero-Crossings with Peak Amplitudes, Gabor Spectrotemporal Receptive Fields (STRF), and Subband Spectral Centroid Histograms. The ASR system was trained with clean data, and in the evaluation phase various types of noise were added to the test data at different Signal-to-Noise Ratios (SNRs). The

types of noise include: white, pink, babble, in-car and traffic noise. The SNRs spanned from 20 dB to -5dB. Results are plotted for each feature type across varying SNR conditions.

Session "Tyre/road noise (Poster)"

Tuesday Tyre/road noise (Poster)

The Brenner Motorway - acoustic monitoring of the road surface

Andrea Osele
Autostrada del Brennero SpA

The Brenner Motorway was one of the first Italian motorways to address the issue of noise pollution caused by traffic. The first studies aiming at measuring the level of noise and characterizing the acoustic design of noise barriers have been already carried out within the technical activities of the Company since 1987. The same period was marked as well by significant investments in the field of research of complementary techniques of noise reduction, such as the use of special sound-absorbing draining asphalt, until then almost exclusively used in the airport environment. In the following years, different methods were evaluated to detect the noise emitted by the tyre/road interaction, main source of noise produced by motorway traffic. Among the different tested techniques, the use of a trolley, equipped with suitable microphones, travelling at high speed (110 km/h), proved to be the best measurement system. In fact, although not impacting on motorway traffic, it allows to obtain high-accurate measurement values of the road surface acoustic performance and to monitor its sound-absorbing and draining capacity over time. The information acquired allows to plan the motorway platform maintenance intervening when and where needed.

Tuesday Tyre/road noise (Poster)

CPX analysis of a Rubber Asphalt road in Meran

Marco Chetoni[a], Gaetano Licitra[a], Maurizio Bocci[b] and Luca Teti[c]
[a] *CNR-IPCF, Pisa;* [b] *Università Politecnica delle Marche, Ancona;* [c] *Università di Siena*

The aim of this work is to acoustically analyse the road surface in Asphalt Rubber (0/12) Gap Graded laid in 2011 on an extra-urban road, in Merano (BZ). The Close Proximity Index method (CPX, ISO/CD 11819-2) has been applied to characterize the noise emission due to tyre/road interaction and results will be shown. The acoustic performances of this special surface will be compared with ones of two other road surfaces on the same extra-urban road: a standard Italian surface (0/12) laid in 2008 and a Splitmastix Asphalt (SMA, 0/12) laid in 2011. Measurements have been carried out in three sessions during the past year, to the purpose of evaluate the acoustic performances in time and the their trend. The acoustic analysis is carried out comparing sound pressure levels (A-weighted) and normalized noise emission spectra between the three surfaces. Moreover, the Asphalt Rubber effectiveness as noise mitigation action has been evaluated through the comparison with the pre-existent standard asphalt as reference surface and through the comparison with contemporary SMA.

Paper and poster sessions Wednesday 20.03.2013

Session "Psychoacoustics"

Wed 8:40 Kurhaus meeting room 1 Psychoacoustics

Influence of time constants and compression on the prediction of temporal integration of loudness

Jan Hots[a], Jan Rennies[b] and Jesko Verhey[a]

[a] *Otto von Guericke Univ. Magdeburg, Dep. Experimental Audiology;* [b] *Fraunhofer IDMT - HSA, Oldenburg*

Short signals have a higher level than equally-loud long signals. This effect is referred to as temporal integration of loudness and is commonly modelled by leaky integrators. In a linear system, leaky integrators are directly characterised by their time constant. The normal auditory system, however, is nonlinear. This nonlinearity changes the slope of temporal integration functions (the level at equal loudness as a function of duration) and the derived time constants characterise the "effective" temporal integration of loudness in the auditory system. On the basis of experimental data from the literature at medium levels, it is investigated how predictions of temporal integration of loudness are affected by the structure of the temporal integration stage and its interaction with the preceding nonlinear compression stage. It is shown that a simple approach with a realistic compression followed by a single low-pass filter fails to predict the slope of the temporal integration function. The effect of compression is less pronounced if more elaborate established loudness models are used. However, even those show a deviation at intermediate durations. Predictions can be reconciled with the data by assuming a temporal integration stage with two parallel leaky integrators.

Wed 9:00 Kurhaus meeting room 1 Psychoacoustics

Preference and loudness of multi-tone sounds

Stephan Töpken[a], Jesko Verhey[b] and Reinhard Weber[c]

[a] *University of Oldenburg, AG Akustik;* [b] *Otto von Guericke Univ. Magdeburg, Dep. Experimental Audiology;* [c] *University of Oldenburg*

The noise from machines with rotating parts often contains prominent complex tones. These sounds can be perceived as rather unpleasant, especially with multiple harmonic tone complexes where nonlinear sound generating mechanisms lead to additional combination tones. This study investigates the relative contribution of the different sound elements to the perception of the sound by measuring the point of subjective equality (PSE) for preference and loudness in comparison to a reference noise for synthetic multi-tone sounds with an adaptive procedure. A paired-comparison paradigm is used where the level of the multi-tone sounds is varied to elicit the same sensation as the reference sound with a constant level. The dBA level differences between the multi-tone sounds and the reference at the PSE can be regarded as a measure for the preference and loudness of the sounds. In this study, the PSEs for preference and loudness are measured

for the individual constituting sound elements (the two complex tones and the combination tones) with respect to the reference noise. It is shown that the contribution to the perception of the whole sound differs between the harmonic complexes and the combination tones.

Wed 9:20 Kurhaus meeting room 1 Psychoacoustics

Modeling release from masking of single components in tone complexes

Martin Klein-Hennig, Mathias Dietz, Stephan D. Ewert and Volker Hohmann
University of Oldenburg, Medical Physics

In a harmonic tone complex, it is difficult to hear out a single component, as the harmonic components are fused into a single auditory object based on their common fundamental frequency. Mistuning a single component by a frequency shift destroys this common frequency relationship, and the mistuned component ”stands out” as an additional auditory object. Mistuning facilitates the detection of a single component in presence of the remaining harmonic components of the tone complex, leading to decreased detection thresholds for mistuned components compared to harmonic components [Klein-Hennig et al., DAGA (2012)]. Here, the role of alternative detection cues originating from mistuning, as, e.g., changes in the envelope spectrum are assessed. The detection thresholds measured in the psychoacoustic experiments were compared to model predictions obtained with a time-domain implementation of the envelope power spectrum model [EPSM; Ewert and Dau, J. Acoust. Soc. Am. 108, 1181 (2000)] and with the perception model [PEMO, Dau et al., J. Acoust. Soc. Am. 99, 3615 (1996)] which uses an optimal detector and more elaborated auditory periphery in comparison to the EPSM. The model results are discussed with regard to the role of envelope cues in detection of the single component.

Wed 9:40 Kurhaus meeting room 1 Psychoacoustics

Suprathreshold perception of tones in conditions of masking release

Katharina Egger and Bastian Epp
Centre for Applied Hearing Research, DTU (DK)

The ability of the auditory system to use beneficial signal properties (cues) for improved communication in complex acoustical environments is commonly assessed by measuring masked thresholds. In everyday situations however, relevant sounds are well above masked threshold.

To quantify suprathreshold perception, listeners rated the audibility of a masked tone at constant levels above individual masked threshold. Masked thresholds were modified by introducing coherent masker intensity fluctuations across frequency, interaural signal phase disparities, or a combination of both.

It is hypothesized that the same audibility results in the same “internal representation“ of the signal, independent of the physical intensity. To obtain an objective measure, auditory evoked potentials were measured for the same stimuli and listeners as used in the psychoacoustical experiment.

Audibility ratings increased with increasing signal level relative masked threshold. While at low levels relative masked threshold all conditions showed similar ratings, conditions without beneficial cues showed a tendency for higher audibility for high levels, indicating a residual effect of physical stimulus intensity in the rating. In line with the hypothesis, the P2 components of the auditory evoked potentials were found to be similar for all conditions at same levels relative masked threshold, independent of the differences in physical intensity.

Wed 10:00 Kurhaus meeting room 1 Psychoacoustics

Modeling Masked Thresholds of Technical Signals in Real Backgrounds

Lena Schell-Majoor[a], Jan Rennies[a], Stephan D. Ewert[b], Birger Kollmeier[b]
[a] *Fraunhofer IDMT - HSA, Oldenburg;* [b] *Univ. Oldenburg, Medical Physics*

The audibility of acoustic signals in the presence of background noises is important in many practical applications. Depending on the context, it can be important to assure the perceptibility of a signal, e.g., for warning signals, whereas other signals such as annoying sounds are desired to be inaudible. In order to ensure the respective design goal, detection thresholds can be measured in listening tests. A model-based calculation of such thresholds would be beneficial because it could partly supersede the listening tests and thereby simplify the development process. In this study, an existing perception model [Dau et al., J. Acoust. Soc. Am., 102, 2892-2904 (1997)] is used to predict detection thresholds for signals from different application areas. In previous studies, the model was applied to more fundamental psychoacoustic masking experiments using mostly synthetic signals. Here real (predominantly technical) signals were used as target and background signals. For validation purposes thresholds were also measured in a listening test with normal-hearing listeners using a 3-AFC procedure. The data indicate that the model predicts masked thresholds for a variety of signals, while some discrepancies require further investigations. The results are discussed with regard to different model parameters and prospective modeling of sound quality evaluation.

Wed 10:20 Kurhaus meeting room 1 Psychoacoustics

Partial loudness of a signal for different masker types using categorical loudness scaling

Wiebke Heeren and Jesko Verhey
Otto von Guericke Univ. Magdeburg, Dep. Experimental Audiology

Categorical loudness scaling (ISO 16832) is a fast standardized procedure to measure loudness over a large level range. The procedure was primarily standardized for the usage in audiology to measure the audible range of a listener. For this purpose, loudness functions are measured for narrowband signals as a function of the center frequency using verbal (and often intermediate non-verbal) categories. In the present study, this procedure is used to measure the partial loudness, i.e., loudness growth functions for masked signals. The target signal is a pure tone embedded in two different masker types: (i) amplitude modulated and (ii) unmodulated broadband noise.

These two masker types differ in their ability to mask the signal, being less effective in the case of the modulated masker. The difference is referred to as modulated-unmodulated difference (MUD). The present study investigates how the masker type influences the supra-threshold perception and if the effect of the reduced masking for the modulated masker is equivalent to a condition where the masker is reduced in level by the magnitude of the MUD. The results are compared to loudness matching data for the same masker types to investigate the accuracy of the scaling procedure.

Wed 10:40 Kurhaus meeting room 1 Psychoacoustics

Comparison of Dichotic and Binaural Reproduction in an Experiment on Auditory Selective Attention

Janina Fels[a], Josefa Oberem[a], Britta Karnbach[a], Vera Lawo[b] and Iring Koch[b]

[a] *Inst. of Technical Acoustics, RWTH Aachen University;* [b] *RWTH Aachen University, Institute of Psychology*

Specific acoustic stimuli are required in psychoacoustic experiments on cognitive performance such as auditory selective attention. These stimuli are usually presented dichotically or monaurally using headphones. However, acoustic scenes in our everyday life are binaural and complex. It can be assumed that different sound sources (noise and signals) placed at selected positions in an environment (i.e. a classroom, an open-plan office) have an influence on cognitive performance. In this case the acoustic stimuli in experiments can be presented via headphones using binaural techniques. The goal is to provide artificially generated acoustic scenes in a way that the difference between a real situation and an artificially generated situation has no influence in psychoacoustic experiments on auditory selective attention. An experiment on auditory selective attention is carried using dichotic presentation of the stimuli (left and right ear), with loudspeakers located at +/- 90° in the horizontal plane, and with individual binaural reproduction using headphones (and individual headphone calibration). First results will be presented and discussed.

Wed 11:00 Kurhaus meeting room 1 Psychoacoustics

Psychoacoustics in Imaging Localization of Sound Sources

Stefan Neugebauer, Benjamin Riebold and Dirk Döbler

GFaI, Berlin

Delay-and-Sum-Beamforming is the state of the art investigation technique for complex space and time variant sound sources of consumer devices delivering a sound pressure level based imaging evaluation. However often also psychoacoustic parameters like loudness, sharpness, tonality or roughness have to be taken into account to achieve a complete rating of sound quality of these devices. GFaI - developer of the ”Acoustic Camera” which provides acoustic mapping in 2D-virtual planes and 3D-models - implemented algorithms to calculate the most important psychoacoustic parameters which were integrated into the acoustic mapping. The values of the respective psychoacoustic parameters are represented by a color scale and superposed to the optical image of the investigated object.

The combination of both - imaging localization of sound sources and psychoacoustic evaluation - provides a powerful tool for enhancement of sound quality and efficient noise reduction.Opportunities of application are demonstrated using typical examples.

Wed 11:20 Kurhaus meeting room 1 Psychoacoustics

Probabilistic Modeling of Auditory Cues for Binaural Speaker Localization

Hendrik Kayser, Stephan D. Ewert, Volker Hohmann and Jörn Anemüller
University of Oldenburg, Medical Physics

Auditory models serve as a suitable source of binaural localization cues in the computational analysis of acoustic scenes. Nevertheless, the stream of information must be further processed to extract knowledge about individual sound sources. Therefore, it is crucial to identify points of measurement carrying reliable information and conduct analysis based on these so-called glimpses. In the present work, an auditory front-end was employed to decompose binaural signals, composed of directional speech with noise interference, into spectral bands and to extract a measure of interaural coherence in addition to interaural phase and level differences. Interaural coherence was used to label each data point in terms of reliability regarding location information. A novel probabilistic localization back-end is proposed that models distributions of binaural cues as random variables that are conditioned on the observed value of interaural coherence. While the use of only the most reliable data points lead to the most precise estimation of angle of incidence, these data are relatively sparse in a complex acoustic scene. Consequently, the system is forced to exploit less reliable data points to achieve a location estimation in limited time, e.g., when tracking moving sound sources, which causes a ”binaural sluggishness” depending on the task.

Wed 11:40 Kurhaus meeting room 1 Psychoacoustics

Revision of ISO 532 ’Acoustics - Method for calculating loudness level’ - recent developments and future outline

Joachim Scheuren
Müller-BBM GmbH

Since it’s start in 2007, the revision of ISO 532 ”Acoustics - Method for calculating loudness level” turned out to be a very complicated and controversial process. This was mainly due to the existence of two alternative approaches, the Zwicker method (ISO 532:1974; stationary sounds and DIN 45631:2010; arbitrary sounds) and the Moore/Glasberg method (ANSI S3.4-2007; stationary sounds). Unfortunately, the situation got conflicting when the ladder approach was claimed to be superior enough to justify normative discontinuity. Although clear scientific evidence of the superiority of any of these approaches could not be given for the multiplicity of real life sounds, the drafted new standard ISO/DIS 532-1:2011 finally removed the Zwicker method, thus defining the Moore/Glasberg method as the only future standardized approach. However, the discontinuity caused by this scientifically unfounded withdrawal of a proven standard provoked

many substantial objections from science and industry and finally has been rejected by a clear majority of the ISO member bodies. As a result, future loudness calculations for arbitrary sounds can be based on both methods as two different and independent standards. After a review of preceding discussions, the present situation is summarized and an outline of the standards to be expected is given.

Wed 15:30 Kurhaus meeting room 1 Psychoacoustics

Speech Production in Temporally Modulated Noise

Ewen Macdonald[a] and Stefan Raufer[b]
[a] *Centre for Hearing and Speech Sciences, DTU (DK);* [b] *Jade-Hochschule Oldenburg*

The Lombard effect refers to the phenomenon where talkers automatically increase their level of speech in a noisy environment. While many studies have characterized how the Lombard effect influences different measures of speech production (e.g., F0, spectral tilt, etc.), few have investigated the consequences of temporally fluctuating noise. In the present study, 20 talkers produced speech in a variety of noise conditions including both steady-state and amplitude-modulated white noise. While listening to noise over headphones, talkers produced randomly generated five-word sentences. Similar to previous studies, talkers raised the level of their voice in steady-state noise. While talkers also increased the level of their voice in amplitude-modulate noise, the increase was not as large as that observed in steady-state noise. Sentence duration increased, regardless of whether the noise was amplitude modulated or steady-state. Importantly, for the 2 and 4 Hz amplitude-modulated noise conditions, talkers altered the timing of their utterances, reducing the energetic overlap with the masker by approximately 2%. However, for the 1 Hz amplitude modulated condition, talkers increased the overlap by approximately 4%. Overall, the results demonstrate that talkers are sensitive to the temporal aspects of noisy environments and will alter their speech accordingly.

Wed 15:50 Kurhaus meeting room 1 Psychoacoustics

Auditory Streaming in Cocktail Parties: Better Ear vs. Binaural Processing

Esther Schoenmaker and Steven van de Par
University of Oldenburg

A headphone experiment was designed to investigate the role of spatial cues in auditory stream formation in cocktail party settings. More specifically the contribution of binaural cues versus monaural listening with the better ear was investigated. Listeners were requested to follow a sequence of logatomes spoken by one target speaker in a mixture of three speakers placed at different azimuth angles. In the first of two experiments, the speech stimuli were presented with interaural time differences (ITDs) in order to test pure binaural processing. In the second experiment, the same stimuli were filtered with head-related transfer functions (HRTFs) and therefore possessed full sets of realistic spatial cues. As a consequence, better ear listening was possible in the second, but not in the first experiment.

Furthermore, spatial continuity was disrupted in various experimental conditions. Either the logatomes of the target stream, those of the interfering streams or those of all three streams were presented from changing azimuth positions during the stream. Influences of the various spatial cues and their continuity on auditory streaming will be analyzed and discussed.

Wed 16:10 Kurhaus meeting room 1 Psychoacoustics

Level Dependency of Auditory Stream Segregation

Christopher Hauth[a], Simon Krogholt Christiansen[b] and Torsten Dau[c]

[a] *Jade-Hochschule Oldenburg;* [b] *Centre for Applied Hearing Research, DTU (DK);* [c] *Centre for Hearing and Speech Sciences, DTU (DK)*

A critical feature of the human auditory system is its ability to segregate mixtures of sounds into components or streams, enabling a listener to direct his/her attention towards a single acoustic source. Previous studies (e.g., Bee and Klump, 2004) suggested that peripheral processing and, in particular, forward masking, play a dominant role in auditory stream segregation. In this study, the role of level-dependent peripheral processing in stream segregation was investigated. Using the classical ëgalloping tone' experimental paradigm (van Noorden, 1975) with alternating two-tone sequences presented at 40, 60 and 80 dB SPL, the effect of level-dependent frequency selectivity on the auditory percept (one versus two streams) was studied. Furthermore, the influence of forward masking was examined by introducing a level difference between the two tone sequences and by changing the duration of the successive tones in the sequence. Surprisingly, the perceptual data showed little influence of presentation level and duration across the conditions. The robustness of the auditory processing in this task was analysed using a physiologically inspired computational model of auditory stream segregation that comprises a level-dependent nonlinear cochlea stage, an adaptation process accounting for perceptual forward masking, and an across-frequency coherence back end.

Wed 16:30 Kurhaus meeting room 1 Psychoacoustics

Soft Metrology in acoustics: influence of noise on Stroop effect.

Laura Rossi[a], Andrea Fardin[a] and Alessandro Schiavi[b]

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Quantify the effects of external stimuli on humans requires the synergistic effort of natural and humanistic sciences going beyond metrology as commonly understood. The measurement of aspects of human perception and cognition are the objectives of Soft Metrology, defined as ”the set of techniques and models that allow the objective quantification of certain properties of perception, in the domain of all five senses”. The goal of this experiment is to evaluate the influence of different kinds of noises on human performance (a task that uses the Stroop effect). Discovered by J.R. Stroop (1935), it consists in the dilation of reaction time in humans: when the name of a colour is printed in a colour not denoted by the name (e.g., the word ”blue” printed in red ink), naming the colour of the word takes longer and is more prone to errors than when the colour of the ink matches the name of the colour. An influence on performance due to different kinds

of noise is detected for the 20 subjects tested and it is quantified through the measurement of three parameters: psychological, operational and physiological (heart rate), in reference condition (silence) and in presence of noise.

Wed 16:50 Kurhaus meeting room 1 Psychoacoustics

Global and local temporal envelope processing

Thomas Biberger and Stephan D. Ewert
University of Oldenburg, Medical Physics

In daily life people are often part of acoustical scenes where complex signals with dynamic variation over time, such as speech or music, occurs besides noise and the auditory system is able to utilize amplitude modulation (AM) cues to cope with such scenes. Recently is has been shown that the concept of the envelope power spectrum model [EPSM; Ewert and Dau, J. Acoust. Soc. Am. 108, 1181 (2000)] which accounts for psychoacoustic AM detection and masking data by calculating envelope signal-to-noise ratios (SNR) at the output of modulation filters, is also suited to predict speech intelligibility [Jørgensen and Dau, J. Acoust. Soc. Am. 130, 1475 (2011)]. In both models, the SNR is calculated over the whole signal duration (global) disgarding the short-time signature of the signal (local). However, in situations with fluctuating maskers a higher temporal resolution in the modulation filter might help to exploit temporal gaps in a masker to detect a target signal. Here, a time-domain version of the EPSM was assessed in conditions of AM masking and detection using global and local SNRs and complex AM waveforms. Results from basic psychoacoustic experiments will be presented and compared to model predictions.

Wed 17:10 Kurhaus meeting room 1 Psychoacoustics

Scile, a Matlab-based Software Tool for the Conduction of Psychoacoustic Experiments

Arnau Vázquez
Fachhochschule Köln

A Matlab-based software tool for conducting psychoacoustic experiments is presented. In psychoacoustics, experiment measurements are obtained using human subjects as the relevant measuring instrument. Stimuli are presented to subjects and their responses are the results from the measurements. The software is divided into three main modules: experimental setup, procedure of the experiment and interpretation of the results. In the experimental setup, tests are prepared selecting one of the available methods, customizing it and selecting the stimuli. Test methods include e.g. adaptive n-AFC and impairment evaluation. In the procedure module the stimuli are presented to the subjects and their responses are obtained. Stimuli can be accessed locally from a stimuli pool or using external reproduction systems. The remote control of a binaural render is possible, enabling the representation of virtual auditory scenes. Results can be plotted and compared using several averaging methods and plotting options. A subject data base with information about the subjects is also created. The

software provides a single tool for the complete test chain and the graphical interface (GUI) is intended to be easy to handle and to understand for both test conductor and subject.

Wed 17:30 Kurhaus meeting room 1 Psychoacoustics

HRTF-Measurements with Earmolds and Conventional Ear Plugs - A Comparison

Stefan Raufer, Eugen Rasumow and Matthias Blau
Jade-Hochschule Oldenburg

Measuring Head Releated Transfer Functions (HRTFs) is a common procedure to quantify and, if necessary, reproduce spatial aspects of sound fields. The most popular method to measure HRTFs is the so called blocked-ear method in which a microphone is placed in front of the blocked ear canal. In order to obtain highly reproducible results with this method, individual earmolds are often used. A much less expensive alternative (in particular, in terms of preparation time) would be the use of conventional foam ear plugs. In this study, binaurally (via headphones) presented stimuli based on equalization filters derived from measurements with individual earmolds and from measurements with foam ear plugs were compared to each other and to free-field presentations via loudspeakers. For three directions in the horizontal plane, subjects had to evaluate differences of the signals in an A/B direct comparison with respect to loudness, direction, distance, source width and coloration. In summary, the results indicate that both methods yield comparable virtual perceptions. No significant differences were found that would justify a preference of the individual earmold setup.

Wed 17:50 Kurhaus meeting room 1 Psychoacoustics

Magnitude Production of Pitch Ratios: A Comparison of Musicians and Non-Musicians

Florian Kattner and Wolfgang Ellermeier
TU Darmstadt

The subjective auditory attribute corresponding to tonal frequency figures prominently in psychoacoustical models, e.g. via the bark or mel scales. The aim of the present study was to determine, whether pitch actually constitutes a ratio scale, much like loudness. To that effect, 20 participants (half of them practicing musicians) were asked to adjust pitch intervals defined by pure tones in a frequency range between 264 and 699 Hz to specific ratios (e.g., 1/2 or 2/3) of a standard interval. These adjustments were subsequently checked as to whether they conformed with crucial properties (’axioms’, see Narens, 1996) of a ratio scale, namely monotonicity, commutativity, and multiplicativity. A few axiom violations were observed, particularly when asked to adjust pitch intervals beyond an octave. However, there were differences between musicians and non-musicians, with the former producing adjustments that were more reliable and closer to semitones.

Wednesday Psychoacoustics (Poster)

AFC - A modular framework for running psychoacoustic experiments and computational perception models

Stephan D. Ewert
University of Oldenburg, Medical Physics

AFC is a free, versatile, and highly flexible tool to design and run psychoacoustic measurements in MATLAB. In addition to measurements with subjects, AFC allows computer models to interface with the measurement core and to conduct exactly the same experiments as in human subjects with the model as artificial listener [e.g., Jepsen et al., J. Acoust. Soc. Am. 124, 422 (2008)]. Previous versions of AFC have been used as measurement and modeling tool for over a decade in several highly ranked psychoacoustic research sites and were used for data collection in dozens of scientific papers. AFC requires no specific hardware or sophisticated programming skills. Response collection is possible via computer keyboard, mouse or touch screen and language and feedback settings are configurable. The software offers freely adjustable n-interval, m-alternative forced choice procedures including interleaved tracks in addition to, e.g., method of constant stimuli and identification tasks. Here, an improved version of the software is presented. The improved modular design offers an easy way to overload or add, e.g., measurement procedures, audio drivers, and calibration methods. Use cases involving a number of example experiments and models utilizing different psychoacoustic procedures are presented.

Wednesday Psychoacoustics (Poster)

Frequency difference limens at high frequencies for normal-hearing and hearing-impaired subjects

Stephan M.A. Ernst[a] and Brian C.J. Moore[b]
[a] *University of Oldenburg, Medical Physics;* [b] *University of Cambridge, Dep. of Experimental Psychology*

The smallest detectable change in frequency of a pure tone (Δf/f) may be based on a place mechanism (basilar-membrane filtering) and a temporal mechanism (phase locking in the auditory nerve). The precision of phase locking weakens at high frequencies. If there is a transition from a temporal mechanism at low frequencies to a place mechanism at high frequencies, the function relating Δf/f to f should show a breakpoint at the frequency where temporal information becomes unusable. Until recently, published data did not show such a breakpoint. However, recently we showed that, for normal-hearing subjects, a breakpoint occurred at about 8 kHz, which is above the typically assumed upper limit for phase locking of 4-5 kHz. In the present study, we measured Δf/f for subjects with cochlear hearing loss, using center frequencies up to 14 kHz. The method only required detection of a change in frequency, not naming the direction of the frequency change. The usefulness of loudness cues was reduced by roving the level of every tone. The results provide evidence for a breakpoint in the function relating Δf/f to f, but the frequency at which the breakpoint occurred depended on the magnitude of the hearing loss.

Session "Effects of noise"

Wed 8:40 Kurhaus meeting room 2 Effects of noise

Cardiovascular Disease: Relationship to Night Employment and/or Nightly Traffic Noise

Dirk Windelberg
Leibniz Universität Hannover

Often authors look for a cause of cardiovascular disease and try to find a correlation to percentage night employment - whereas other authors try to find a correlation to annoyance of nightly traffic noise. Of course both types of authors find such relationships and publish their results. But what happens, if we try to find a 3-dimensional correlation between these three parameters (neglecting more possible relations)? - Correlations between two parameters (e.g. traffic noise and annoyance) are often escribed by a line (IF-Studie) or by a parabola (Miedema) - without the statistical spread; at DAGA 12 I presented mathematical methods for a 'better' description ('Dosis-Wirkungs-Beziehung'). - But here I will present an example of higher dimension (e.g. three for simple geometric representation). But a neglect of one of this 3 parameters may lead to wrong (or true) correlations: There exist a medical proved relationship between cardiovascular disease and night employment: 'the more working hours during night the higher the quantity of cardiovascular drugs (Breitsh Medical Journal July 2012)' and a medical reviewed relationship between cardiovascular disease and annoyance of traffic noise: 'the more traffic noise the more cardiovascular drugs (Greiser)'. Any interpretation depends at least on these three parameters - visible by geometric 'pictures'.

Wed 9:00 Kurhaus meeting room 2 Effects of noise

Reaction in the Brain to Low-Frequency Noise

Detlef Krahé and Tobias Weigler
Bergische Universität Wuppertal

A certain part of people has serious problems in low-frequency noise (LFN) and the reason for that is unknown. It could be located in the sensor ear, which is sensitive in special way, and /or it could be located in the brain, which reacts to the LFN in a special way. In this conjunction the fact is interesting, that additional higher frequency components can reduce the annoying effect of LFN up to a certain point. Based on that, an investigation was done measuring the EEG of probands known as LFN-sensitive or insensitive while hearing LFN-stimuli with or without additional higher frequency components. Dependent on the stimuli, reactions in the EEG are observable regarding the group of the sensitive probands. It will be discussed, if these results can explain the influence of LFN on the mental performance of LFN-sensitive sufferer.

Wed 9:20 Kurhaus meeting room 2 Effects of noise

Experiments to engage the difference of noise and sonority based on subjects TCM-related body spontaneous reactions during the 27. VDT Audiomedia Convention

Florian M. König
Florian König Enterprises GmbH

The possibility to use modern reproduction of sound techniques enables to simulate a daily 2D / 3D acoustic ambience realistically. This leads to questions how humans react on different auditory events via neuronal effects, psychic and physical ways: ”Noise contra sonority”. Seeing music it could be sometimes disturbed or relaxed by harmonics or just grumbling about an annoying industrialized life noise. On the other hand neuronal analysis describes only some elements how music impacts our soul. Where is to find the line of demarcation in spontaneous body reaction differences, if a wellbeing auditory event goes contra a health damaging annoying soundscape? Is there to find a small organic reaction difference and it is possible to lift something out from given Traditional Chinese Medicine (TCM) measurement methods spontaneously? Exactly here was motivated this pilot study regarding live comparison tests via loudspeakers and headphones during the 27. VDT Audiomedia Convention 2012. We used a body meridian feedback measurement devices called BIOPULSAR (certified as electromedical device class type 2A). This hand table element is daily used to find out the in-sito reaction after a pharmaceutics’ and homeopathy intake or how small electro-magnetic field’s effect on humans after $<$ 1 minute exposure time.

Wed 9:40 Kurhaus meeting room 2 Effects of noise

Noise and Community Annoyance: Stress correlation.

G. Mario Mattia
EuroAcustici e Bruel Acoustics, Libero professionista, Roma

The human beam interaction with the environment. Our culture works like an adaptive system to be able to survive in different environments: we identify the danger with a genetic registered reaction called stress. As a consequence of human virtual capacity of interaction with the environment we can understand why it is so difficult to link community noise pollution to reaction of the population. The reaction cannot be simply related to sound level but has to be linked to subjective human evaluation. When the acoustic perception is negative subjectively we can evidence that the individual starts to react with complains to the noise pollution. Noise is one of the most important or large physical pollution for all, so there are many noise policy-working groups to tray to link the population reaction to noise pollution and annoyance. We have to face two completely different aspects of noise pollution: 1. The administrative aspect can be evaluated on statistical approach, as WHO and UE are doing, 2. The subjective aspect can be evaluated only on individual parameters (social, cultural and neuropsychological approach).

Session "Acoustic urban planning"

Wed 10:00 Kurhaus meeting room 2 Acoustic urban planning

Acoustic for Smart Cities

Sergio Luzzi
Vie En.Ro.Se. Ingegneria, Firenze

More than 50% of earth inhabitants are living in cities. In the most developed countries policy makers are facing the problem of smart governance of cities, considering environmental and energetic aspects combined with social issues like education, cohesion, inclusion. Technology and resources should be consequently integrated into a comprehensive and sustainable approach to urban planning. Good strategies and good practice for noise reduction and control in urban areas can be connected to the development of greener and sustainable urban environment. A collection of strategic experiences and technologic solutions for noise reduction, quiet area preservation and acoustic quality improvement in urban areas is reported here, together with some possible ideas for integrated Smart Urban Plans, inspired by a holistic approach to city planning.

Wed 10:20 Kurhaus meeting room 2 Acoustic urban planning

How traffic noise captured our cities and how to regain our cities

Henk Wolfert
DCMR EPA, Schiedam (NL)

The first round of Noise Mapping, according to the Environmental Noise Directive 2002/49/EC, showed that road traffic noise is the most dominant noise source. This was also found in the Noise Questionnaire set out by Working Group Noise EUROCITIES (WGN) in 2008. About 60 millions of the European citizens, living in agglomerations as meant in the directive are exposed to noise levels higher than 55 dB LDEN resulting in annoyance and in other health effects. It is expected that these numbers will increase to 180 - 220 million people. Due to these findings and expectations WGN decided to start the battle against road traffic noise as one of their main priorities. Therefore, numerous actions were already undertaken such as requests to the European Commission to strengthen the Emission Limit Values of vehicles, lorries, motorized two and three wheelers and tires. Besides the crusade against noisy vehicles WGN also provided the cities with information on Best Practices in order to tackle the noise. This paper will give insight in the causes of transport, the unwanted effects and how to avoid, reduce or mitigate this by good urban planning.

Wed 10:40 Kurhaus meeting room 2 Acoustic urban planning

Factors Affecting the Restorative Quality of Space on University Campus

Abigail Bristow[a], Kirill Horoshenkov[b] and Clive Wilson[b]

[a] *Loughborough University, Civil and Building Engineering (UK);* [b] *University of Bradford (UK)*

This paper explores the limited evidence on the way students perceive, rate, use and value restorative spaces on campus. About 2.5 million students study each year in UK Higher Education Institutions of which around 0.3 million are international students from outside the EU. Yet surprisingly little research has been undertaken on the perceptions, preferences and needs of students for restorative space on campus. This paper reviews the evidence with a particular focus on audio and visual stimuli.

We then report empirical investigations of the noise climate and quality of space around the University of Bradford. These include subjective and objective assessments of sound quality at a range of locations; student satisfaction with the visual appearance of the University and an initial estimates of the economic value of such space. These initial explorations enable us to develop a framework for future research on restorative space in Universities.

Wed 11:00 Kurhaus meeting room 2 Acoustic urban planning

Dynamic Noise Maps as Decision Tool

Sebastian Eggers

LÄRMKONTOR GmbH

Lärmkontor has developed a software tool to speed up noise prediction calculations e.g. in the scope of the Environmental Noise Directive. Many changes in a given scenario can be rapidly analyzed with the ”dynamic noise map”. Noise abatement measures at source can be checked and can be presented with their quantitative effect in seconds.

All noise source related parameters, as the amount of traffic, the HGV percentage, the speed limit and the road surface, can freely be chosen. Besides conventional noise calculation rules (such as the ”RLS-90”) the software has implemented an emission model sensitive to measures (based on ”TraNECaM”). By this, measures at the vehicle fleet, the impact of electric vehicles, low-noise tires or improvements in traffic flow can be analyzed.

The results can be shown as well in form of a noise map or in form of a table with the number of people exposed to noise as in a presentation of the façade levels, a hot-spot analysis and a difference map. It is also possible to analyze which noise emitter is contributing to the total noise level for any grid point or façade receiver point. Thus the most relevant source of noise is identified quickly.

Wed 11:20 Kurhaus meeting room 2 Acoustic urban planning

The Integrated Action Plan for Road Traffic Noise in the City of Turin

Enrico Gallo[a], Federico Saporiti[a], Jacopo Fogola[b] and Daniele Grasso[b]
[a] *Città di Torino;* [b] *Arpa Piemonte, Torino*

According to the Directive 2002/49/CE and the Italian regulation, in 2011 the city of Turin finally adopted its action plan for road traffic noise. The plan has been developed from the road traffic noise map, built in 2007, which contains a detailed assessment of the noise levels at the façade of each building and the estimation of people exposure to noise, improved on the basis of a large number of noise measurement and field tests, thanks to close collaboration between municipality and local environmental agency. The action plan is based both on strategic actions and short/medium term priorities for noise mitigation. Strategic actions are connected with mobility planning, public transport and new technologies, but mainly enhance an integrated approach concerning urban planning, building permits requirements and roads or public buildings maintenance and optimizations. Short and medium term priorities are mainly based on hot spots; city center is also included, due to urban restoration process and air quality actions. This paper will illustrate vision and contents of the plan, the problems encountered in its early implementation and the first results achieved.

Wed 11:40 Kurhaus meeting room 2 Acoustic urban planning

Noise Annoyance Before and After Enlarging Danish Highway

Lene Nøhr Michelsen, Jakob Fryd and Hans Bendtsen
Danish Road Directorate

Due to increased traffic, Motorway 3 in Copenhagen has been enlarged from four to six-lanes on a 17 km long stretch. As part of the project the initial noise barriers along the motorway was replaced by 4 m high noise barriers. In total nearly 18 km of higher barriers were applied together with noise reducing road pavements and façade insulation. Calculations showed that the road project including noise mitigation measures resulted in a reduction of dwellings exposed to more than 58 dB (Lden), from 6300 dwellings before to 2200 dwellings after. An investigation on annoyance due to road traffic noise was carried out by the Danish Road Directorate as a pre-post study in six residential areas covering 1200 dwellings. Responses were collected by two mail questionnaires a year before the construction started and a year after it was completed with response rates of 71 % and 65 %. Results showed an improvement on the perceived noise annoyance from road traffic in the whole area including noise from the motorway as well as local roads and other main roads. The total percentage of very and extremely annoyed respondents decreased from 37 % to 16 %.

Wed 15:30 Kurhaus meeting room 2 Acoustic urban planning

Acoustical assessment of the impact of low noise pavement on a section of the PARIS ring road

Fanny Mietlicki
Bruitparif, Paris

To assess the impact of the use of low noise pavement on the Paris ring road, a special device has been set up to have noise data before and after the new pavement. Bruitparif teams deployed at the beginning of May 5 permanents noise measuring stations. The first was installed on the central reservation (in the immediate vicinity of the noise source) and the other 4 stations in front of buildings bordering the ring road. One of them located outside the perimeter of the experiment used as " awitness" to assess the effectiveness of the low noise pavement. To complete the measures will be carried out in a vehicle with a head and torso simulators to recording acoustic noise levels perceived by the human ear and make digital audio recordings. This will document the gain in terms of acoustic comfort for drivers as well. The device will remain in operation for several months, because one of the important issues for this type of solution is to establish its sustainability over time due to the very high traffic load on the ring road. The operation is carried out in the project Harmonica cofinanced by the European programe LIFE + 2010.

Wed 15:50 Kurhaus meeting room 2 Acoustic urban planning

A new approach to road traffic noise assessment in Milan

Giovanni Zambon[a], Fabio Angelini[a], Alessandro Bisceglie[a], Giovanni Brambilla[b] and Simone Radaelli[a]
[a] *Università degli Studi Milano Bicocca;* [b] *CNR-IDASC, Roma*

In the last years the Municipality of Milan has promoted some important policies in order to obtain an in-depth knowledge of road traffic noise. The city government has paid particular attention to cost containment, especially concerning the monitoring activities. One of the main features of the noise source under investigation, i.e. road traffic, is the repetitiveness of the trend of 24 hour time series of hourly LAeq. Thanks to this feature and on the basis of roads classification it is possible to obtain the noise levels generated from the almost all urban roads by means of a limited number of measurement points. For this purpose we used the methodology called "stratified spatial sampling". Since the aim is to get the noise levels generated by road traffic it is necessary to identify and remove unwanted sound events from measurements. The Disat-UNIMIB and IDASC- CNR are developing an automatic procedure to identify and remove unwanted sound events from measurements by using the results of permanent monitoring terminals. In the future we expect to achieve a monitoring network/noise simulation model integrated system that allows to update in real time the city noise map for road source from data provided by the monitoring terminals.

Wed 16:10 Kurhaus meeting room 2 Acoustic urban planning

Analysis of Dose-Effect Relations for Noise Annoyance and Sleep Disturbance in an Urban Area of Genoa

Aglaia Badino and Corrado Schenone
Università degli Studi di Genova

In the European Directive 2002/49/EC the dose-effect relations have been introduced for the first time at regulatory level, in order to assess how many and how people are affected by a long exposure to a noise source. These relations have been formulated on the basis of a huge number of socio-acoustic surveys, carried out in countries of North Europe, Centre Europe, North America and Australia. The relations are not based also on surveys done in countries of South Europe. This lack might lead to incorrect assessment, if the relations are used in these territories, because urban development, transportation system, infrastructure net, climate, culture, etc. are historically different between countries of North and South Europe. The present research is focused on the verification of the applicability of dose-effect relations in territories of South Europe, starting from an urban area of Genoa (Italy). Only dose-effect relations related to road traffic noise have been verified. An important arterial road, crossing a residential area, was considered for this aim. Once made the noise map of the area, the respondents were selected, basing on the different noise exposure levels. It is surfaced by this first survey that the dose-effect relations underestimate the real situation.

Wed 16:30 Kurhaus meeting room 2 Acoustic urban planning

An approach to Socioacoustic Diagnosis in Urban Spaces. The case of Tarragona.

Miguel Alonso-Cambrón
Independent Researcher, A Coruña (E)

Starting from the case study conducted in the city of Tarragona as part of the doctoral thesis ”Sociophony, Identity, and Conflict” (URV, 2011), an introduction to socioacoustic methodology as a tool for urban diagnosis will be done. On the basis of ethnographical observation, description, and anthropological analysis of sociophonic phenomenology of urban spaces as well as the acoustemological patterns attached to its social practice, a series of general guidelines on socioacoustic approach will be presented. Through these techniques and strategies it’s possible to access not only to valuable information regarding the current state of urban tissue, but also to the sensory hierarchies of populations associated to the analyzed spaces. This will be presented through the case study of the historic centre of the mediterranean city of Tarragona.

Wed 16:50 Kurhaus meeting room 2 Acoustic urban planning

Noise Management Around Airports - A Brazilian Case Study

Tania Caldas
INFRAERO - Empresa Brasileira de Infra

Noise is the main environmental impact related to airpot operation and air transport in general. This paper presents a case study of airport noise management, considering the policy adopted by INFRAERO, a Brazilian airport operator, identifying the evolution of the cooperation procedure between the company and local authorities, in order to face the challenge of reaching airport development and environmental protection. The results of the program and the opportunities found during the process will also be presented, analysing the target of reaching better practice of the company's environmental policy.

Wed 17:10 Kurhaus meeting room 2 Acoustic urban planning

Study of a representative part of the territory of the municipality of Rome

Guido Carati, Enrico Carlini, Giovanni Fascinelli, Gianluca Ferri, Mariagrazia Rizzo, Valeria Romano Franchi De Notarvanni and Bruno Cignini
Roma Capitale - Dip. Tutela Ambientale e del Verde - Protezione Civile

The Environmental Department of the municipality of Rome has chosen to study a part of its territory to understand better the role of the traffic noise in the urban context. The chosen part is representative of all the aspects of the city of Rome: there are residential areas, schools, parks, hospitals, railway station, buses, main streets, but also local streets. The study includes noise measurements, traffic measures, use of acoustic calculation models to estimate acoustic levels linked to traffic noise. The investigated area is 73 square kilometres, and represents about the twentieth part of the whole territory of the city of Rome. The results of the study allow to know sound levels on the front of the buildings and to know where are acoustic critical points in the investigated area. The study permits to generalize results to other areas of the municipality of Rome with similar aspects. This kind of results are also useful to choose the best mobility politics to preserve the environment.

Wed 17:30 Kurhaus meeting room 2 Acoustic urban planning

LIFE+2008 HUSH - Stakeholders' satisfaction in terms of non-acoustic data after the realization of pilot interventions in the city of Florence

Raffaella Bellomini[a] and Arnaldo Melloni[b]
[a] *Vie En.Ro.Se. Ingegneria, Firenze;* [b] *Comune di Firenze*

Among particular H.U.S.H. project's objectives, one is to define a new development system (procedures and database) for action planning, by testing it in two pilot cases, in the city of Florence. In each selected area a qualitative analysis phase besides a quantitative standard analysis phase is carried out, by means of surveys on sensitive areas, hotspots and quiet areas, as well as through inquiries about people's opinion regarding the disturb perception. In this paper results of non-acoustic data collection, procedures adopted for sample selection, methods for building up and analysis of questionnaires, in the frame of a participatory planning approach, are described. The results of ante and post operam non-acoustic surveys already carried out on a significant sample of people are reported. Expected outcomes are a collection of information that can be used to plan the actions and the community involvements.

Wed 17:50 Kurhaus meeting room 2 Acoustic urban planning

Combining participatory sensing and prediction models to evaluate noise action plans

Maria Niessen[a], James Rex[a], Andreas Merentitis[a] and Christian Debes[b]
[a] *AGT International, Darmstadt;* [b] *AGT International*

The Environmental Noise Directive (END, 2002/49/EC) calls upon European member states to set up action plans for noise mapping in major cities. An action plan should include results of noise mapping, measures that authorities will take to reduce noise, and a strategy for evaluating the implementation of the action plan. Most noise mapping efforts rely on calculations that predict noise levels based on source models and parameters that influence sound propagation. However, the results from mathematical models are long-term averages and do not facilitate decision making on a temporal scale. Furthermore, noise modeling is possible only for known sources, usually traffic, aircraft, and industry noise, and cannot support decision making for other types of noise such as neighborhood noise. We propose a participatory sensing methodology to provide the temporal granularity that is desirable to formulate an effective action plan. Using measurements from both mobile and fixed low-cost microphones the propagation model can be fine-tuned with real data. Instead of an average noise map, this methodology will provide a heat map visualization that can be updated regularly. As a consequence, a noise map can be calculated based on average noise levels over different time scales, from hours and days to months.

Wed 18:10 Kurhaus meeting room 2 Acoustic urban planning

Acoustic efficiency: improving the comfort of our cities through the environmental certification of the built

Elena Stoppioni[a] and Norbert Lantschner[b]

[a] *Envircom, Firenze;* [b] *ClimAbita Foundation, President and Founder*

There are times in life where you have to choose whether to wait or act: today that the development and the economy seem enveloped in a limbus of uncertainty is the time to act, to write a new future in the way we design, build and live in our environment. The knowledge is not enough. We need to want to, and above all to do it. It is no longer possible to speak in general terms of acoustic comfort in our cities and in buildings without considering ways to integrate the acoustic with sustainability, energy efficiency, healthy indoor. We really need to chart a new path on which they can meet the design integrated, in site application, serious certification, and finally a collective consciousness that generates a widespread culture of sustainable. This paper presents the environmental certification ClimAbita from the point of view of its Protocol of acoustic certification of buildings, whereas ClimAbita Certification defines a new sustainable city concept and fits well with a new concept over and above the energy efficiency: the acoustic efficiency.

Session "Rail/wheel noise 2"

Wed 8:40 Kurhaus conference room Rail/wheel noise 2

Acceptance of Railway Vehicles within the simplified Evaluation Method according to TSI Noise - conventional Rail System (2011/229/EU) - practical Application of the Procedure and its Limitations

Frank Steinbach

Müller-BBM GmbH

According to the TSI Noise (2011/229/EU) railway vehicles can be assessed according to the simplified evaluation method. In this context a suitable proof must be provided showing evidently that the acoustically relevant components and characteristics of the vehicle under test are identical to those of a reference type or that they will not increase the noise emission level.

The TSI Noise offers various possibilities for the proof of conformity, a precise calculation scheme however is not defined. Nevertheless, the method has already been applied successfully and first vehicles have been assessed based on it.

Müller-BBM as a testing institute has already applied the simplified evaluation method successfully in several projects and thus enabled the approval of new vehicle types. This paper describes the application of the method in two practical examples. Applicability and limitations of the simplified evaluation method are pointed out from the perspective of a testing institute - helpful information for judging whether this method can be an efficient alternative to the full approval procedure as far as new vehicle developments are concerned.

Wed 9:00 Kurhaus conference room Rail/wheel noise 2

Determination of the state of the art of noise emissions from European rail Vehicles & TSI Noise Revision

Urs Reichart[a], René Weinandy[a], Stefan Lutzenberger[b] and Christian Gutmann[b]

[a] *Umweltbundesamt, Dessau-Roßlau;* [b] *Müller-BBM GmbH*

This research project done by Müller-BBM on behalf of the Federal Environment Agency of Germany, gives a representative overview of the noise emissions of European rail vehicles as measured according to TSI Noise. The aim was to determine the state of the art and thus to provide a basis for establishing limit values within the TSI Noise revision. From the statistical indicators and an assessment of the technologies available proposals for limits were derived. The current status of TSI Noise revision will be presented. It will be discussed how these proposals will be included in the revised TSI Noise.

Wed 9:20 Kurhaus conference room Rail/wheel noise 2

How to measure brake noise of railbound vehicles

Christoph Eichenlaub[a], Jörn Arendholz[a] and Joan Sapena[b]

[a] *Alstom Transport Deutschland;* [b] *Alstom Transport, St Ouen (F)*

With the new revision of the EN ISO 3095 the brake noise measurement procedure will be changed completely. The measurement positions will depend on that position, where the vehicles is located after performing the procedure. Every test run needs to be checked for being valid, using a tolerance scheme provided in the standard. The method will be described and a proper way of handling the procedure will be presented. Examples for measurements will be shown and possible improvements will be discussed. Additionally the indicators for brake noise will be discussed.

Wed 9:40 Kurhaus conference room Rail/wheel noise 2

Influence of wheel-mounted brake discs on the structural dynamic behavior of railway wheels

Torsten Kohrs and Sebastian Groth

Bombardier, Hennigsdorf

The structural behavior of a railway wheel is influenced by attached parts like wheel-mounted brake discs with respect to mass, stiffness and damping. These modifications can have a significant impact on the resulting rolling noise of the wheels. The objective of the present work is to develop a guideline for FE-modeling of a typical railway wheel with wheel-mounted brake discs that provides a physical basis for reliable rolling noise predictions. Therefore, the influence of the brake discs on the structural dynamic behavior of the wheel is investigated using FE-calculations and experimental modal analysis. The experimental modal analysis is performed on a typical wheel without and with wheel-mounted brake discs using different mounting torques. The results serve as a basis to include the measured damping in the FE-model and to validate the selected approaches for modeling of the brake discs including the contact faces between the brake disc and the wheel.

Wed 10:00 Kurhaus conference room Rail/wheel noise 2

A direct method for the determination of the wheel roughness of railway vehicles

Christian Gutmann
Müller-BBM GmbH

Rail traffic noise is mainly determined by rolling noise. Concerning rolling noise, the interaction of the running surface of the rails and wheels plays a decisive roll. Due to the roughness of the running surface of the wheels and rails, vibrations of the wheels and rails are caused which, in turn, lead to a radiation of airborne sound. Regarding acoustic acceptance tests of rail vehicles, among other things specific demands are made on the rail roughness of the test track. In the standards, the roughness of the running surface of wheels has not yet been taken into account. Usually, the wheel roughness is greater than the roughness of the running surfaces of the rails of TSI reference tracks. Thus, the pass-by noise of the rail vehicles to be tested largely depends on the wheel roughness. In this lecture, a test method is suggested which is based on the determination of the rail roughness.

Wed 10:20 Kurhaus conference room Rail/wheel noise 2

Acoustic Investigations in and at Railway Vehicles on the New Route Vienna - St. Pölten

Michael Göbl[a], Günther Achs[a] and Michael Mach[b]
[a] *FCP Fritsch, Chiari & Partner ZT GmbH;* [b] *ÖBB Infrastruktur AG*

In the scope of test runs of the Austrian Railways ÖBB on the occasion of the start of operation of the new route Vienna - St. Pölten in summer 2012 acoustic measurements in and at rail vehicles were carried out. For this purpose a defined track test coach of the ÖBB was primarily instrumented and investigated during several test runs at different running speeds. In addition measurements in a passenger train (RailJet train set) were carried out for the analysis of the sound immissions in the passenger compartment. Acoustic impacts by the track section (free route, tunnel section, etc.) and the reflections on the track (ballasted track, ballast-less track, track absorbers, tunnel absorbers, etc.) in the area wheel-rail-contact, at the outer shell of the vehicle and in the passenger compartment were determined from the results gained.

On the basis of the recorded measurement data important findings regarding effectiveness and performance of track absorbers, track systems, noise protection elements and vehicle damping could be acquired. Furthermore conclusions on the acoustic rail condition shall be drawn in order to be able to plan maintenance and repair.

Wed 10:40 Kurhaus conference room Rail/wheel noise 2

The Influence of Rolling Stock on Railway Induced Vibrations and Mitigation Measures on Vehicles

Philipp Huber
PROSE AG, Winterthur (CH)

The EU-Project RIVAS (Railway Induced Vibration Abatement Solutions) aims at reducing the environmental impact of ground-borne vibration while safeguarding the commercial competitiveness of the railway sector. RIVAS focuses on low frequency vibration from open lines which is a concern mainly for freight traffic. In Workpackage 5 mitigation measures on vehicles are investigated. Therefore a field study in Switzerland was conducted and thousands of different train passings were evaluated with the focus on rolling stock parameters. The statistical evaluation of this vibration measurements showed that especially freight locomotives, respectively the out-of-roundness of the wheels in combination with a high unsprung mass, are responsible for high vibration emissions. In parallel numerical simulations were conducted to quantify the influence of the most important parameters of rolling stock. Based on the outcome of this study, different measures applicable on the vehicle were evaluated. The measures were divided into maintenance and prevention of wheel imperfections, measures on existing rolling stock and measures on new rolling stock. The study shows that some of the investigated measures show quite high potential of vibration mitigation. Field tests of the most promising mitigation measures are planned in spring 2013.

Session "Tyre/road noise 1"

Wed 11:00 Kurhaus conference room Tyre/road noise 1

European Road Administrations Desiderata on Noise Research

Patrizia Bellucci
ANAS S.p.A., Centro Sperimentale Stradale, Cesano di Roma

Il rumore rappresenta un importante specifica progettuale nel processo di sviluppo, costruzione e manutenzione delle reti stradali. Per l'abbattimento dei livelli di rumore si spendono nei Paesi della UE significative risorse finanziare che incidono in modo apprezzabile sul bilancio delle Amministrazioni Stradali, da cui l'interesse per la promozione di studi mirati all'ottimizzazione di procedure che consentano di massimizzare l'efficacia e l'efficienza degli interventi di mitigazione sonora, a partire dalle attività valutative preliminari, sino alla realizzazione e collaudo delle opere stesse. A fronte di obiettivi comuni, le varie Amministrazioni Stradali Europee hanno aderito allo studio sul rumore stradale promosso dal CEDR (Conference of European Directors of Roads) nell'ambito del Piano Strategico 2009-20013, con l'obiettivo di scambiare esperienze ed individuare le tematiche meritevoli di ulteriori approfondimenti su cui focalizzare le future attività di studio e ricerca. Allo scopo è stato, quindi, elaborato un questionario, distribuito nei primi mesi del 2011, per individuare i temi della ricerca di maggiore interesse e/o prioritari, su cui impostare e sviluppare progetti congiunti. I risultati conseguiti hanno evidenziato l'importanza di incentrare

le attività di ricerca sulle problematiche inerenti il risanamento delle aree critiche e l'individuazione di soluzioni a maggiore efficacia ed efficienza.

Wed 11:20 Kurhaus conference room Tyre/road noise 1

Global Road Noise Development: Example for the use of a DfSS approach to optimize the vehicle development

Markus Gewalt and Volker Grützmacher
Adam Opel AG

Today's vehicle architectures require a high variety of wheels and chassis setups to fulfill customer expectations in regard to noise and handling performance in different regions of the world. Due to the general restriction of time and hardware availability, the vehicle development process needs to be optimized in order to achieve the required road noise performance with a minimum amount of test setups. The task for the development engineer is to find an optimal chassis setup which leads to low interior road noise and low road noise sensitivity concerning production variations of parts and ambient conditions. This survey exemplifies an approach based on the concept of "Design for Six Sigma". As a key element of that concept, the Taguchi Design of Experiment (DOE) technique is employed in order to get a robust chassis part design with a reduced amount of test setups. In the current survey it will be shown how this approach can be used in an early stage of the vehicle architecture development process. Results will be presented which lead to a deeper understanding of the main parameters influencing road noise in the given vehicle architecture.

Wed 11:40 Kurhaus conference room Tyre/road noise 1

Towards low-noise Paving Stone Road Surfaces

Manuel Männel
Müller-BBM GmbH

Road surfaces built with paving stones have several advantages compared to standard asphalt or cement concrete road surfaces considering road maintenance and visual aspects. However, in spite of the wide application of paving stone road surfaces in urban areas, this type of road pavement has hardly been matter of research activities with respect to tyre/road noise so far. The German project "Low noise cement concrete paving stones" in the framework of the "Roads innovation program" addresses several aspects for building low-noise road surfaces with paving stones made of cement concrete. Part of this project and the content of this paper is to determine the influence of different parameters of the joints between the paving stones such as joint width, joint orientation and vertical displacement between single stones on the acoustic properties of road surfaces. The acoustic properties of different joint geometries have been simulated with SPERoN. The results of the SPERoN calculations have been validated by means of measurements on 20 paving stone tracks. The paper will show the results of this project and show the main influencing factors of the joint geometry on the tyre-road-noise.

Wed 15:30 Kurhaus conference room Tyre/road noise 1

Reduction of Tire/Road Noise due to Application of Thin Pavement Layers

Christian Schulze[a], Sebastian Kluth[a], Mirko Ruhnau[a], Jörn Hübelt[b] and Wolfram Bartolomaeus[c]

[a] *Gesellschaft für Akustikforschung Dresden;* [b] *Hochschule Mittweida;* [c] *Federal Highway Research Institute (BASt)*

An increasing problem of modern times is the noise pollution due to tyre/road noise caused by increasing traffic density. Primary noise reduction strategies attempt to reduce the noise generation at the contact area of tire and road. Within the present work, the physical effects of the noise reduction of thin pavement layers were examined. Therefore, acoustical measurements according to ISO 11819-1 and measurements of the properties of the road surface (texture profiles, sound absorption coefficient and specific airflow resistance) were carried out. Using the properties of the road surface as input parameters for the SPERoN model (Statistical Physical Explanation of Rolling Noise), the sound immission level next to the road was calculated and compared to the measurement results. Finally, tendencies for the development of noise reduced pavements are derived.

Wed 15:50 Kurhaus conference room Tyre/road noise 1

Noise Reduction and Long-term Effectiveness of Low Noise Road Surfaces in Urban Streets of Munich

Manfred Liepert[a], Ulrich Moehler[a] and Michael Schumm[b]

[a] *Möhler + Partner Ingenieure AG;* [b] *Landeshauptstadt München, Baureferat Tiefbau*

The Munich city council decided to test low noise road surfaces on urban streets on 8 different test facilities. In the years 2009 to 2011 road surfaces of existing roads with speed limits of 50 and 60 km/h were renewed by low noise pavements. The projects were supported by the ”Konjunkturprogramm II”. Two different types of low-noise surfaces were tested: low noise stone mastic asphalt (SMA-LA) and thin layers (DSH-V). In order to quantify the noise reduction measurements were taken immediately before and after replacing the pavements. Long term effectivenes is controlled by repetitive measurements every year until up to 5 years after replacement. Because of the test sites on urban streets with high density of traffic and only few trucks passing by measurements according to ISO 11819-1 would be too time consuming for 8 test-sites. Therefore a combination of statistical and controlled measurement was chosen: measurement of free floating traffic at different periods of the day and measurements of controlled passbyes of a test vehicle at different speeds. The measurement method and its advantages will be described. Finally results of the long term effectiveness after 3 years of testing will be discussed.

Wed 16:10 Kurhaus conference room Tyre/road noise 1

Raised Crosswalks: Their Effects on Road Noise

Carlo Baistrocchi
Università di Firenze, Dip. Tecnologie dell'Architettura e Design

Raised crosswalks connected by ramps to the road paving are often created, not always appropriately, in order to induce a deceleration of vehicles and to improve pedestrians' safety. In order to see how far these artifacts influence road noise a study was carried out, with sound level measurements related to crosswalks of different geometry (width and height) and building characteristics. The results show that raised crosswalks can in some cases even worsen the noise, as well as the safety of the road.

Wed 16:30 Kurhaus conference room Tyre/road noise 1

Wind Influence on SPB-Measurements

Wolfram Bartolomaeus
Federal Highway Research Institute (BASt)

The Finite Difference in Time Domain (FDTD) method is originally used for calculation of electromagnetic fields solving the Maxwell equations. In acoustic the FDTD method is adopted for solving the Helmholtz equation, which turns out to be a simplification. The main advantage compared to the normal Finite Element (FE) or Boundary Element (BE) method is the possibility to use transient and/or moving signals which are incoherent in radiation. Also moving media (air) is possible to include in the calculation model. Starting from free sound propagation from a point source, reflected on the ground, also a (partly) incoherent source will be used within the model. For two dimensions this was already shown at FORUM ACOUSTICUM 2011 in Aalborg. At the end the sound propagation from a moving source (representing a vehicle passing by) under the influence of wind from different directions (down, opposing and cross) will be calculated for different immission points. The calculations will be discussed with measurements both from artificial sound sources and from vehicles passing by-tests.

Wed 16:50 Kurhaus conference room Tyre/road noise 1

Quiet Road Traffic 3 - Interdisciplinary Research on the Optimisation Potential of Pavements, Tyres and Vehicles

Christina Bückers, Bianca Drewes and Ulrike Stöckert
Federal Highway Research Institute (BASt)

The interdisciplinary research project "Quiet Road Traffic 3" (in German: "Leiser Straßenverkehr 3", LeiStra3) aims for an effective attenuation of road traffic noise. As the noise emission is predominantly determined by interaction processes between rolling tyre and road surface, the project focuses on the acoustic improvement of tyres and the development of noise-reducing pavements. This presentation gives an overview on the research concept of LeiStra3 which is running since 2011 and funded by the Federal Ministry of Economics and Technology (BMWi). Novel materials, new technologies and a simulation tool for theoretical analyses are applied to explore the noise reduction potential of tyres, vehicles and road surfaces.

The practical use of the optimised road construction techniques is finally checked by implementing and monitoring test tracks under realistic conditions. The research activities are coordinated by the Federal Highway Research Institute (BASt) and include universities, research institutes as well as industry. In this manner, scientific and immediately applicable solutions may be found ensuring substantial noise abatement.

Wed 17:10 Kurhaus conference room Tyre/road noise 1

The contribution of air-pumping to tyre/road noise

Julia Winroth[a], Carsten Hoever[a], Wolfgang Kropp[a] and Thomas Beckenbauer[b]

[a] *Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S);* [b] *Müller-BBM GmbH*

It is generally accepted that there are at least two tyre/road noise generation mechanisms commonly referred to as tyre vibrations and air-pumping. While the modelling of tyre vibrations is rather mature, the modelling of air-pumping is still on a basic stage and unsatisfactory in many aspects. Applying the fact that tyre vibrations and air-pumping have different vehicle speed dependency allows for identifying the contribution from each mechanism in field measurements of tyre/road noise. This paper presents an analysis of controlled pass-by measurements and simulations with the tyre/road simulation model at Chalmers. Results show that air-pumping is a major contributor to tyre/road noise. The question arises which physical mechanisms are behind the air-pumping noise observed in measurements and simulations. The analysis indicates that tyre vibrations in the contact may lead to air-pumping noise. This suggestion deviates from generation mechanisms usually assumed in the air- pumping context.

Wed 17:30 Kurhaus conference room Tyre/road noise 1

Research on Selective Manipulation of Tyre/Road Noise under Driving Torque

Frank Stalter

Karlsruhe Inst. of Technology, Inst. of Vehicle System Technology

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 increases tyre/road noise of about 10 dB in the near-field. Since combustion engine noise gets eliminated, tyre noise will not be muffled anymore during acceleration but instead occurs as a disturbing, dominant acoustic source. An acoustically optimized inner drum test rig at the Karlsruhe Institute of Technology is used to investigate the torque induced tyre/road noise. The paper describes the inner drum which allows the reproducible measurement of tyre/road noise at driving and braking torque. Then, test results of special tyres are presented. A new type of tread pattern design is proposed which provides a significant decrease or increase of noise depending on the sense of rotation and of the torque applied to the tyre. Finally the effects

and the mechanisms of these noise phenomena are discussed and constructive features of tyre pattern for a selective modification of the tyre/road noise are derived.

Wed 17:50 Kurhaus conference room Tyre/road noise 1

The Influence of Modelling Parameters on the Simulation of Car Tyre Rolling Noise and Rolling Resistance

Carsten Hoever and Wolfgang Kropp
Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)

The simulation of car tyre rolling resistance and exterior rolling noise is a complex task. To achieve valid results with reasonable computational effort, a variety of different physical processes need to be modelled with the right balance between accuracy and simplification. The tyre itself is a highly complex, heterogenous and anisotropic multi-layered structure. Simulation of the tyre dynamics is only possible if the tyre structure is modelled in a simplified way. Next is the tyre/road interaction, which is also impossible to model in every detail. It is by nature non-linear and the interaction processes can cover length scales from several meters down to molecular levels. Finally, radiation calculations need to account properly for the complex geometric amplification effects appearing in the proximity of the contact region.

During the development of a suitable simulation tool, design choices have to be made for all these areas. The question is always the same: which level of detail is necessary, which processes need to be included, which parameters are critical, and which are less critical? This study will try to answer some of these question based on experiences which were recently obtained when a new tyre was implemented into an existing tyre/road simulation tool.

Wed 18:10 Kurhaus conference room Tyre/road noise 1

Predicting rolling resistance as function of road surface and tyre profile

Wolfgang Kropp and Carsten Hoever
Chalmers Univ. of Technology, Applied Acoustics, Göteborg (S)

Rolling resistance can contributing substantially to the fuel consumption of vehicles especially for truck tyres. Rolling resistance occurs due to the transformation of vibrational energy into heat during rolling. To predict rolling resistance one can utilize the fact that for stationary rolling the input power into the tyre structure through the contact corresponds to the power losses. Consequently rolling resistance can be predicted from rolling models as they are used for predicting contact forces and noise generation. In this paper a study is presented where the influence of road surface properties and tyre profile on the rolling resistance is investigated. Comparison with measurement presented in literature is made and both agreement and differences are discussed. Crucial parameters in such a prediction are contact stiffness of the tread and the damping, parameters that unfortunately are difficult to obtain with sufficient accuracy.

Session "Soundscaping: Understanding and exchanging"

Wed 8:40 Kurhaus Czerny hall Soundscaping: Understanding

Applicability and Application of Music Features in Soundscape

Ming Yang and Jian Kang
University of Sheffield, School of Architecture (UK)

In addition to the conventional parameters, e.g. weighted sound pressure level, in this research more possible parameters are explored for soundscape measurement. Based on the psychoacoustic parameters that have previously been applied in music perception, the applicability of pitch and rhythm features in soundscape research, in addition to loudness and timbre features, has been demonstrated with various types of common environmental sound, and the appropriate algorithms of the features for environmental sounds have been examined through comparison. With the parameters of these music features and corresponding algorithms, different characteristics of various environmental sounds are shown. Moreover, the parameters that contribute to the automatic identification of the type of environmental sounds have been examined. Since in the field of music, relationships between music features and humans' emotion and evaluation have been studied for decades, it is expected that these parameters would benefit further study of the soundscape evaluation, in addition to the study of characteristics of environmental sounds and their identification.

Wed 9:00 Kurhaus Czerny hall Soundscaping: Understanding

Effect of Vegetation on Sound Fields in Idealised Urban Open Spaces

Giuseppina Emma Puglisi[a], Jian Kang[b], Yuliya Smyrnova[b] and Arianna Astolfi[c]
[a] *Politecnico di Torino;* [b] *University of Sheffield, School of Architecture (UK);* [c] *Politecnico di Torino - Dipartimento Energia*

Noise pollution is a major environmental problem within the EU and during the last years vegetation was examined for its benefits in increasing health and well-being of citizens from different viewpoints, including noise control and soundscape enhancement. This work focuses on numerical simulations to investigate the effectiveness of vegetation for controlling sound fields, especially in terms of the abatement of traffic noise. Two idealised urban squares were studied, one rectangular and one octagonal. Three plant types, climbing plants (ivy), living green walls with soil substrate and plants in pots (nephrolepis exaltata), were used in this investigation, based on their measured properties in laboratory, and four aspects of the use of vegetation were evaluated: effect of the amount of vegetation, effect of changing in the scattering coefficient of vegetation, effect of vegetation in different receiver positions and effect of vegetation on different groups of receivers. Parametric studies on the determination of a line source and on the definition of sound power levels referred to traffic noise were also developed. Three simulation tools were used, namely CATT-Acoustic®, CRR (Combined Ray-tracing and Radiosity) and Odeon®.

Wed 9:20 Kurhaus Czerny hall Soundscaping: Understanding

A proposal for a systematic sound documentation

Stefano Zorzanello and Albert Mayr
SSRG onlus - FKL I - COST, Catania

Many collections of soundscape recordings started in the past, and continue to present days, developing in different directions. The experiences of ethnographic, ethnomusicological and oral history archives, that historically preceded the concept of Soundscape may be considered useful and informative from a general point of view, and for some particular purposes of sound environment surveys. But it was only during the '70 that the idea and the task of documenting the sound environment per se, beyond an ethnoanthropological perspective, were taken up seriously. However, for anyone or any organization who wants to create a soundscape archive, the basic question is: what are the criteria according to which we choose the sounds to record? Creating a soundscape archive means to start an exploration project of a space-time context, and, if this exploration wants to go beyond a merely anecdotal or aesthetic approach, it becomes necessary to establish some criteria of completeness and methodology, or at least to work towards them. We will try to define a grid for a "relative completeness" in order to cover the manifold possibilities which the concept of soundscape implies. A sonic-spatial-temporal-actantial grid, called "star model" will be proposed to this purpose.

Wed 9:40 Kurhaus Czerny hall Soundscaping: Understanding

Soundscape evaluation in urban religious spaces through social surveys and soundwalk

Inhwan Hwang, Jooyoung Hong and Jin Yong Jeon
Hanyang University, Seoul

The present study aims to explore soundscape perception due to the religious spatiality and to investigate acoustical and spatial factors affecting tranquility in urban religious places. Myeong-dong Cathedral and Bongeun Buddhist temple located in the center of Seoul were chosen as representative urban religious spaces. Important functions and soundscape elements were assessed by social surveys. In addition, soundscape in urban religious places were evaluated by soundwalk method. As results, religious activities and relaxation were considered as important functions in religious spaces. In terms of factors affecting tranquility perception in urban religious place, effects of acoustical pleasantness and eventfulness were significant. In addition, tranquility was influenced by visual pleasantness and sense of enclosure.

Wed 10:00 Kurhaus Czerny hall Soundscaping: Understanding

Soundwalk analysis of public spaces in the City of Berlin

Kay Sebastian Voigt

TU Berlin, Institut für Strömungsmechanik und Techn. Akustik

Current soundscape research often deals with the issue of better understanding of meaning of sounds, major questions like ”Which features of a sound turns it into noise?” or the appropriateness of sounds to places and vice versa. Beside acoustical measurements, scaling and rating free annotations become important soundscape tools. This paper shows the progress and benefit of gathering information based on the additional discussion following a soundwalk with young students on four different indoor and outdoor locations in the city of Berlin, and also the distinguishing rating influences between field and laboratory situations. The reflection of on-site taken notes enlightens the importance or vacuity of some sonic features and the influence of ambient moderators. Especially the personal validation of expectations of a known place and the referring to similar experienced situations or locations are focused by the participants. The combination of a soundwalk with local experts and the reflection on the on-site validations in discussions deliver a promising database for the data triangulation to identify sonic indicators describing the complexity and personal appreciation of sounds.

Wed 10:20 Kurhaus Czerny hall Soundscaping: Understanding

Silent Soundwalking: an urban pedestrian soundscape methodology

John Drever

Goldsmiths University of London, Music Dept.

The spatial-temporal auditory practice of soundwaking in its classic form involves a group focusing on listening whilst being lead in silence through an everyday environment, a model developed by the World Soundscape Project in the early 1970s, under the rubric of acoustic ecology. Today the discipline of soundwalking is being employed more and more as an active form of social science fieldwork within the meeting points between soundscape studies and noise control: a method of in-situ soundscape surveying/ data gathering. It is also at home in artistic/ music composition territory engendering themes of participation, social context, aesthetic listening, environmental sensitization, interpretation, pedagogy, awareness raising, psychogeographic musings, even catharsis. This complex is manifest when participants are invited to verbalize their experience at the summative discussion when the silence is broken. Urban soundwalking can elicit something of the human (inter)relationship with everyday soundscapes that lab work evades. Furthermore, it can acts as an ear-opener to the sonic dimension of the city, helping re- prioritize the auditory within the rich mix of urban design and the evolving paradigm of ecological urbanism. This paper reflects on the author’s soundwalking strategies and feedback from participants’ experiences undertaken over the past 10 years.

Wed 10:40 Kurhaus Czerny hall Soundscaping: Understanding

Soundscape Monitoring

Dick Botteldooren, Bert de Coensel, Damiano Oldoni and Michiel Boes
Ghent University

The soundscape: the sonic environment as perceived and understood within a context by a user is hard to measure. Still being able to approximately mimic how a human listener would interact with the sonic environment in electronic equipment would open a wide range of opportunities for the soundscape researcher and designer. Monitoring how the soundscape evolves over the day, the week, the seasons, gives insight in the acoustic ecology that is hard to grasp during a short visit or a sound walk. Therefore computational intelligence techniques were developed and implemented on sound monitoring networks that are able to mimic part of the human perception of the sonic environment. For such systems to work in diverse sound environments, some form of learning and adaptivity is essential. In addition attention and gating mechanisms must be implemented to be able to determine the sounds that a human listener would most likely notice. Holistic indicators are added to assess effects on mood and emotion that do not involve sound recognition. The soundscape monitoring system has been deployed as part of the IDEA project at several urban locations and the results are compared to human observations.

Wed 11:00 Kurhaus Czerny hall Soundscaping: Understanding

Audio-visual interaction in the context of soundscape assessment

Anna Preis and Marcin Praszkowski
Adam Mickiewicz University, Poznan (PL)

The aim of the study was to examine how visual information influences soundscape assessment. Seven different city soundscapes and landscapes were recorded. Video samples added to the audio samples were presented to the participants of the psychophysical experiment. They were asked to rate on the numerical scale the degree of comfort or discomfort while imagining to be in such environment. Actually, the participants were sitting in front of the computer screen, watching and listening to the audio and audio-video samples. The assessments of soundscape's comfort or discomfort were carried out in three different conditions: (a) audio samples only, (b) matching video and audio samples (c) nonmatching video and audio samples. The general result of this experiment showed significant difference between the investigated conditions (a) and (b). The results allow to validate the usefulness of the comfort and discomfort scales as the perceptual measures of soundscape. It occurred that in four out of seven cases participants were not able to differentiate the soundscapes regarding the comfort assessment. Therefore, the paper discusses if and when people can differentiate soundscapes and how to construct the subjective scale of soundscape evaluation.

Wed 11:20 Kurhaus Czerny hall Soundscaping: Understanding

Subjective Evaluation of Soundscape Recordings in the Psychoacoustic Experiment

Karlo Filipan, Hrvoje Domitrović and Kristian Jambrošić
University of Zagreb

Soundscape is a term that describes a paradigm that shifts its focus from the harmful sound effects on humans (noise) to the full experience of sound in which people live in. Soundscape thus refers to a variety of sound sources that create the whole sound field. For soundscape description the psychoacoustic experiments are needed, in which subjects in different ways evaluate some of its aspects. In this experiment it was required that the subjects were presented with realistic sounds and therefore binaural technique was used. This paper gives a short description of the experiment preparations – recording with binaural microphones and equalization of headphones transfer functions with minimum phase filters. Moreover, the results of the psychoacoustic experiment, conducted at the University of Zagreb, Faculty of Electrical Engineering and Computing, are given in the paper. In the experiment subjects evaluated on three semantic differential scales the subjective parameters of sounds recorded in different locations – Zagreb and Varaždin in Croatia, and in Malta. During the evaluation of soundscape parameters, subjects listened to recordings with two different levels of signal-to-noise ratio. By comparing the obtained values, the effect of noise in the recordings on the credibility of results will be determined.

Wed 11:40 Kurhaus Czerny hall Soundscaping: Understanding

Quiet zones- is 'quiet' the correct identifier?

Natalia Manrique-Ortiz and Brigitte Schulte-Fortkamp
TU Berlin, Institut für Strömungsmechanik und Techn. Akustik

A detailed soundscape analysis was performed in two parks in Berlin, with a completely different surrounding atmosphere each. In one hand, Treptower park is located in Alt-Treptow district and next to the districts Friedrichshain-Kreuzberg and Neukölln, this area is well-known for its young, multicultural and party-friendly atmosphere and in the other hand, Schlosspark is located in Charlottenburg district, an area known for its familiar and cultural atmosphere. Consequently, the collaboration with the experts in the field was of first importance. In order to analyze the soundscape of both areas, narrative interviews, soundwalks and binaural recordings were carried out. The analysis of the data shows obvious incoherence between the comments about annoyance in the narrative interviews, the soundwalks, and the sound pressure level. It might be reasonable to conclude that the SPL is a good parameter regarding a first impression of the place under study but further research is needed to classify a zone as "quiet". Moreover, it has to be investigated whether "quiet zone" is the correct identifier for an ambiance that is perceived as a "good place" to go.

Wednesday Soundscaping: Understanding (Poster)

Greenery Systems in Historical Urban Centres: Soundscape Evaluation, Design Acoustic Proposals

Ilaria Poma[a], Jian Kang[b], Yuliya Smyrnova[b] and Arianna Astolfi[c]
[a] *Politecnico di Torino;* [b] *University of Sheffield, School of Architecture (UK);* [c] *Politecnico di Torino - Dipartimento Energia*

European cities are fast growing and noise pollution is becoming a major environmental problem. On the other hand, not many green areas remain in cities. The innovative proposal of this contribute consists in the use of green surfaces on buildings façades to abate traffic noise. Vegetation as sustainable element has gathered an increased attention for potential benefit in enhanced well-being of citizens and also for the resulting soundscape, with sounds and also aural visual interaction, useful for biodiversity. The main aim is the reduction of road traffic noise in the city centre of European cities, characterized by historical constrained buildings. Two real case studies, a square and an urban courtyard, respectively placed in Italy and in England, have been evaluated. For each case study, in situ measurements and acoustic numerical simulations have been performed. To run simulations it has been chosen the software CATT-Acoustic®; then, as results check, simulations have been repeated by using CRR (Combined Ray-tracing and Radiosity) and Odeon®. Acoustic properties of vegetation had been previously analyzed in laboratory. Effectiveness of various types of vegetation and their spatial distribution on the buildings facades to reduce traffic noise have been evaluated.

PACS no. 43.28.Hr, 43.50.Cb, 43.50.Gf, 43.50.Lj, 43.55.Ev

Wednesday Soundscaping: Understanding (Poster)

Soundscape-Sensing in Social Networks

Joao Cordeiro, Alvaro Barbosa and Bruno Afonso
School of Arts / CITAR, Portuguese Cath. University, Porto

In this paper we present the design and development stages of a social network mobile application based on soundscapes. The concept falls within the soundscape research and builds upon the assumption that soundscapes represent a valuable contribution for tracing the social context of a given place in a given time. This information is regarded as an important asset on social media interaction. The application includes four modules, which are minutely described in this paper: 1) A soundscape-sensing module that performs a classification task of computational auditory scene analysis, using Zero-Crossing and MFCC audio descriptors and a k-NN algorithm; 2) A client-server database module responsible for storing and distribute the resulting information among the peers of user's social network. 3) A visualization module that shows clusters of peers based on their current acoustic similarities; 4) A web-based history module containing the evolution of users personal soundscapes. Preliminary results on the classification task indicate that simple classification (distinguishing between speech, music and environmental sounds) can be accomplished on

a smartphone (iPhone). Energy resource tests show a considerable increase on battery usage, which may refrain users from use it continuously. Further tests will be accomplished meanwhile.

Wednesday Soundscaping: Understanding (Poster)

Core Affect, Appraisal, and Motivation

Tjeerd Andringa
University of Groningen

While annoying sounds force us to attend our sonic environment and distract, pleasant sound allow us to engage in self-selected activities. This entails that the sounds that comprise our sonic environment motivate us to behave in certain ways. This paper analyses the relation between core affect, appraisal of the sonic environment, and motivation. It concludes that it make sense to analyze the sounds that comprise the sonic environment in terms of pleasant fore- and background sounds and unpleasant fore and background sounds.

Wednesday Soundscaping: Understanding (Poster)

Sanitary Soundscapes: the noise effects from ultra-rapid 'ecological' hand dryers on vulnerable subgroups in publicly accessible toilets

John Drever
Goldsmiths University of London, Music Dept.

A review of the issues arising from a preliminary study of the noise effects of ultra-rapid "ecological" hand dryers in publicly accessible toilets. They are very popular due to impressive data on efficiency, effectiveness, hygiene and speed, the corollary is an increase in noise levels in this socially sensitive environment. The study comprised of a sound power test, followed up by in situ sound pressure tests in a range of different sized WCs. The most extreme example showed for one dryer in situ the equivalent Leq of 19 dryers in a free field environment. From communication on discussion lists and interviews it appears that the noise effects are impacting on a wide range of vulnerable subgroups: breast-feeding mothers, infants and children, dementia sufferers, the visually impaired, hearing aid users and most seriously the discomfort on those with hyperacusis - a condition that is common for those on the autistic spectrum. This study functions as a microcosm for soundscape issues in the urban environment resulting in social exclusion for vulnerable subgroups. To communicate these issues to designers, policy makers and the pubic at large the project was followed up by the devising and presenting a number of sound art works.

Session "Soundscaping: Collecting and documenting"

Wed 15:30 Kurhaus Czerny hall Soundscaping: Collecting

Comparison of Binaural Measurement Systems for Indoor Soundscaping Study

Papatya Nur Dökmeci and Jian Kang
University of Sheffield, School of Architecture (UK)

This study focuses on the comparison of three binaural and one monaural recording equipment set-ups for the indoor soundscape study. Eleven different sounds, generated through human activities from indoor acoustic environments were reproduced for the anechoic chamber recordings. In addition, three standard sounds, including pink noise, white noise, and sine sweep signals, were also used for further technical comparisons. Objective acoustic and psychoacoustic parameters including sound pressure level (SPL), loudness, roughness, sharpness, tonality, and fluctuation and their frequency distributions were evaluated through intra-group comparisons. The results show that different equipment sets may give varying results depending on the different parameters. Internal noise levels of the equipment sets were found to be the main problem affecting the results and overall quality. It is concluded that although binaural recording systems are commonly used for studies, the technical part of recording and analysis parts are crucial for final outcome. Future studies include comparative listening tests and correlations between subjective and objective results, which are being carried out.

Wed 15:50 Kurhaus Czerny hall Soundscaping: Collecting

What "in" the acoustic signal accounts for Soundscape?

Danièle Dubois[a], Maria Neissen[b] and Ana Maria Reyes[c]
[a] *CNRS, D'Alembert LAM & INCAS 3, Paris;* [b] *INCAS 3 (now at AGT International);* [c] *D'Alembert / LAM, Paris*

Research on soundscape has stated that its description can not be reduced to acoustic parameters usually recorded, but has to account for "the way it is perceived by individuals or societies". This is achieved by pluridisciplinary cooperation of different (scientific) knowledge. A difficult question remains: how can these different domains be connected: how do physical properties contribute to soundscape? How can cognitive properties of soundscape be account for in the physical description of the signal: global ones such as "peaceful", "busy", but also analytical ones, such as identification of source location in space, as reported (by subjects) in statements such as "military plane that flies at low altitude" (objective description) or "plane passing above me" (subject centered description). One issue is to rely on a clear distinction and identification of the properties of different types of knowledge: knowledge in acoustics (for the physical world) that is related to the development of technologies of recording and signal processing in artificial systems, and knowledge in psychology (for cognitive representations in human sensory processing). Moreover, the relation between these types of knowledge relies on an integrated theory of knowledgeS as

meaning construction that we can get at through a linguistic analysis of discourses.

Wed 16:10 Kurhaus Czerny hall Soundscaping: Collecting

Soundscape Approach: A Preliminary Exploration of the Urban Study Sites

Pablo Kogan[a], Federico Miyara[b], Jorge P. Arenas[c] and Claudia Arias[a]

[a] *CINTRA, FRC, Universidad Tecnológica Nacional, Argentina;* [b] *Lab. de Acústica y Electroacústica, Univ. Nacional de Rosario, Argentina;* [c] *Instituto de Acústica, Universidad Austral de Chile*

The soundscape approach is currently moving the focus of Environmental Acoustics towards a more human centered paradigm. Beyond the clear benefits of the soundscape approach's results, underlies a complex and expensive task to collect suitable field data. Moreover, every location in a city has its own dynamics and this should be weighed. In this direction, preliminary area identification represents a strategic action in order to optimize the soundscape data acquisition. At the same time this would helps for adjusting some methodologies.

This work corresponds to the first stage of a PhD project involving the soundscape analysis of a certain area of the city of Córdoba, Argentina. The early process of zone exploration is presented, which includes descriptions from frequent visitors, acoustic measurements, audiovisual records, information regarding land use and matching with previous experiences.

Wednesday Soundscaping: Collecting (Poster)

A machine learning based procedure for urban soundscapes classification

Diego P. Ruiz and Antonio J. Torija

Acoustic Lab., Applied Physics Dep., University of Granada (E)

Within the framework of soundscape management in urban environments, the competent authorities have to be provided with tools that allow the successful accomplishment of such task. Moreover, a subjective and acoustical categorization of a soundscape is the first step to evaluate it, providing a basis for designing or adapting it to match people's expectations as well. For these reasons, in this work an automatic tool to classify urban soundscapes is put forth. The development of this tool is based on the knowledge acquired in a previous work of the research group, where a methodology for the categorization and differentiation of urban soundscapes using acoustical descriptors and semantic-differential attributes was introduced. In that previous work the main relationships between a number of selected acoustical and perceptual variables was analyzed. In this communication, a classification model is proposed to be constructed using two different machine learning techniques: (i) Multilayer Perceptron (MLP) and Support Vector Machines (SVM) with the aim of obtaining from this tool an automatic classification of urban soundscapes based on the previously developed underlying acoustical and perceptual criteria.

Wednesday Soundscaping: Collecting (Poster)

Costruction of a Possible Soundmap:The Experience of the Province of Turin

Daniele Grasso[a], Danilo Corgnati[a], Jacopo Fogola[a], Stefano Zorzanello[b], Cecilia Alemagna[c] and Laura De Caro[d]

[a] *Arpa Piemonte, Torino;* [b] *SSRG onlus - FKL I - COST, Catania;* [c] *SSRG onlus, Catania;* [d] *SSRG onlus, Torino*

The Paesaggi Sonori project, carried out by the Province of Turin in collaboration with ARPA and SSRG onlus, aims to promote and develop, on both a local and web-community level, the culture and practice of listening. The project's basic purpose is to raise people's acoustic awareness and to introduce citizens, schools and organizations to the concepts of the soundscape and of acoustic ecology. Over 2.000 minutes of recordings were collected in the Province area and were made with the most common field recordings techniques: typical stereo, binaural, parabolic, contact microphones, hydrophones. The audio material was then reduced to 90 short examples of "sound situations", for a total of 200 minutes. Each sample was geo-referenced on a digital map and catalogued according to twelve previously defined categories. This set of selected sounds aims to provide an answer to questions concerning what sounds to communicate and how to do so, and whether they could constitute a possible point of access to the understanding of a territory, a culture or a social system from an acoustical perspective. Moreover, the soundmap on the website can be implemented by the web user, encouraging participation and providing opportunities for discussion.

Session "Soundscaping: Harmonising"

Wed 16:30 Kurhaus Czerny hall Soundscaping: Harmonising

Linking Context and Health with Soundscape Experiences in COST Action TD0804 - Soundscape of European Cities and Landscapes

Brigitte Schulte-Fortkamp[a] and Peter Lercher[b]

[a] *TU Berlin, Institut für Strömungsmechanik und Techn. Akustik;* [b] *Division of Social Medicine, Medical University Innsbruck*

The aims of Working Group 3 of COST Action TD0804 - Soundscape on European Cities and Landscapes - are related to 3 major tasks: 1. Establishing valid and reliable descriptors of effect in soundscape research: to enhance understanding of positive (restoration, coping) and adverse (reduction of Quality of Life and well-being) impacts on both subjective and objective levels of observation. 2. Finding a set of single or integrated context descriptors which allow comparison of the results of soundscape studies across study types and allow linkage to related research areas (restoration research, socio-ecologic Quality of Life, annoyance and perception related research). 3. Selection and recommendation of appropriate methodologies for the integrative analysis and presentation of data generated in the various types of soundscape studies. These tasks are based on strong

interactions with the other Working Groups of COST Action TD0804. Specifically, WG-3 activities are closely linked to the acoustical assessment of soundscapes (WG-1), the existing soundscape study data base (WG-2) and the running efforts towards standardization and implementation (WG-4) and dissemination (WG-5). The framework and selected examples from the outcome and conclusions of the work hitherto done in several international workshops with invited experts will be presented.

Wed 16:50 Kurhaus Czerny hall Soundscaping: Harmonising

Fruitful Interdisciplinarity for Soundscape Research and Design

Frans Mossberg

Sound Environment Center, Lund University (S)

The Sound Environment Center at Lund university has since 2005 hosted interdisciplinary research of 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 health studies on noise effects to hearing and voice disorders, music and cognition the center covers and tries to harmonize a multitude facets of sound and noise. The work of the center is to a growing extent connecting to both national and international research networks and partners.

Going from research to practice and change, in joint collaboration with acoustics, logopedics and cognitive science the center is initiating research on how memory, cognition and reception are affected by light and acoustics in a multi sensory input, focussing on communication of heavy intellectual material in academic education with an aim of providing an empirical foundation and incentives for development of the university campus and its indoor soundscape.

The preliminary outcome of interdisciplinary design has been positive and fruitful leading to deepened network collaborations and continuously new research projects.

Wed 17:10 Kurhaus Czerny hall Soundscaping: Harmonising

Noise exposure and health effects in children: Results from a contextual soundscape perspective

Peter Lercher[a], Alex Eisenmann[a], Luc Dekoninck[b], Dick Botteldooren[c], Ulrich Widmann[d] and Gary W. Evans[e]

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Empirical research on noise impacts has focused mainly on direct effects. However, human reactions to physical environmental conditions occur within a social and ecological context that shapes their responses. In such a contextualized perspective the potential direct effects of noise can be moderated by individual, social, housing and neighbourhood factors in both

directions (attenuation and aggravation). When these moderating factors are neglected environmental health impact assessments may be wrong or miss factors which are possible targets for prevention. This paper presents analyses from two studies on children in two alpine valleys exposed to transportation noise from a major transit traffic route (road and rail noise). In one study we found children lacking a quiet room did exhibit higher annoyance, lower sleep quality and reading scores and their short-term memory and their well-being was imaired. In the second study, children living in multi-dwelling homes did exhibit higher blood pressure readings. However, children who perceived their environment as quiet (adjusted for the noise level) did show lower blood pressure readings - even, when other risk factors were present. These results show that health effects research and environmental noise assessment and management would benefit from the inclusion of a ecologically oriented soundscape approach.

Wed 17:30 Kurhaus Czerny hall Soundscaping: Harmonising

Characterization of quiet areas with a new indicator of contrast

Pauline Delaitre, Catherine Lavandier and Damien Masson
Université de Cergy Pontoise, Laboratoire MRTE

Since 2002, various indicators have been proposed by scholars or authorities to define quiet areas. Among these indicators, the acoustic contrast has been proposed to characterize sudden changes of noise level. But what is a contrast for human perception? Six urban acoustic environments have been recorded through different walks in Paris. These recordings have been evaluated by thirty participants in laboratory context. They have been asked to declare the moment when they notice a change in the sound environment and the moment when they are sure that this acoustic environment has really changed. They have been also asked to evaluate the degree of the perceived contrast with a five category scale. The mean moments correspond to different precise locations on a map. This paper shows that it is possible to predict the position of these locations with a contrast indicator calculated from a classical noise mapping with edge detection method. The degree of contrast can be characterized with the chosen threshold in the contrast calculation.

Wed 17:50 Kurhaus Czerny hall Soundscaping: Harmonising

Soundscape Quality

Östen Axelsson
Stockholm University, Department of Psychology

With the formation of the working group ISO/TC 43/SC 1/WG 54 ”Perceptual Assessment of Soundscape Quality” of the International Organization for Standardization (ISO) in 2008, a debate has arisen on what soundscape quality should mean. The Swedish Soundscape-Quality Protocol defines soundscape quality operationally as a single, one-dimensional Good-Bad scale. Critics argue that this is unsatisfactory, because there is no one ideal soundscape. Rather, they argue that soundscape quality is relative to a place and the outcomes that the soundscape of that place facilitates or

enables (e.g., conversation without interruption, nature appreciation or psychological restoration). In 2013, a questionnaire study will be conducted in Sheffield, UK, including about 900 users/visitors in 45 urban and peri-urban areas, divided on 9 different kinds (e.g., pedestrian areas, residential areas, parks, and plazas). The purpose is to define soundscape quality and to further develop measurement methods in this field. The results are expected to contribute to methods for 'green labelling' of soundscapes, and to support the development of the International Standard ISO 12913 on soundscape. The present paper discusses research plans and initial results.

Wed 18:10 Kurhaus Czerny hall Soundscaping: Harmonising

Realism and ecological validity of sound quality experiments on household appliances

Jochen Steffens
University of Applied Sciences Düsseldorf

Test environments in sound quality research often significantly differ from human's everyday world. Hence the claim for ecological validity of such experiments is reasonable, but too vague in its bare formulation. The estimation of ecological validity requires theoretical knowledge about the meaning and the totality of factors influencing everyday listening and their interaction. Therefore the influence of "reality factors" on the sound evaluation of household appliances was investigated within the framework of nine experiments. These tests were performed in four different settings with varied reality degrees. The psychological realism and the perceived face validity of the tests were examined by means of interviews. The results reveal, on the one hand, that stimuli are perceived as more pleasant in everyday-like environments. The analysis of the relative judgments shows, on the other hand, that the influence of the experimental realism is moderated by a number of factors. These are the saliency and meaning of the sounds, differences between the assessed devices, and personality traits. The correlation and regression analysis confirms that the perceived sound character is widely independent from experimental realism. However, there is great empirical evidence, that valid assessments of sound quality require the reconstruction of everyday attention and action processes.

Session "Environmental noise: END and legislation"

Wed 8:40 Kurhaus Lentner hall Environmental noise: END

The assessment of environmental noise impact in the European Union.

Marco Paviotti
European Commission, Brussels

The overall assessment of environmental noise in the EU has been so far difficult because of a set of issues that, despite the promising strict requirements of the Environmental Noise Directive, has not been thoroughly effective in estimating correctly the exposure of European citizens to noise. The set of issues encountered are: the incomplete performing of the required noise mapping within the given deadlines; the different format of data

reported at EU level; the different calculation methods used; the different settings concerning the selection of e.g.: roads to be mapped and the distribution of the population within the buildings; the missing of a specific set of dose-response curves. The paper will briefly explain the different elements and present the actions that the EU is taking to resolve these technical issues, like the development of the CNOSSOS-EU. A good estimation of the exposure of EU citizens is a pre-requisite to support a reasonable policy on environmental noise reduction, and evaluate the effect of the policy at European level.

Wed 9:00 Kurhaus Lentner hall Environmental noise: END

Ongoing activities of the European Union institutions to tackle environmental noise.

Marco Paviotti
European Commission, Brussels

The environmental noise in the European Union is not showing any clear sign of reduction, notwithstanding that in the EU there is an increasing concern on the health impact on the European citizens. The European Commission is in the process of revising the legislation related to environmental noise. At present, two new legislations are proposed by the European Commission on noise from road vehicles and on noise operating restrictions at airports. Moreover, initiatives related to noise limits for railway vehicles are in place and being revised. On the top of all, the Environmental Noise Directive, which is an overarching directive aimed at a common approach towards environmental noise, is in the process of review. This article is presenting the general framework of the actions taken by the European Commission and the European Environmental Agency and the European Railway Agency on the issue of environmental noise. Also, it presents possible way forward of the European policy on environmental noise.

Wed 9:20 Kurhaus Lentner hall Environmental noise: END

Noise Exposure in EU Cities: a Challenging Comparison

Gaetano Licitra[a] and Elena Ascari[b]
[a] *CNR-IPCF, Pisa;* [b] *CNR IDASC, Roma*

The Noise Observation and Information Service for Europe maintained by the European Environment Agency (EEA) on behalf of the European Commission contains all data delivered in accordance with European Directive 2002/49/EC by members states of the first round of implementation of the END. This large database offers the opportunity of a comparison between the environmental noise pollution in agglomerations in EU, that should take into account the difference in estimating people exposure in each country/agglomeration (due to the national methods both for source database, noise level assignment, etc). Nevertheless, this paper intends to analyse data grouping for single Member State and between them. Further analysis will include noise exposure distribution shapes. The research aim is to find useful indicators to compare the agglomerations results; to evaluate the global

pollution of the cities. GDEN indicator will be evaluated and applied as estimator of highly annoyed people. Noise exposure as function of population amount, population density, city extent will be considered too.

Wed 9:40 Kurhaus Lentner hall Environmental noise: END

Proposals of the ALD for the revision of the Environmental Noise Directive END

Michael Jäcker-Cüppers
Arbeitsring Lärm der DEGA (ALD)

The END of 2002 has successfully stimulated a harmonized approach to the assessment and management of environmental noise in Europe. The strategic noise maps and the information/consultation of the public have contributed to an increased awareness of the noise problems throughout Europe. Nevertheless, the reduction of impairments by noise has been limited due to some deficits of the END and its implementation in the Member States. Above all there are no common and binding targets for the noise reduction; for the implementation of the noise action plans no deadlines are set. The ALD (Working Party Noise Abatement of the German Acoustical Society) will present some proposals to make the END more efficient. Among others it is suggested to make the END to a powerful framework directive for all environmental noise problems.

Wed 10:00 Kurhaus Lentner hall Environmental noise: END

Evaluating effectiveness of noise policy instruments: reflections on practice in the Netherlands

Miriam Weber
DCMR EPA, Schiedam (NL)

Noise policy is characterised by complexity, in cause and effect mechanisms and in actors. As a consequence a mix of noise policy instruments has been in place in the Netherlands since many decades. Goal attainment though has been limited, which is explained by the increase of mobility, further densification of residential areas and cities and omissions in the noise act. The original policy aims of (i) no noise exposure levels above 70 dB and (ii) isolation for all dwellings with noise exposure levels above 55 dB before 2010, have not been achieved. Even, these policy goals have been dropped; current policy goals target a noise source (vehicle) reduction of 2 dB and insulation for dwellings along highways with noise exposures above 65 dB. In the summer of 2012 the Dutch parliament accepted new noise legislation regarding noise emission ceilings along highways and railways. And today a revision of noise legislation regarding major roads, municipal roads, industrial areas and spatial planning is developed. Will this legal instrument improve effectiveness of the Dutch noise policy instrument mix? In this paper the author will reflect on her recent PhD research on effectiveness evaluation and the empirical case of Dutch noise policy.

Wed 10:20 Kurhaus Lentner hall Environmental noise: END

Evaluation of EU regulations on aircraft operating restrictions

Thomas Myck and Jens Ortscheid
Umweltbundesamt, Dessau-Roßlau

Many residents of European airports are exposed to aircraft noise levels which may lead to adverse effects on health in particular with regard to the cardio-vascular system and considerably impairs quality of life. In order to improve the aircraft noise situation all possible noise abatement measures must be taken. These measures include aircraft operating restrictions which exit at numerous airports. Moreover, there is a proposal of the European Commission for a regulation on noise-related aircraft operating restrictions. It has the aim to create a uniform framework on the establishment of rules and procedures for noise-related operating restrictions at airports in the European Union. This regulation should repeal the current Directive 2002/30/EC in the near future. It is evaluated concerning its effectiveness to mitigate aircraft noise especially at night because undisturbed and sufficient long sleep is a biological necessity and therefore of great importance. On the basis of this analysis further proposals to improve the protection of the population from aircraft noise are presented.

Wednesday Environmental noise: END (Poster)

The Regulation of Environmetal Noise in the Principality of Liechtenstein

Manfred Bischof
Amt für Umweltschutz, Liechtenstein

The Office of Environmental Protection is responsible for all noise-related topics in the Principality of Liechtenstein. Both, the procedure for the determination of noise and the respective noise limits are regulated in the Ordinance on Environmental Noise (Lärmschutzverordnung). These noise limits are based on the experiences made in Switzerland and aim at protecting people against harmful and disturbing noise.

The Office of Environmental Protection is also responsible for the preparation of strategic noise maps and action plans.

Starting point for the preparation of the national strategic noise maps was a detailed traffic model covering the entire territory of the Principality of Liechtenstein. In combination with a respective terrain model, the noise levels were calculated for all relevant buildings.

The results are now available on the website of the Office of Environmental Protection. The next step will be to analyze and define the necessary noise reduction measures. The remediation of roads and railways has to be finished in accordance to the Ordinance on Environmental Noise until 2023.

Session "Environmental noise: Noise from sources"

Wed 10:40 Kurhaus Lentner hall Environmental noise: Sources

The "Movida" in Milan: a Year of Noise Monitoring

Mario Gregorio Piuri, Stefano Ferrari, Michele Gravelloni, Davide Pavesi, Maria Rosaria Barone, Stefano Zerbo, Federico Antognazza, Adriano Cati and Franco Olivieri
ARPA Lombardia

The so-called "movida" has become a serious noise trouble for the city of Milan. Concerning this, the usual control and prevention tools, provided by the Italian acoustic laws in force, are sometimes lacking. For instance, the required identification of the specific disturbing noise may be very hard, if there are too close different noise sources. For this reason, new striking strategies are needed to cope with the problem, i.e. planning alternative environmental monitoring programmes.
The municipality of Milan and the local department of ARPA Lombardia have undersigned an official agreement, in order to get a reliable and up-to-date acoustic instrumental database. Consequently, ARPA Lombardia has been charged with planning and carrying out a yearly monitoring project about the soundscape of some of the most "movida"-oriented districts of Milan.
The project engaged ARPA engineers from september 2011 until september 2012. This paper shows the outcomes of the research, highlighting the seasonal trends of the environmental noise in different setting conditions: i.e. pedestrian precincts, busy streets, gazebos, etc. Data analysis has provided quantitative tools to the city council, to be effectively used in decisional processes: some regulatory actions have already been adopted, and their effects on the city soundscape have been assessed.

Wed 11:00 Kurhaus Lentner hall Environmental noise: Sources

Open Air Cinema Arrangement with Minimized Noise Emission

Axel Roy and Hartmut Zschaler
Akustik Bureau Dresden Ingenieurgesellschaft mbH

The rising number of open air performances, especially in the summer months, causes more and more conflicts with the residents' legitimate demand for rest and silence. This applies especially for venues in city centres because there it is difficult to keep enough distance between venues and habitations as the significant places of noise impact. Particularly for open air cinema performances, it is rarely possible to avoid the night hours due to lighting conditions. That's why one has to deal with the lower sound level limit values during the night. Using the example of an open air cinema venue, it will be demonstrated how different sound reinforcement concepts have an effect on the rated sound level to be expected at the place of impact. In this context, computer simulated level distribution plots for both central and distributed sound reinforcement systems will be compared. The distributed sound reinforcement concept which was finally chosen will be

explained and its results will be presented. They show that appreciable effort and careful design may lead to a cinema sound system that combines high acoustical quality with low sound level emission.

Wed 11:20 Kurhaus Lentner hall Environmental noise: Sources

Manual for the assessment of noise in Austrian farms

Michael Kropsch[a] and Christoph Lechner[b]

[a] *AREC Raumberg-Gumpenstein;* [b] *Amt der Tiroler Landesregierung*

In former times farms have hardly been noticed as potential sources of sound and noise. However, in the last few years this situation has changed significantly. To support Austrian farmers in this special field the Agricultural Research and Education Centre Raumberg-Gumpenstein (AREC) developed an agricultural sound assessment guide. The Manual of Sound Technology in Agriculture focuses on the assessment of noise on existing farms and the provision of data for the planning of new farm buildings particularly in connection with livestock husbandry. All important sources of noise, agricultural traffic, rural technical equipment and vocalisation of animals, were included. Especially noise emissions originating from livestock had to be considered. On the one hand animals are sources of emissions which follow biological rhythms, on the other hand the motivation to produce sound is strongly influenced by external factors, e.g. by the management. The knowledge about these facts is at least necessary to assess animal sound emissions and was included in the manual. The manual was developed in cooperation with the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management and will be published at the beginning of 2013 via the homepage of the Austrian Federal Environment Agency.

Wed 11:40 Kurhaus Lentner hall Environmental noise: Sources

Comparative assessment of aircraft noise due to future runway layouts for the Airport of Florence

Cristina Giannardi and Tamara Verdolini

ARPAT - AVC - Settore Agenti Fisici

The airport of Florence is a city airport located in an urbanised area. In the surroundings of the airport are densely populated municipalities, and people living here has progressively become more sensitive to airport noise issues, along with the increase in flights number and plane size in last 10 years. Today, population exposed to airport noise dwells mainly in the city of Florence.

The requirement to adapt the runway to reach new destinations has recently brought out. Consequently Italian Civil Aviation Authority (ENAC) and Florence airport manager proposed two new runway locations.

Italian legislation foresees to evaluate the environmental effects of the proposed locations. In this context the noise contour (in term of Lden and italian noise indicators) of the supposed runways have been evaluated by the software INM and the effect on population have been estimated by GIS tools, applying dose response relationships between aircraft noise and annoyance.

A noise model have been implemented for both scenarios supposed and for the actual runway location assuming a new fleet mix. The software INM allowed to compare different scenarios, evaluating the amount of population exposed and annoyed by aircraft noise.

Wed 15:30 Kurhaus Lentner hall Environmental noise: Sources

Permanent Noise & Vibration monitoring as a valuable tool to the construction industry

Daniel Vaucher De La Croix and Christian Freneat
ACOEM, Limonest (F)

The construction of large infrastructures in dense urban areas comes along with a number of environmental challenges. Roads, railways, subways and large building constructions necessarily have a significant impact on residents as well as surrounding buildings. This is especially true when it comes to consider large projects duration which generally counts in months and even years.

In this context, noise and vibration induced by the construction activities are major sources of annoyance to the community and may also induce potential damages to the immediate surroundings. Both issues have thus to be properly monitored in order to reduce adverse effects on residents, help mitigating risks and prevent potential interruption of the construction site's activity which would increase the overall project cost.

The proposed paper will focus on how available communication technologies as an essential added value to noise and vibrations measurements. Operational conditions and project managers' requirements for system deployment will be reviewed. Then benefits to the different parties will be highlighted on the basis of recent practical situations where adequate measures could be taken in the right timing and kept the project running while minimizing its noise & vibration environmental impact.

Wed 15:50 Kurhaus Lentner hall Environmental noise: Sources

Sound power level of speaking people

Marco Caniato[a], Federica Bettarello[a] and Michele Taffarel[b]
[a] *Studio Associato Acusticamente, Conegliano;* [b] *Studio associato M & T, Pieve di Soligo*

In restaurants and cafés many sound sources are present: music, refrigerant and cooling equipment and people speaking. The smoking prohibition law did move out people creating a lot of aggregation areas outdoor, both in summer and in winter time. As a matter of facts many cafés open on the outer part a stallage in order to provide beverages to outside costumers. In this way, the "people speaking" source became a common problem to deal with and solve. In order to characterize this particular sound source in terms of sound power level of a typical stallage situation full of speaking people, sound pressure power measurements according to ISO 3446 standard were carried out. The results confirm the first investigation achievements provided by Sepulcri et all with a non-direct method.

Wed 16:10 Kurhaus Lentner hall Environmental noise: Sources

AHAAH - A Comprehensive Concept to Assess Auditory Hazard Risk

Dietrich Kühner[a] and Karl-Wilhelm Hirsch[b]
[a] *debakom, Odenthal;* [b] *Cervus Consult, Willich*

The EU-directive EN 71-1 provides rules to protect children while playing with toys that are designed to make sounds. These rules consider both the metabolic exhaustion of the auditory system due to a long term exposition as well as hazards caused by high level impulse sounds. The current draft of EN 71-1 uses the AHAAH to justify 125 dB CPeak levels at 50 cm for short impulses of 0.5 ms or less which lead close to the ear to 140 dB and more. The AHAAH (Auditory Hazard Assessment Algorithm for Humans) relies on the prediction of the displacement of the basilar membrane, as a measure for instantaneous hazards for the auditory system. AHAAH is based on the validated ear model developed by Price et all used successfully since more than a decade. Paulsen [Lärmbekämpfung 2012] measured several high impulse sounds of daily life that do exceed the 140 dB limit and concludes that exceeding this limit does not lead directly to auditory hazards. The paper presents results of the assessment of sound produced by percussion caps using the AHAAH model and discusses these findings based on the otoacoustic emissions obtained shortly after exposition to such sounds.

Wed 16:30 Kurhaus Lentner hall Environmental noise: Sources

From Noise Monitoring to Noise management

Andrea Cerniglia and Markus Petz
ACCON Italia Srl.

Achieving appropriate noise management can be difficoult without a complete description of acoustic climate. In many situations a simple short measurement is not enough to describe a complex acoustic environment; on the other hand long measurements campaigns needs big amount of man power to process all data. This paper will describe how live monitoring can helps to obtain all the needed informations for a serious Noise Management, using limited resources, and with a very short feedback to improove the total system reliability.

Wed 16:50 Kurhaus Lentner hall Environmental noise: Sources

Acoustic and Energetic Efficiency of Air Transport Systems

Peter Brandstätt and Philip Leistner
Fraunhofer-Institut für Bauphysik, Stuttgart

Noise and acoustic environment conditions affect health, well-being and performance inside and outside of work and living spaces. While energy-saving lamps and energy-efficient air conditioning systems are obvious, considerable reserves still exist in the sound-absorbing components. They are obstacles to the air transport and the effort to overcome this resistance has to be provided in terms of energy by increased power of fans. Thus, in its optimized configuration lies potential for energy savings while improving the acoustic quality.

The article analyzes the acoustic boundary conditions taking into account the effects of energetic consequences in the use of silencers. Solutions for their design will be presented and demonstrated with examples of achievable energy savings. As a kind of a flagship project serves a painting facility with large dimensions: Only through the exchange of conventional by innovative silencers in a large industrial air conditioning system it was possible to reduce both noise pollution and to achieve an annual energy savings worth more than 500 000 Euro. In this way, innovative silencers link high, appropriate attenuation effects to low flow resistance, expressed by the pressure loss.

Wed 17:10 Kurhaus Lentner hall Environmental noise: Sources

Lawsuits for Neighbour Noise: an Attempt of Comparing Judicial Noise Standards in European Countries

Giorgio Campolongo
acoustical consultant, Milano

Neighbour noise (can be family, trade or productive activity) and noise pollution of road-rail-air traffic annoy millions of people in both cases. But people severely annoyed by the neighbour are more (perhaps much more) than those annoyed by road-rail-air. Severely annoyed are people who cannot bear it, they cannot live any longer in their own house and are desperate to the critical point they apply to the court. The consultants with experience in lawsuits of neighbour noise are only a few. They are far less than those dealing with noise pollution of road-rail-air traffic. Also the number of papers on neighbourhood noise annoyance is far less than the tons of papers on noise pollution of road-rail-air traffic. To assess noise intrusion in dwellings as allowed by law, Italian judges endorse the limit of 3 dB over L95(Fast) background noise. The rule is very clear and simple. A comparison has been attempted of judicial noise standards in various European countries (France, Belgium, Switzerland, England, Germany and Italy). The aim is to excite the discussion on this subject that deserves a better attention and that ought to be hold at European level.

Wed 17:30 Kurhaus Lentner hall Environmental noise: Sources

Noise Propagation and Meteorology?

Dieter Knauß and Carl-Christian Hantschk
Müller-BBM GmbH

It is common knowledge that noise levels depend on meteorological conditions, e.g. on wind speed, wind direction and the vertical temperature profile. Thus, in standards for noise measurement downwind conditions (DW) - favourable noise propagation conditions - are recommended to determine noise levels. Downwind conditions are usually defined as wind directions from source to receiver at a wind speed of larger than 1 m/s. In terrains with buildings and larger trees the wind will depend on the exact measurement position, making it difficult to find the correct DW conditions. In the proposed paper results from noise and meteorological measurements at different distances from an industrial site will be presented and the correlation between the measured noise levels and the meteorological conditions will be investigated. The significance of the results will be demonstrated for broadband noise levels as well as for noise with significant tonal components.

Wed 17:50 Kurhaus Lentner hall Environmental noise: Sources

Estimation of the Directivity Pattern of Muzzle Blasts

Karl-Wilhelm Hirsch[a] and Werner Bertels[b]
[a] *Cervus Consult, Willich;* [b] *Wehrtechn. Dienststelle für Waffen und Munition, Meppen*

The acoustic source model is a crucial feature for any sound prediction scheme. For explosion in air the so-called Weber model is a simple but reliable approach to define the source data in terms of an analytical complex Fourier spectrum for such blasts. The Weber model only depends on the so-called Weber radius which is strongly correlated to the energy the explosives provide [ISO EN 17201]. Hence, the source strength can be given for any sound prediction scheme based on well-known source data. Muzzle blasts are very similar to explosions in air. However, these blasts show a strong directionality. Nevertheless, the Weber model reproduces the shape of the signal in good agreement to measured data if an angle dependent Weber radius is assumed. The paper proposes a cosine rule depending on two model parameters to estimate the directivity pattern of the Weber radius for the muzzle blast. The parameters can be adapted to measurement results to represent a broad class of guns. The calculation of the parameters in terms of characteristic data of barrel dimensions and eventually propellant charge remains a future challenge. Guidance is provided on how to evaluate the Weber radius from a given one third octave spectrum.

Wed 18:10 Kurhaus Lentner hall Environmental noise: Sources

The EU research effort towards the control of noise emissions from ships: the SILENV Project (7FP)

Aglaia Badino, Davide Borelli, Tomaso Gaggero, Enrico Rizzuto and Corrado Schenone

Università degli Studi di Genova

The rising concern about the environmental impact of ship noise recently pushed national and international bodies to face the problem. Within the 7th Framework Programme of the EU the SILENV Project has been launched (Ship Innovative soLutions to rEduce Noise and Vibrations). The project acts with an holistic approach on three main areas: Noise & Vibration on board, Airborne Radiated Noise, Underwater Radiated Noise. The activity is subdivided into 5 work packages. In WP1 the present normative framework have been analysed. In WP2 an experimental campaign has been carried out together with the collection of already available data, resulting in a database containing noise and vibrations measurements of 172 different ships. In WP3 design guidelines for the control of noise have been provided. In WP4 models for the ship noise radiations both in air (inside and outside the ship) and in water have been developed and used to assess the efficiency of the previous proposed solutions. In WP5, new, pre-normative requirements (the so-called 'Green Label') have been defined for the three main areas above mentioned. The paper, after a brief overview of the project, will focus on the main results achieved, represented by the formulation of the 'Green Label' requirements.

Wednesday Environmental noise: Sources (Poster)

Noise Impact of Ships Moored in Venice Harbour

Francesca Remigi and Antonino Di Bella

University of Padova, Department of Industrial Engineering

The aim of this work is to perform a deep analysis of the noise impact generated by ferries and cruise ships moored in Venice harbour. The study area includes the port area, where the noise sources of interest are located, and neighbouring residential areas. The analyzed ships come in a variety of types and sizes. The size of a ship is measured by its weight carrying capacity (DWT), that includes the weight of the cargo and anything else on the ship, and by Gross Tons (GT) that is the volume of the enclosed spaces of the ship. In order to point out how the presence of cruise ships and ferries may affect on LAeq values, many variables are considered, such as number of ship for a day, their tonnage or their location in the port.

Wednesday Environmental noise: Sources (Poster)

Statistical analysis of a combination of objective and subjective data concerning environmental noise using Factor Analysis and Multinomial Logistic Regression

Margret Engel, Emerson Hochsteiner De Vasconcelos Segundo and Paulo Henrique Trombetta Zannin
Federal University of Paraná

The aim of this study was to show the efficiency of the use of Factor Analysis and Multinomial Logistic Regression to account for a combination of objective data (noise measurement results) and subjective data (interview results of noise perception in an urban setting) in a noise pollution research, conducted in the city of Curitiba, in the south Brazil. In this study the noise was monitored at 23 points in tree parallel streets along a distance of 5 km and 397 interviews were conducted with the dwellers around these points. The questionnaire for conducting the interviews was made up of 21 questions (variables). In order to reduce these variables, it was necessary to extract the main factors (7 factors) which later on were added to the objective part (noise measurement data). After that a Multinomial Logistic Regression was performed. The dependent variable in this regression was called ”symptoms and reactions linked to the environmental noise by the interviewee”. The outcome of these two statistical procedures led to the conclusion that 81.5% of the symptoms and reactions could be accounted for by the combination of these seven factors with the noise measurement data.

Wednesday Environmental noise: Sources (Poster)

Sounds of countryside

Alessandro Scavazza[a] and Nadia Nadal[b]
[a] *Architetto, Bolzano;* [b] *Scienze ambientali, Bolzano*

Sounds of countryside

This book is the real story of Francesco, a deaf child with cochlear implant. The authors are Francesco parents and they want to awake the readers about deafness and provide some useful information from technical, communicative and psychosocial points of view.

Francesco has never heard the world sounds. The book tells the discovery of these sounds after the application of the cochlear system. The book addresses in the first place children in pre-school age both deaf and hearing. For hearing children the book can help to know the deafness problem. With teachers or parents, the children can understand how to approach to a deaf person. The deaf child can identify it in the book protagonist. This is very important to supports the development of a positive image of itself and reach a good child psychic balance.

In the book appendix there are information about the working of the cochlear system, the deafness effects on language, the communication and the relation. Some tips will help to talk about the listening importance in a fun way.

www.rumorincampagna.com

Session "Building acoustics: Legislation, standards and protocols"

Wed 8:40 Puccini Theatre Building acoustics: Legislation

Building Acoustics: Strengthened Requirements of the New VDI 4100 Standard and their Impacts on Final Customers and Industry

Oliver Wolff

Geberit International AG

The impacts caused by the current revision of the VDI 4100 standard will be visible in various ways. Increased costs for the complex acoustic planning and higher costs for acoustically improved constructions will be spread across final customers. This development will lead to higher rents with extensive consequences for the social housing sector. This issue might be less relevant for upmarket residential buildings as mainly solvent owners or tenants are addressed. Technically the switch from component related acoustical quanitities to now situation dependent quantities, as proposed by the new VDI 4100, is not beneficial. On the contrary, the new acoustical quantities lead, based on the fact that the new VDI 4100 foresees noise protection only for rooms with surface areas of 8 m2 minimum, to a spurious accuracy. Neglected factors like e.g. the diffusivity of the sound field have higher impact and exhibit higher uncertainties compared with the switch from the component related to the situation related quantities. This approach leads merely to a more complicated description of the acoustical topic lacking any visible benefit for the customer. This is not a good basis for a directive that needs to be technically strong and in consensus with all relevant stakeholders.

Wed 9:00 Puccini Theatre Building acoustics: Legislation

Update of German Standard DIN 4109 with Respect to Lightweight Frame Constructions

Heinrich Bietz[a], Volker Wittstock[a], Werner Scholl[a], Georg Krämer[b], Sven Bohnsack[c] and Lutz Weber[d]

[a] *Physikalisch-Technische Bundesanstalt;* [b] *Sachverständiger, Nordhausen;* [c] *Saint-Gobain Rigips GmbH;* [d] *Fraunhofer-Institut für Bauphysik*

The German building acoustics standard DIN 4109 is currently under fundamental revision. Amongst others, this standard includes a "catalogue of components", which lists sound insulation figures for common building techniques and components. These are allowed to be used for the proof of noise abatement without individual testing. Regarding lightweight frame constructions (metal framework lined with plasterboard), the figures in the current standard have to be reviewed due to technical development of the plasterboards, a fact which has been considered only partially in past updates. Also, to a wide extent the origin of the figures listed in the recent standard is unclear. Accordingly, action has been taken in order to verify the sound insulation figures for flanking transmission of lightweight frame constructions and heavy walls with linings by means of measurements within the framework of a research project. In this context, the usability of test certificates supplied by the industry was also taken into consideration.

The research project was conducted by PTB, the measurements have been performed by IBP Stuttgart. Cooperative funding was provided by DIBt and the industrial associations IGG and HDB. A report on the achieved measurement results and a resulting proposal for the revised standard will be presented.

Wed 9:20 Puccini Theatre Building acoustics: Legislation

Acoustic Classification of Buildings in Italy. What Has Happened in the Last 3 Years?

Matteo Borghi and Stefano Benedetti
ANIT, Milano

In July 2010 was published the UNI 11367, which defines a method for the acoustic classification of buildings in Italy. In this work the authors intend to estimate how (and if) this method has been applied in the absence of specific legal limits.

Wed 9:40 Puccini Theatre Building acoustics: Legislation

Acoustic certification in buildings: fulfilling CasaClima Nature protocol and recent Italian classification of non-serial buildings.

Martina Demattio[a] and Lorenzo Rizzi[b]
[a] *Agenzia CasaClima, Bolzano;* [b] *Suonoevita ingegneria, Lecco*

The recent CasaClima Nature protocol asks for stricter acoustic requirements to be followed as compared to the National ones in force at the moment (DPCM 5/12/97). An extensive on site measurement campaign at the end of construction is specifically required. The article deals with merging CasaClima protocol to the recent Italian technical norm UNI 11444:2012 on acoustic classification of non-serial buildings (also based on in-field measurements and possibly similar to the future National law). An analysis method of both the project and the state of things on site is here analyzed in order to satisfy both protocols in view of a double certification and to maximize final comfort. A case study is here discussed.

Wed 10:00 Puccini Theatre Building acoustics: Legislation

The ClimaHotel Acoustic Protocol in accordance with CasaClima Agency's Guidelines - Case studies

Massimo Rovere[a], Cristian Bortot[b] and Lorenzo Soligo[c]
[a] *Tecnico Competente in Acustica, Mansue';* [b] *Tecnico Competente in Acustica, Pieve di Soligo;* [c] *Tecnico Competente in Acustica, Padova*

CasaClima Agency Bolzano -Italy- is a corporation with a ten year experience in the field of energetic certification of buildings. In the last years, the new requirements and the evolution of regulations and the intrinsic problems of constructing have led the Agency to a stronger sensibility towards acoustic properties of buildings, aiming to combine and develop both the demands in thermal and acoustic comfort, by means of the implementation of protocols which could allow to follow and to monitor a project from its design to its final realization.The receptive buildings have been included in the ClimaHotel protocol, which is articulated with three steps: pre-certification; certification and re-certification. Two study cases of hotels both sited in two

important Italian touristic areas will be presented (Lake Garda Verona and Province of Venice) In both of them, the phases of preliminary acoustical and environmental analyses, of designing of the acoustical properties of construction structures and of testing of the values at the end of the works are included.ClimaHotel is a precise and effective tool because it's designed following guidelines which focus on the standardization of computing, monitoring and accomplishing methods, for the achievement of a Final Certification.

Wed 10:20 Puccini Theatre Building acoustics: Legislation

Acoustic comfort in CasaClima Work&Life protocol: office building case studies.

Martina Demattio[a], Massimo Rovere[b] and Lorenzo Rizzi[c]
[a] *Agenzia CasaClima, Bolzano;* [b] *Tecnico Competente in Acustica, Mansue';* [c] *Suonoevita ingegneria, Lecco*

The Work & Life protocol regards office and service buildings. CasaClima Agency indicates a sustainability path to ensure primary importance to ecological solutions for the building shell, its fittings and interiors.
Acoustical parameters are obligatory to obtain the Work & Life certification, both in the design stage through calculations and a technology analysis and at the end of construction through measurements on site. Sound insulation is defined through D2m,nT for façade measurements, equipment noise is defined through levels normalized to reverberation times Lic and Lid. Open space offices and common rooms must have a correction of reverberation and these must be obtained by controlling reverberation time T60, Speech Transmission Index STI and Clarity C50. The article ends by discussing two case studies.

Session "Building acoustics: Lightweight structures"

Wed 10:40 Puccini Theatre Building acoustics: Lightweight

Measured Sound Insulation of Double Leaf Plasterboard Walls Part 1: Measurements concerning the basic acoustical Behaviour

Martin Schneider, Steffi Reinhold and Heinz-Martin Fischer
HFT Stuttgart

In the test stand at the HFT Stuttgart the sound insulation of different plasterboard walls was investigated. Besides the standard building acoustics evaluation of the sound insulation a variety of additional acoustical measurements were carried out, to deepen the understanding of the sound transmission of double layer walls. Experimental modal analysis was used to visualize eigenforms of the wall which determine the sound transmission at low frequencies. Measurements of the velocity levels on different parts of the surface of the plasterboard (close to the screwing, near and between studs) when excited by airborne sound were carried out to evaluate the radiation efficiency and help to explain sound transmission effects at higher frequencies. Comparing the sound insulation of a double wall with the same wall where the plasterboards cover only one side helped to understand transmission effects at high frequencies.

Wed 11:00 Puccini Theatre Building acoustics: Lightweight

Measured Sound Insulation of Double Leaf Plasterboard Walls Part 2: Influence of Cavity Depth, Number of Layers and other Construction Parameters

Steffi Reinhold, Martin Schneider and Heinz-Martin Fischer
HFT Stuttgart

The sound insulation of approximately 15 plasterboard walls is determined by measurements as a function of constructive properties in the test facilities of the HFT Stuttgart. Each series of measurements include the effect of design changes in the assembly of the plasterboard walls, for example different cavity depth and the change in the material of the plasterboards. The measured sound insulation is compared with the calculated sound insulation according to DIN 4109 supplement 1. In a second step further design parameters, such as the construction of the connection between the stud and the test stand, different porous materials in the cavity and different stud materials are varied for a single assembly of the plasterboard wall. One goal of the study was to achieve a high degree of sound reduction index of the plasterboard walls. The measurements show that not only the cavity depth, the degree of absorbent filling and the number of layers have an influence on the sound insulation. The connection at the edges has also an influence on the sound insulation. Therefore the sound insulation can be improved especially at high frequencies, when the best construction parameters are considered.

Wed 11:20 Puccini Theatre Building acoustics: Lightweight

Vibroacoustic characteristics of light-weighted slabs - Part 1: Aspects of Numerical Modeling, Model Updating and Parametric Studies using the Buckingham π-Theorem

Mathias Kohrmann[a], Martin Buchschmid[a], Axel Greim[a], Gerhard Müller[a] and Ulrich Schanda[b]
[a] *Chair of Structural Mechanics, TU München;* [b] *University of Applied Sciences Rosenheim*

Nowadays a trend towards using wooden constructions in multi-story buildings for industrial and for residential use is recognized. This can be explained by reasons of profitability and by the necessity to develop sustainable engineering concepts. The serviceability linked with vibrations is a key issue for light-weighted structures especially for wooden slabs. In particular in a frequency range beneath 100Hz these structures are prone to pedestrian-induced vibrations, footfall noise and re-radiated sound caused by induced vibrations. Measures to tackle these problems can consist in tuned-mass-dampers or adequate suspended ceilings respectively floating floors. In order to assess those systems complex models have to be built, which consider the sensibility of the structural vibration and the radiation behaviour to the geometrical and material parameters. This contribution focuses on aspects for appropriate numerical models, such as support conditions, element types and contact phenomena, which usually are sources

for numerical errors. Furthermore these models are calibrated with measured data using a model-updating algorithm based on the system's eigenmodes. Parametric studies for different system geometries based on an updated model are presented using dimensionless parameters derived by the Buckingham π-Theorem. Nomograms of the results can give a prediction of the structures sound-radiation-characteristics for varying geometries.

Wed 11:40 Puccini Theatre Building acoustics: Lightweight

Vibroacoustic characteristics of light-weighted slabs - Part 2: Measurement-Based Investigation of the Sound Radiation of Suspended Ceilings

Martin Buchschmid[a], Mathias Kohrmann[a], Christoph Winter[a], Raphael Völtl[b], Ulrich Schanda[b] and Gerhard Müller[a]
[a] *Chair of Structural Mechanics, TU München;* [b] *University of Applied Sciences Rosenheim*

In part 1 the development of an appropriate numerical model of a wooden slab - calibrated and model-updated using measurement data - was described and its application for questions of sound-radiation was presented. In this contribution the limits of modal approaches in the spatial domain due to an increasing modal density (already beneath 100Hz in case of light-weighted structures like wooden slabs with suspended ceilings) are discussed in detail. An alternative approach transforming the problem into the wavenumber-domain, where a direct link to physical parameters (like the wavenumber of the bending wave for instance) becomes visible, is advantageous and can be applied also in a higher frequency range. In addition radiation of sound, which occurs for finite structures also beneath the coincidence frequency, can be predicted in the transformed domain out of the velocity-pattern, which could be obtained out of measurements or numerical (FEM) analyses for instance, using Integral Transform Methods. A validation of the method is presented, where both the velocity pattern and the sound pressure-field were measured on a real structure. The radiated sound computed in the transformed domain out of the measured velocity-pattern is compared against the results measured by an intensity probe.

Wed 15:30 Puccini Theatre Building acoustics: Lightweight

Prediction of horizontally transmitted Sound from Impacted Lightweight Stairs - Part 1: Case Study

Jochen Scheck[a], Barry Gibbs[b] and Heinz-Martin Fischer[a]
[a] *HFT Stuttgart;* [b] *University of Liverpool*

A laboratory characterisation of lightweight stairs as structure-borne sound sources is needed to predict the sound transmission in building situations. An approach is followed where a stair is treated as an active component, in a similar manner to that used for vibrating machines. With this approach stairs can be characterised on a power basis. In consideration of the mobility ratio in heavyweight building situations, a blocked force required as input data for the building propagation model EN 12354-2 is determined. An elaborate case study on a lightweight timber construction, connected to a supporting wall in a staircase test facility is outlined and summarized. By

comparison of predicted and measured impact sound pressure levels, the achievable accuracy is assessed. This investigation forms the basis for the proposal of a practical standard test procedure.

Wed 15:50 Puccini Theatre Building acoustics: Lightweight

Prediction of horizontally transmitted Sound from Impacted Lightweight Stairs - Part 2: Proposal for a Standard Test Procedure

Christoph Fichtel[a] and Jochen Scheck[b]

[a] *STEP GmbH, Winnenden;* [b] *HFT Stuttgart*

Based on the results of an elaborate case study a practical standard test procedure is proposed that enables comparison of the acoustic quality of lightweight stairs and prediction of the sound transmission in heavyweight buildings using EN 12354-2. The procedure involves measurements of the impact sound pressure level of the stair and the separating wall in a defined reference situation. This procedure is similar to that applied for floating floors. Practical difficulties are solved by using an electrodynamic tapping machine for excitation of the reference wall. The proposed procedure could be implemented in standards like the new version of DIN 4109 that up to now doesn't contain any information on lightweight stairs. Several lightweight stairs have already been investigated in a staircase test facility, the results are compared and the use as input data for the prediction of sound protection is discussed.

Wed 16:10 Puccini Theatre Building acoustics: Lightweight

First year of the Lightweight Test Suite in Dübendorf, Measurements of the acoustical performance of timber constructions

Christoph Geyer[a], Rudolf Bütikofer[b], Andreas Müller[a], Bernhard Schuppisser[a] and Ali Sanavi[c]

[a] *Berner Fachhochschule, Architektur, Holz und Bau;* [b] *Empa, Swiss Fed. Labs for Materials Science & Technology;* [c] *Bern University of Applied Science*

The lightweight test suite in Dübendorf, Switzerland was commissioned until spring 2012. The separating element was a timber floor with a high level of sound insulation. At the end of the commissioning a very high performance of the test suite with a sound reduction index of R'w (C;Ctr) = 86 (-4; -11) dB, C50-5000= -15 dB and a normalized impact sound level of L'n,w (CI) = 23 (2) dB, CI 50-2500 = 23 dB was achieved. In the year 2012 the flanking sound transmission for airborne and impact sound of various timber stud wall constructions were measured in the test suite. The influence of several modifications of the flanking walls, as additional claddings or acoustic linings, on the flanking sound transmission was studied, to get a better understanding of the sound transmission in timber buildings. The measurement data will be included in the Swiss database of acoustical performance of timber constructions. The presented results of the measurements demonstrate that there are timber constructions available for the separating and flanking elements to achieve a high level of acoustic separation, necessary to build multi-storey houses with timber constructions.

Wed 16:30 Puccini Theatre Building acoustics: Lightweight

Development of wall- floor -junctions in timber buildings with resilient layers to reduce flanking sound transmission

Ali Sanavi
Bern University of Applied Science

A high quality level of the building acoustic is necessary to meet the demands of the inhabitants in multi-storey buildings. To attain this level of acoustic quality, it is necessary to reduce the direct and flanking sound transmission for the impact and airborne sound. The flanking sound transmission can be reduced by installing resilient layers in the junction between the floor and the wall. The resilient layers were optimized for timber constructions by measuring the velocity level difference between the excited and the radiating element in prequalifying measurements. As a result of these measurements a set of resilient layers with a maximum impact sound reduction was identified. Test specimens of the junction with these optimized resilient layers are build in the lightweight test suite in Dübendorf, Switzerland. By measuring the flanking airborne and impact sound of these constructions, the reduction in flanking sound transmission using resilient layers is determined. The results of the measurements are presented.

Wed 16:50 Puccini Theatre Building acoustics: Lightweight

Experimental Investigations on Direct and Flanking Sound Transmission in Lightweight Timber Frame Constructions

Lieven de Geetere
Belgian Building Research Institute

CEN/TC 126/WG 2 is currently revising the EN 12354 series on prediction models for sound transmission in buildings based on the performance of elements. One major goal of this revision is the extension of the current models towards lightweight building constructions. In a first step, new expressions are being proposed to predict the flanking sound transmission due to airborne excitation. Measurements of both the flanking sound transmission index Rij and the normalized direction-averaged vibration level difference Dv,ij,n in a 3-room real-size timber frame mock-up have been performed in order to investigate the validity and applicability of these expressions. Further more, some experimental investigations trying to improve direct sound insulation of walls and floors are reported in this paper.

Wed 17:10 Puccini Theatre Building acoustics: Lightweight

Prediction of the Dynamic Properties of a Cross Laminated Timber Plate from an Investigation of the Eigenmodes Using a Scanning Laser Vibrometer

Claire Churchill[a] and Carl Hopkins[b]

[a] *Empa, Swiss Fed. Labs for Materials Science & Technology;* [b] *University of Liverpool*

There are a wide variety of timber building systems available on the market. However there is little research into the prediction of acoustic parameters of hybrid heavyweight/lightweight and solid timber construction (Massivholz). The difficulty of modelling the airborne sound insulation of a Grossformat Platte (GFP) - an orthotropic cross laminated plate - was investigated by Krajči, Hopkins, Davy & Tröbs [1]. GFP forms the basis of some T-junctions commonly found in Swiss buildings as well as in X-junctions where it can be used in combination with the Holz-Beton-Verbundsystem (HBV), a hybrid (heavyweight/lightweight) floor system previously modelled using SEA with some success, (Churchill, Hopkins, Krajči [2]). Prediction of flanking transmission across these junctions of combined systems requires a better understanding of the dynamic properties of the GFP over the building acoustics frequency range. To date, the sound reduction index of the GFP has not been successfully predicted. In this work, experimental modal analysis was carried out on the cross-laminated timber plate (GFP) using a scanning laser vibrometer. The eigenfrequencies of the plate were determined with a view to solving the inverse problem and obtaining the elastic constants. Further work will investigate the performance of the GFP installed in a simple T-junction.

Wed 17:30 Puccini Theatre Building acoustics: Lightweight

Radiation efficiencies of timber joist ceilings

Jan-Henning Schmidt[a], Volker Wittstock[a] and Sabine Langer[b]

[a] *Physikalisch-Technische Bundesanstalt;* [b] *Institut für Angewandte Mechanik, TU Braunschweig*

A compact measurement setup was developed 2009 in the course of an AIF-funded project to determine the impact sound reduction with a small setup (1.2m x 0.8m x 0.2m) which replaces the special test facility according to ISO 10140. For concrete- and timber joist ceilings, the determination of the impact sound reduction at a compact measurement setup worked quite well. In the frame of another AIF-funded project which started in 2011, the possibility to determine the normalised impact sound pressure level at a compact measurement setup is investigated. For this determination, the radiation efficiency of the investigated timber joist ceiling has to be known. Radiation efficiencies of multiple timber joist ceilings determined in-situ and under laboratory conditions are compared. For the determination, the radiated sound power is measured by means of intensity scanning and of the averaged sound pressure level in the receiving room. A structural excitation by a tapping machine and an airborne excitation by a dodecahedron were applied successively. The structural velocity is measured by a scanning

laser vibrometer. The resulting radiation efficiencies for the different excitations and the different methods to measure the radiated sound power are compared and discussed.

Session "Building acoustics: General 1"

Wed 17:50 Puccini Theatre Building acoustics: General 1

Interlaboratory test on walking noise

Sylvia Stange-Kölling, Volker Wittstock and Werner Scholl
Physikalisch-Technische Bundesanstalt

In 2011, the FprEN 16205 "Laboratory measurement of walking noise on floors" has been introduced. It describes a laboratory method to determine walking noise on all kinds of floor coverings. The noise radiated from a floor covering is measured in the room where the floor covering and the excitation are located. The measurements take place on a standard concrete floor when excited by a standard tapping machine. Also the impact sound improvement can be measured within this method, it is very similar to the known impact sound measurements. An additional measurement with so called "pads" is necessary to determine the self noise of the tapping machine. With these two measurements, the walking noise can be calculated. In 2011/2012 an international Round Robin Test was organised by the Physikalisch-Technische Bundesanstalt to evaluate this method. About sixteen laboratories take part and four different floorings (carpet, PVC and laminate with two different underlayers) were tested, The method itself and the first results of the Round Robin Test will be presented.

Wed 18:10 Puccini Theatre Building acoustics: General 1

Methods for the Determination of Laboratory Airborne Sound Insulation at Low Frequencies

Andrea Prato and Alessandro Schiavi
INRIM, Torino

Measurement of airborne sound insulation between rooms in laboratory through a single partition at low frequencies (50-100 Hz) is required to improve the actual ISO 10140:2010 standard. The strong modal behavior of acoustic field at such frequencies in tipical laboratory rooms (50 m^3) needs a different measurement approach with respect to the standard one. The main guidelines to be adopted in measurement procedure in relation with such acoustic field are described. Different data analysis methods and related problems have been investigated in order to provide a metrologically accurate measurement of sound level pressure difference in third-octave bands between source and receiving rooms. In addition, from theoretical calculation of sound level pressure in the coupled system (room-panel-room), normalization terms have been added to obtain a reliable evaluation of sound reduction index R_w.

Wednesday Building acoustics (Poster)

Dry Systems for Impact Noise Insulation of Floors in Laboratory

Leonardo Luison[a], Cora Pavarin[b] and Antonino Di Bella[b]
[a] *Isolgomma Srl, Albettone;* [b] *University of Padova, Department of Industrial Engineering*

The use of dry systems in buildings has been increasing in the last years, mainly in building refurbishment, due principally to laying easiness and quickness. A good evaluation of the insulation properties of dry systems for impact noise reduction can be done accurately in laboratory, according to ISO 10140 standard. A laboratory evaluation allows also to study the behavior of impact noise reduction systems applied to different base floors and the differences with a traditional floating screed, made of sand and cement. The aim of this work is the evaluation of dry floating floors made of a combination of different resilient sub-layers loaded by rigid heavy panels, with a focus on the test conditions and sample setup. The results of the experimental analysis are intended to give a better indication of the efficiency of these systems, instead of using estimated impact noise reduction values coming from the dynamic stiffness only, for a more accurate prediction of onsite acoustic performance of floors, according to EN 12354 standard.

Wednesday Building acoustics (Poster)

Acoustic Retraining of Buildings Starting from Window Replacement.

Lorenzo Rizzi and Francesco Nastasi
Suonoevita ingegneria, Lecco

The replacement of old windows for energy saving requirements always leads to decreasing the level of ground (residual) noise inside. This increases the attention that is needed in the design of acoustic insulation of partitions between apartments, especially in the case of the retraining of the building itself. A frequency analysis is carried on using in-field airborne isolation curves R' (f): starting from case studies from the authors' professional practice they have been compared to measured nighttime background noise levels with closed windows. Our study analyzes if the use of a LAeq unique number and the Rw value, combined with the adaptation coefficients C and Ctr, is useful to calculate the disturbance that may arise in the finished building.

Wednesday Building acoustics (Poster)

ClimaHotel Certification Program and requirements of acoustic comfort for hospitality buildings. Case studies.

Martina Demattio[a], Cristian Bortot[b] and Massimo Rovere[c]
[a] *Agenzia CasaClima, Bolzano;* [b] *Tecnico Competente in Acustica, Pieve di Soligo;* [c] *Tecnico Competente in acustica, Mansue'*

The KlimaHaus Program has been developed in order to guarantee a high level of quality of the construction process of low-energy buildings. Since 2002 the KlimaHaus certification system is a widely recognized method. ClimaHotel is the certification program of the KlimaHaus Agency focused on the evaluation of sustainability in hotel planning and construction. The certification offers a complete assessment method which evaluates complex hotel buildings in three fields: environmental impact, comfort aspects and economical factors. In hospitality buildings sustainability is strictly related to acoustic comfort, which is perceived as a crucial parameter for the satisfaction of the activity both during the night (rooms), and the day (cafes, restaurants, conference halls). In this paper two case studies of hospitality buildings are presented. Results of forecasting analysis and final tests are described. The relationship with the fulfillment of ClimaHotel requirements is explained in each phase: pre-certification, certification and re-certification.

Wednesday Building acoustics (Poster)

Acoustic planning experiment and final verification of acoustic requirements, in ancient country buildings near Pordenone

Dino Abate
ing. Dino Abate - Studio Ingegneria, Pordenone

Acoustic planning experiment and final verification of acoustic requirements, for the restoration of a complex of ancient country buildings not far from Sesto al Reghena, near Pordenone, with the transformation of the above buildings in residential purpose under the management of ATER of Pordenone. Comparison between the design simulations of the evaluation indexes and the corresponding values, determined by means of final on site measurements.

Wednesday Building acoustics (Poster)

Experimental Results of Flanking Transmission in Hollow Brick and Concrete-Slab Floor

Giovanni Semprini and Luca Barbaresi
University of Bologna, Dep. of Industrial Engineering - DIN

Hollow brick and concrete-slab floors can reach high acoustic performances with floating floor over a resilient layer. However in situ acoustic performances may vary significantly depending on the presence of flanking transmission paths from the base floor to lateral walls. Those flanking paths depend on floor size, warping of beams, on the presence of floating floors and mainly on the specific junctions and junction lengths to lateral walls. In this paper some experimental results of the sound reduction index Kij for different junctions on brick-concrete slab floors are presented. Measuring are carried out according to EN 10848 procedures, and all calculated values are compared to theoretical ones proposed by EN 12354-1 standard. Results show significantly variation in frequency domain and some discrepancy with theoretical formulations.

Wednesday Building acoustics (Poster)

Acoustic Performance of a Green Modular System

Elena Candelari[a], Valentina Serra[a], Paolo Tarizzo[b], Alessandro Schiavi[b] and Francesco Russo[b]
[a] *Politecnico di Torino - Dipartimento Energia;* [b] *INRIM, Torino*

Green modular systems (GMS) are modular vertical systems made by panels containing a vegetated substratum hosting different plant species, which can be mounted on a opaque façade, as a cladding ventilated skin wall system. This technology is more and more widely adopted by designers. In literature there are some studies on the thermal behavior of these systems, but few quantitative data are available. Moreover significant and in-depth researches on the acoustic behavior of GMS are still not present. Within a research project a consistent analysis on the thermal performance of a GMS , with different substratum and three different plants (Lonicera, Bergenia and Heuchera), have been carried out and some acoustic measurements have been done. This work is focused on the experimental analysis concerning the acoustic behavior. In particular to evaluate the sound absorption coefficient of the GMS, the measurements were carried out in a reverberation chamber, on a surface of 12 m2 (according to EN ISO 354 Standard) on both the panel with vegetation and the panel with the bare substrate. The obtained spectra, in both cases, demonstrate that the GMS is highly performing, in terms of sound absorption.

Wednesday Building acoustics (Poster)

Comparison between Sound Reduction Index of single and double massive walls built in Italy and United Kingdom

Patrizio Fausti[a], Elisa Nannipieri[b], Simone Secchi[b] and Sean Smith[c]
[a] *Università di Ferrara;* [b] *Università di Firenze;* [c] *Inst. for Sustainable Construction, Napier University, Edinburgh*

In European countries, the acoustic performance of internal partitions between apartments are subject to quite different performance standards. This is a result of different habits and cultures in the various countries, as well as diverse construction techniques. In this presentation the results of a comparison of the most common partitions, used both in Italy and United Kingdom, are reported. On the basis of a statistical survey conducted on a large number of partitions measured in-situ on finished buildings, the average values of the apparent sound reduction index of these different construction systems were compared. The two types of wall analysed within this study were double-leaf cavity walls and single-layer concrete walls. The comparison was made both on the performance with regard to frequencies and single numbers, in order to understand better the reasons and possible solutions for the different performances that can be observed at mid and high frequencies for some of these technological solutions.

Wednesday Building acoustics (Poster)

Definition of a Privacy Index by testing internal doors and partitions

Gianpiero Majandi[a], Roberto Bianucci[b] and Giovanni Bonansegna[c]
[a] *STUDIO MAJANDI, Bonemerse (CR);* [b] *Studio Tecnico Bielettro;* [c] *Studio Tecnico Bonansegna, Empoli*

At the moment there is no standard and no specific index for determining the sound reduction index of windows and interior partitions needed to maintain privacy. This problem is particularly evident in public places where it is necessary to maintain a good level of privacy of conversations. This study analyzes the various possible situations and defines the methods of analysis for a correct approach to the problem.

Wednesday Building acoustics (Poster)

Measurement and Evaluation of the Acoustic Insulation of Building Envelope for Low Frequencies Noise Emitted by Wind Turbines Generator (WTG).

Costantino Carlo Mastino[a] and Carlo Bernardini[b]
[a] *Università di Cagliari - D.I.C.A.A.R.;* [b] *Università di Cagliari*

The current energy situation imposes an acceleration toward the development of techniques for the exploitation of renewable energy sources. Recent European regulations impose percentages of energy produced by more and more renewable sources. The current technological development indicates the wind energy as the renewable energy source on which we can rely more and more; this technology uses big wind turbines with nominal powers of about 3 MW. Among the main environmental problems that we have to face in planning a new wind farm, there is the acoustic impact due

to the noise generated by WTG, with a particular reference to the assessment and measurement of the noise emitted at low frequencies. With this work we want to clarify both the methodologies currently used in measuring the noise emitted at low frequencies, and to estimate the acoustic insulation of the buildings envelope, of the buildings that are populated by people and that are often near the areas in which wind farms are settled.

Session "Application of ultrasound in medicine"

Wed 8:40 Hotel Terme room 1 Ultrasound in medicine

Review of quantitative tools in diagnostic ultrasound

Klaus-Vitold Jenderka
Univ. of Applied Sciences Merseburg

Generally medical ultrasound is recognized as a diagnostic imaging modality. Additionally, ultrasound imaging systems offer a broad range of tools for the determination of quantitative parameters. Primarily, the measurement of distances, areas or volumes is carried out and documented in daily clinical practice. The Doppler-Sonography modalities, like Color or PW Doppler, are regularly applied to access flow parameters quantitatively. By means of ultrasound contrast agents and special scan sequences perfusion parameters are established and fast imaging regimes are used to measure the shear wave velocity in tissue to access their elastic properties. In some cases, e.g. grading stenosis, further diagnostic measures taken and therapy relevant decisions drawn from the values of the determined parameters. For many applications the uncertainty of the measurement results is not thoroughly declared or still under discussion. Unfortunately the displayed values on the screens pretend a wrong certainty for the user. This leads to the unsatisfactory situation, that e.g. distances in the order of 1 mm are measured with wave lengths in the order of 0.3 mm and the results are displayed with a resolution of 0.01 mm. The uncertainty contributions of selected applications are discussed and judged in comparison to the clinical practice.

Wed 9:00 Hotel Terme room 1 Ultrasound in medicine

1,5 and 3 Tesla MR Imaging of the Beating Heart Using Doppler Ultrasound Triggering

Friedrich Ueberle[a], Fabian Kording[b], Manan Patel[a], Saboo Samarth[a], Eike Dettmann[a], Christina Eden[a], Jeevitha Jayakumar[a], Marisa Jelinek[b], Chressen Much[b], Björn Schönnagel[b], Manuela Tavares De Sousa[b], Jin Yamamura[b], Gerhard Adam[b] and Ulrike Wedegärtner[b]
[a] *HAW Hamburg;* [b] *Universitätsklinikum Eppendorf*

Cardiac MR is increasingly used in the grown-up heart diagnosis. The complete heartbeat cycle is recorded over several heart beats by triggering on e.g. the R- wave of the ECG, which becomes increasingly difficult with higher field strength. Therefore the potential of Ultrasound was assessed. Ultrasound Doppler triggering also offers a novel diagnostic opportunity of visualization of anomalies of the foetal heart and the great vessels. The

heartbeat of adult pregnant sheep and their foetuses was recorded during the whole scanning time using a modified commercial CTG device. The U/S head was cleaned of all ferromagnetic materials and additionally shielded to reduce RF interference on the ultrasound signal chain. The rectified Doppler signals are fed into a laptop, which analyses the wave forms, extracts the heart cycles and creates a synchronized trigger signal for the MR. The search algorithm was able to identify the local peaks of the Doppler envelope and a precise software trigger was generated at most of the local peaks at adult and foetal heart rates ranging from $<$60/min to $>$170/min. In the animal study images of the foetal sheep hearts (at 1,5T) and of the adult hearts (1,5 and 3T) were successfully gained.

Wed 9:20 Hotel Terme room 1 Ultrasound in medicine

Ultrasound Breast Cancer Diagnosis and Therapy - a Design Study
Benedikt Kohout, Robin Dapp and Nicole Ruiter
Karlsruhe Institute of Technology
At Karlsruhe Institute of Technology we developed a new 3D ultrasound diagnostic system to detect breast cancer at a very early stage (3D Ultrasound Computer Tomography). In the next generation of our system, we also aim to treat small tumors. In terms of thermoablation and hyperthermia, high temperatures have to be achieved within the tumor region, while other tissue areas must not be heated. The challenge is to adapt a special optimized diagnostic system to also enable breast cancer therapy. A system like this could benefit non-invasive surgery of small breast tumors and overcome typical ultrasound therapy problems like monitoring of the treated tissue.
This work will present theoretical solutions for system and transducer design as well as simulated results to enable a therapeutic use case.

Wed 9:40 Hotel Terme room 1 Ultrasound in medicine

Definitions of Dose for Therapeutic Ultrasound
Julian Haller and Volker Wilkens
Physikalisch-Technische Bundesanstalt
Contrary to other therapeutic applications like for example radiotherapy, there is no agreed definition for ”dose” in therapeutic ultrasound applications. Such a definition will be useful for patients (minimization of over- or undertreatments), clinicians (better and more reliable treatment planning), manufacturers and regulators. Several definitions for a unified quantification of therapeutic ultrasound have been proposed in literature already, sometimes already differing in the very fundamental approach - one fundamental question for example is whether an appropriate definition should be based on acoustic quantities or rather on thermal quantities. We evaluated some of these definitions and approaches with respect to several criteria. We conclude that a definition of dose should fulfill the four following most important criteria: 1.) measurability with reasonable uncertainties and traceability; 2.) relevance to biological effects; 3.) conformity with common terminologies; 4.) relevance and practicability for everyday clinical use.

Wed 10:00 Hotel Terme room 1 Ultrasound in medicine

Non-invasive Temperature Estimation in a Tissue-mimicking Phantom Using Ultrasonic Imaging

Olga Bessonova and Volker Wilkens
Physikalisch-Technische Bundesanstalt

High intensity focused ultrasound is currently utilized in many modern medical applications for cancer therapy. The use of HIFU for thermal ablation of human tissues requires safe real-time monitoring of the temperature rise and lesion formation during the treatment. Several methods have been proposed for temperature imaging using diagnostic ultrasound, and echoshift estimation is the most promising and commonly used technique. It is based on the thermal dependence of the ultrasound echo that accounts for two different physical phenomena: local change in sound speed and thermal expansion of the propagating medium due to changes in temperature. Within this study, the applicability of the technique for standardized dose recording of HIFU equipment with respect to quality control and testing routines for treatment planning is investigated. In our experiments we used two separate transducers: HIFU exposure was performed using a 1 MHz focusing transducer; the ultrasound diagnostic probe of 11 MHz operated in B mode for image guidance. The echoshifts were estimated in a tissue-mimicking agar phantom near the geometrical focus of the HIFU source where the temperature is highest. These echoshifts were used to determine the temperature evolution in the medium. The experiments were performed for temperatures up to 45 °C.

Wed 10:20 Hotel Terme room 1 Ultrasound in medicine

Thermocromic Gel as Tissue Mimicking Materials for Investigation of Temperature Rise Induced by HIFU Transducer

Adriano Troia and Chiara Magnetto
INRIM, Torino

A thermochromic hydrogel optically transparent has been realized to investigate the heating effect induced by high-intensity focused ultrasounds (HIFU). The reversible thermochromism of this hydrogel allowed to investigate the heating profile of acoustic fields in function of time and power. A rapid increase of temperature, measured also with thermocouple, has been observed, revealing that temperature of 60 °C can be reached immediately, even in the near field region of the HIFU transducer. The thermochromic hydrogel is based on encapsulation of cobalt (II) chloride as a dopant into the inorganic silica matrix. The acoustic properties of this material have been measured. The acoustic impedance is similar to the values in very soft tissue, while the attenuation coefficient is approximately eight times lower than soft tissues. Although these differences, from typical value that tissue-mimicking materials commonly have, the thermal properties of this material could represent a practical method for investigate the anomalous increase of temperature reported from different medical treatments in vivo, especially in the fat region tissue and even with skin burns. Furthermore this material could be used as reusable tool for investigate the heating

effect from different HIFU transducers and monitoring the stability of the operating HIFU transducer.

Wed 10:40 Hotel Terme room 1 Ultrasound in medicine

Ultrasound-mediated Oxygen- nanotherapy in superficial tissues

Caterina Guiot[a], Mauro Prato[a], Chiara Magnetto[b] and Adriano Troia[b]
[a] *Università degli Studi di Torino, Dip. Neuroscienze;* [b] *INRIM, Torino*

Tissues hypoxia is a common phenomenon originated by metabolic, ischaemic or infective deseases. Many of such hypoxic regions (e.g. bedsores, diabetic foot...) are located superficially and extra oxygen, properly encapsulated in Oxygen Loaded Nanobubbles (OLNs) could be provided through ultrasonic transdermal sonophoresis.
Nanobubbles consist in a shell of biocompatible and biodegradable material (chitosan or dextran) and an oxygen-storing perfluoropentane core (PFP). OLNs can be manufactured in liquid (water) or gel (hydroxyethylcellulose) formulations, with the latter being more suitable for skin spreading. Local sonophoresis throughout natural membranes (pig skin) can be induced by OLNs sonication with a 5 minutes standard procedure (f= 2.5MHz, P=5W). The transdermal O2 release, monitored by measuring the dissolved O2 concentration, is sustained and lasts for longer times than the corresponding O2-saturated formulations. The administration of OLN on both JEG-3 choriocarcinoma cell cultures and small fragments of human chorionic villi incubated in hypoxic conditions dramatically reduces the expression of HIF-1α, proving their biological efficacy. OLN were also effective on MMP-8 secretion by human monocytes.
OLN sonication, being a non-invasive and low-cost nanotechnological device, is a good candidate to treat hypoxia-related superficial diseases.

Wed 11:00 Hotel Terme room 1 Ultrasound in medicine

Experimental apparatus for measurement of the ultrasound absorption coefficient

Chiara Musacchio, Rugiada Cuccaro, Paolo Alberto Giuliano Albo and Simona Lago
INRIM, Torino

The measurements of the acoustic properties of materials at ultrasonic frequencies is of great interest for different fields, from medical applications to building acoustic. At the INRiM thermophysical laboratory an experimental apparatus for the measurement of the ultrasonic absorption coefficient is currently being implemented. The measurement method used consists in the comparison of an ultrasonic tone burst signal passed through a reference material with that one passed in the sample under test. The Fast Fourier Transforms (FFT) of the received signals are then analyzed comparing their amplitudes at specific frequencies. Different transducers are used to cover the frequency range of interest. In this work the apparatus is described and preliminary measurements conducted on bones sample and gels mimicking biological soft tissues in the frequency range between 1 to 10 MHz are presented.

Session "Medical acoustics"

Wed 11:20 Hotel Terme room 1 Medical acoustics

Preclinical Stress Test for Coding Strategies in Cochlear Implants

Michele Nicoletti, Christian Wirtz and Werner Hemmert
IMETUM, Bioanaloge Informationsverarbeitung, TU München

Although modern cochlear implants (CI) are able to restore speech perception to a high degree, there is still a large potential for improvements e.g. in music perception and speech discrimination in noise. To evaluate and optimize novel coding strategies, we have developed a toolbox which codes sound signals into spike-trains of the auditory nerve. We have previously developed a model of the intact inner ear, which we have complemented with detailed models of a CI speech processor, channel crosstalk and the electrical excitation of spiral ganglion neurons. With our toolbox we present qualitative comparisons of neurograms elicited by different coding strategies with the situation in the healthy inner ear. Moreover, we conducted quantitative evaluations using two methods: i) We harnessed the framework of automatic speech recognition to evaluate speech discrimination using a noisy database. ii) We applied a binaural model which processed interaural time differences and quantified if the temporal precision of cochlear implant coding strategies is sufficiently precise to convey spatial information. The major advantage of our approach is that we are able to evaluate both spectral and temporal aspects of novel coding strategies before we conduct extensive clinical studies.

Wed 11:40 Hotel Terme room 1 Medical acoustics

Objective Evaluation of Binaural Noise Reduction Schemes

Christoph Völker, Giso Grimm and Stephan M.A. Ernst
University of Oldenburg, Medical Physics

Separating sound sources in complex acoustical environment is an everyday challenge for our auditory system. Listeners with normal hearing are able to use binaural cues to solve this problem, but in impaired hearing these mechanisms are often disturbed. The aim of binaural noise reduction schemes in hearing aids is to improve the signal-to-noise ratio (SNR) in complex acoustic environments and to support hearing impaired listeners in utilizing relevant spatial information.

In this study three binaural noise reduction schemes are evaluated with a battery of technical performance measures. The algorithms make use of the interaural coherence function. The effect of systematically varying main algorithm parameters (e.g. the efficiency exponent) as well as the sensitivity to input SNRs has been assessed. The measures include output SNR improvement, speech intelligibility index (SII), the binaural extension of SII (BINSII) and the auditory-based quality model PEMO-Q.

Several combinations of realistic speech and noise signals (including male and female speakers in binaural recordings of cafeteria noise) serve as test-stimuli for the algorithms. The speech-noise mixtures are evaluated at different SNRs ranging from -5 dB to 5 dB.

The results provide an indication for balancing the benefit of signal processing and possible reduction of perceived quality.

Session "Recent advances on sound and vibration active control 1"

Wed 15:30 Hotel Terme room 1 Sound and vibration control 1

Nonlinear Damping for Energy Harvesting

Maryam Ghandchi Tehrani and Steve Elliott
University of Southampton, ISVR (UK)

In this paper, a nonlinear damping strategy is considered for energy harvesting with an electro-mechanical energy harvester. A nonlinear quadratic damper is proposed and analysed, in order to determine the performance, with regard to the average absorbed power and the displacement transmissibility. An analytical solution is then derived using the concepts of the describing function and the harmonic balance. In addition, the performance of the nonlinear semi-active damper is compared with the linear one. It has been shown that the nonlinear damper can harvest much more power for high level of base excitation, despite having much smaller displacement in comparison to the linear damper. A practical implementation of the nonlinear damping is then proposed using shunted electromagnetic actuator.

Wed 15:50 Hotel Terme room 1 Sound and vibration control 1

Potential of Active Vibration Attenuation on a Complex Structure

Britta Späh and Stephan Rinderknecht
TU Darmstadt, Institute for Mechatronic Systems

This paper systematically investigates the potential of active vibration attenuation on the complex structure of an automotive manual transmission. Transmissions are cause of many vehicle noises. At certain load conditions the gear meshing excites resonance vibrations of the transmission. This phenomenon is known as gear whining and is the object of this study. A 1.8 million degrees of freedom finite element model of the transmission, which is matched to results of an experimental modal analysis, is used to set up a mechanical state space model. Applied on this model, a genetic optimization algorithm offers sensor and actuator positions, which are optimal in terms of observability and controllability in the frequency range of interest. On these positions, piezopatches whose dimensions are optimized with respect to the piezoelectric coupling factor are coupled with the transmission FE-model. They are used as actuators or sensors respectively. For the hybrid model, passive and active shunt damping as well as closed loop control is implemented. The comparison of the dynamic characteristic of the purely mechanic system with that of the active systems allows the final evaluation of the potential of different vibration attenuation methods regarding the gear whining.

Wed 16:10 Hotel Terme room 1 Sound and vibration control 1

H2 optimal vibration control using tuned mass dampers and inertial actuators: comparison of passive and active control effects.

Neven Alujevic[a], Guoying Zhao[a], Bruno Depraetere[b], Bert Pluymers[a] and Paul Sas[a]

[a] *KU Leuven;* [b] *FMTC, Heverlee (B)*

Tuned mass dampers (TMD) can be added to structures to reduce vibrations originating from an especially pronounced resonance. The simplest model of a TMD comprises a mass which is connected through a spring-dashpot pair to the primary structure. Important parameters of a TMD are its resonance frequency, determined through the mass and the spring stiffness, and the damping coefficient. These have to be carefully chosen with reference to the primary structure properties in order to achieve good vibration reductions in a broad frequency band. If a force actuator is added in parallel to the spring-dashpot pair, a tuned mass damper becomes an inertial actuator, which can be used to further attenuate vibrations of the primary structure. In this case a velocity sensor can be placed at the inertial actuator footprint whose output is fed back via a negative gain to the actuator, yielding a velocity feedback loop. This brings another parameter into the consideration which is the feedback gain. The optimum resonance frequency and the damping coefficient for passive TMDs have been determined using various optimality criteria throughout the 20th century. In this study we derive closed form expressions for the optimal parameters of an active tuned mass damper.

Wed 16:30 Hotel Terme room 1 Sound and vibration control 1

The research project LOEWE-Zentrum AdRIA: recent results and latest developments

Joachim Bös[a], Thilo Bein[b] and Holger Hanselka[a]

[a] *TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM;* [b] *LOEWE-Zentrum AdRIA, Fraunhofer LBF*

The LOEWE-Zentrum AdRIA (Adaptronics - Research, Innovation, Application) is a large interdisciplinary research project located in Darmstadt, Germany, that is mainly funded by the government of the German federal state Hessen. The project partners are the Fraunhofer Institute for Structural Durability and System Reliability LBF, 21 research groups from six different departments of the Technische Universität Darmstadt, and one department of the Hochschule Darmstadt (University of Applied Sciences). The project aims at increasing the marketability of devices for active noise and vibration control by means of a balanced mixture of basic research, applied research, and industrial applications within the three application scenarios ”adaptive car”, ”quiet office”, and ”adaptive tuned vibration absorber”. Areas of research include materials (e.g., improvements of lead-free and transparent piezoceramic materials), simulation (e.g, fluid-structure interaction, model order reduction), innovative sensor and actuator concepts, new control strategies and electronics, and innovative production processes for robust sensors and actuators.

This paper gives a general overview of recent results and the latest developments of this research project. It serves as an introduction to some of the following presentations and papers that cover various specific topics of the LOEWE-Zentrum AdRIA in more detail.

Wed 16:50 Hotel Terme room 1 Sound and vibration control 1

Identification of Power Transfer Matrices

Gregor Lukas Stein, Oliver Janda and Ulrich Konigorski
TU Darmstadt

Power transfer matrices allow for the calculation of time-average structure-born sound power when the velocity profile of the emitting structure is known. Since the time-average sound power is bound to be nonnegative, the power transfer matrix is known to be positive definite. A novel method is presented for the experimental modeling of these matrices. The structure's velocity profile is approximated by a finite number of mode shapes which are detected by an array of modal filters. The emitted sound power is calculated from measurements of sound pressure and particle velocity at a finite number of points on a surface enclosing the structure. We show how an approximation of the power transfer matrix can be computed from certain transfer functions which are connecting structural modal velocities and acoustic quantities. These transfer functions are required to be strictly positive real in order to yield a positive definite power transfer matrix. Thus, the identification procedure includes two steps. First, a discrete-time parametric model is fitted to the measured frequency response data. In a second step, the obtained model is modified to guarantee the strict positive realness property. Both steps are formulated as convex optimization problems. Experimental results from a rectangular plate are provided.

Wed 17:10 Hotel Terme room 1 Sound and vibration control 1

Reduction of the sound transmission through a double-glazed window by the use of adaptive methods

Tim Bastian Klaus and Sven Herold
Fraunhofer Inst. for Struct. Durability and System Reliability LBF

In times of growing traffic loads the acoustic enclosure of private households and employments gets more and more important. Operating against the growing noise level, sound transmission paths into rooms have to be evaluated for the reduction of the sound nuisance. In this context windows turn out as great weak spots. Incoming sound waves excite the outer glass plate. The vibrations are transmitted by the acoustic fluid inside the window to the inner glass plate. Although the acoustic energy is decreased by each impedance step the vibrations effect a considerable sound radiation inside the building. By the use of adaptive measures, like Helmholtz resonators that act on the acoustic fluid between the glass plates, it is possible to reduce the sound pressure and the associated noise transmission. For the investigation of the sound transmission a double-glazed window is mounted on the acoustics demonstrator of the LOEWE Centre AdRIA depicting a real room. The wall-characteristic of this rectangular cavity are designed

as sound reflecting. Exciting the acoustic volume inside it is possible determining the transmission through the window and to derive its reduction by use of adaptive methods.

Wed 17:30 Hotel Terme room 1 Sound and vibration control 1

Acoustic masking by means of an active system

Christian Thyes, Johannes Tschesche, Joachim Bös and Holger Hanselka
TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

The effect of hiding a quiet sound behind a loud one is called acoustic masking. At the LOEWE-Zentrum AdRIA in Darmstadt a test stand was designed and built to investigate this effect. The test stand simulates the housing of a machine and some sort of machinery noise.
Various strategies of acoustic masking were designed and implemented at the test stand including a hardware-in-the-loop control system and smart material actuation by means of piezoceramic patch actuators.
The main concept that is described in this paper uses additional narrowband noise to change the sound characteristics. Therefore, the machinery noise is filtered according to the characteristics of the human hearing. Then for each frequency band an additional noise signal is generated depending on the excitation. This signal is transferred to an amplifier and fed to the actuation. The behavior of the controller can be changed with various amplifications and time constants of the controller making it react faster or smoother.
This way masking can be used to change the sound characteristics. The influence of this approach on psychoacoustic metrics is discussed.

Wed 17:50 Hotel Terme room 1 Sound and vibration control 1

Simulation of smart wolf note eliminators

Johannes Tschesche, Christian Thyes, Joachim Bös and Holger Hanselka
TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

The wolf note is an unwanted acoustical phenomenon that occurs on string instruments, in particular on violoncellos. It is characterized by a flickering, howling sound. Due to its similarity to the howling of a wolf, the phenomenon is called ”wolf note” or ”wolf” for short. The wolf occurs particularly if the fundamental frequency of a played note equals a natural frequency of the cello body. A common solution is the application of a so-called wolf eliminator. Wolf eliminators are mechanical resonant absorbers that are usually applied on the strings between the bridge and the tailpiece. Unfortunately, resonant absorbers work only at a single frequency. In case of temperature changes or an altered state of air humidity, the natural frequencies of the cello body may change and the wolf eliminator is not effective any more. Improved resonant absorbers based on smart materials are developed at the LOEWE-Zentrum AdRIA. These smart absorbers can be applied to serve as improved wolf eliminators. A numerical demonstrator that simulates the wolf note was set up using the FEM. This paper describes how smart wolf eliminators can be simulated. The principle effect is demonstrated and the impact of the smart wolf eliminator is shown.

Wed 18:10 Hotel Terme room 1 Sound and vibration control 1

Investigation of the Applicability of Dielectric Elastomer Actuators (DEA) for Active Vibration Attenuation on Planar Structures

Roman Karsten[a], Mesut Ibis[b], Peter Groche[b] and Helmut F. Schlaak[a]
[a] *TU Darmstadt, Institute of Electromechanical Design;* [b] *TU Darmstadt, Inst. for Production Engineering and Forming Machines*

This paper presents an approach to use dielectric elastomer actuators (DEA) for active influence on the planar structures like windows or curved sheet metal parts. Nowadays, piezoelectric patch actuators are deployed for these applications. Instead, the DEA offer an alternative. A dielectric elastomer actuator is built like a parallel plate capacitor. It consists of two compliant electrodes and a soft silicone dielectric between them. An applied voltage at the electrodes causes an electrostatic pressure and thus a compression of the actuator. Due to the constant volume of the elastomer the actuator spreads in plane, too. Dependent on the design of the DEA planar or normal force can be used. Two different actuator designs are investigated. The first one is a single layer DEA (60 x 30 mm^2) with stiff metal electrodes which produces planar force. The second investigated actuator is a multilayer DEA with 50 layers which generates higher normal stroke compared to the first design. It is deployed as an inertial exciter and produces normal force. The experimental results show that the multilayer DEA is more suitable for the frequency range between 20 - 500 Hz. Instead, the single layer DEA is better applicable for higher frequencies above 1 kHz.

Session "Listening and understanding speech in rooms 2"

Wed 8:40 Hotel Terme room 2 Speech in rooms 2

Envelope enhancement for improving hearing in reverberant spaces

Bernhard Seeber[a] and Jessica Monaghan[b]
[a] *Audio Information Processing, TU München;* [b] *MRC Institute of Hearing Research, Nottingham (UK)*

Cochlear implants are neural prostheses which give a sense of hearing to deaf people by stimulating the auditory nerve. In many users they restore the ability to understand speech in quiet, but noise and reverberation cause severe problems. It seems that implant users have difficulties hearing out one source in a potpourri of sources. This so called "auditory scene analysis" relies, amongst other cues, on binaural information which is degraded with implants. Here we focus on the coding of binaural information to improve the perception of sound direction - an important aspect for locating and understanding speakers. Past approaches have generally attempted to reduce the energy of the interfering reverberation or noise. Our novel approach instead aims to increase the perceptual saliency of the cues used to locate sounds in reverberation. In simulations of implant use with normal-hearing listeners we demonstrate that by changing the coding of the target sound to better transmit its binaural cues, it can be localized better in reverberation. Despite the envelope alteration, speech understanding is not affected. The new approach only alters the transmitted envelope signal and

can thus be implemented in commercial devices without changing the implanted part.

Wed 9:00 Hotel Terme room 2 Speech in rooms 2

A subjective measure to quantify effortful listening

Nicola Prodi and Chiara Visentin
Università di Ferrara, Dip. di Ingegneria

The understanding of speech in rooms can be achieved under acoustical conditions which are rated as essentially different by the listeners concerning the resources that they expended in the task. In fact for a comfortable listening it is necessary that the users, together with the highest possible intelligibility, employ a minimal effort. A quantification of the latter effect can be obtained, in the case of recognition of low-context words, by a simple psychophysical measure known as ”response time (RT)” that is the time elapsed from presentation to tester’s feedback. By matching RT with the intelligibility scores the new ”listening efficiency” metrics is defined. This quantity is a subjective measure of the performance (intended as the ratio between accuracy and speed) achieved in the word recognition. By using listening efficiency the role of the sound system in the communication chain is better outlined. In this work this method is described and applied to a ”difficult” conference room and to a ”simple” church.

Wed 9:20 Hotel Terme room 2 Speech in rooms 2

Voice Care - A low-cost Platform for Monitoring Voice Professionals

Arianna Astolfi[a], Alessio Carullo[b], Alberto Vallan[b] and Lorenzo Pavese[a]
[a] *Politecnico di Torino - Dipartimento Energia;* [b] *Politecnico di Torino - Dipartimento di Elettronica e Telecom.*

For voice professionals, erroneous vocal behavior or changing in the voice production due to poor acoustics in the environment where the voice is used, can be investigated through recently developed voice monitoring devices. These devices are portable data-logger that use a miniature accelerometer glued to the jugular notch as a sensor of the skin acceleration level due to the vibration of the vocal folds. They estimate the SPL at a certain distance from the speaker’s mouth as a result of a calibration. Other provided parameters are the fundamental frequency and the time dose. Uncertainty specifications are not always available and the cost is in some cases prohibitive for a large monitoring campaign. The low-cost platform ”Voice Care” is proposed in this contribution, that includes a wearable data-logger and a processing program that allows the vocal parameters to be extracted from the recorded signal. The data-logger is equipped with a contact microphone as a phonation sensor. Suitable calibration procedures are implemented for the estimated parameters and their effectiveness is shown through specifically conceived experimental tests. Uncertainties are estimated and experimental results are reported that refer to the normal use of the device during monitoring interval of several hours in university classrooms.

Session "History of acoustics"

Wed 9:40 Hotel Terme room 2 History of acoustics

History of the Istituto di Acustica at Consiglio Nazionale delle Ricerche in Rome

Adriano Alippi
Università degli Studi 'Sapienza' di Roma

A short history of the Italian Institute of Acoustics is presented, from the foundation by O.M.Corbino in 1938 up to the most recent times, with the changing of the name and the corresponding evolution of the researches going on. Mainstreams of physical acoustics lead to the studies of internal friction in solid and the discovery of the so-called Bordoni peak and to pioneering works on acousto-optics, while attention has been successively given to room acoustics. Biomedical acoustics investigation was developed at the times that first experiments on echography were performed in few laboratories round the world and studies on transducer efficiency were correspondingly prosecuted in the Institute.

Wed 10:00 Hotel Terme room 2 History of acoustics

Concert hall design 1960-2010, a historical review

Jürgen Meyer
Braunschweig

Statistics of about 160 neu-designed concert halls show that in the 1960s hexagonal and fanshaped halls have been prefered. In the following decades their proportion decreased totally whereas shoebox halls and halls with surrounding audience increased more and more. Thia tendency is compared with the relevant progress of knowledge in room acoustics as well as in musical acoustics during these decades.

Wed 10:20 Hotel Terme room 2 History of acoustics

A New Catalogue of the Historic Acoustic-Phonetic Collection (HAPS) of the TU Dresden

Dieter Mehnert
TU Dresden

At DAGA2006, the historic acoustic-phonetic collection (HAPS) of the TU Dresden was presented for the first time. It covers the history of experimental phonetics and speech technology with a high degree of completeness. Since the date of establishing the collection, much effort was done to publish about the historic devices and their application, to present the museum items in different exhibitions, and to include the objects in the academic teaching. Additionally, we worked at the inventory of the collection and at the project of a comprehensive printed catalogue. Recently, the first part of this catalogue was completed and is available on the book market now. It includes the historic phonetic devices, which form the most valuable subset of the collection. It covers 244 items which are described in 8 chapters. The descriptions are complemented by 393 photographs by Rolf Dietzel. The catalogue is expected to be a valuable tool for those who are working

in the history of phonetics and, more general, speech and audio communication. The AIA-DAGA meeting will be a good place for this presentation because many of the exhibits date back to Panconcelli-Calzia, who had Italian ancestry, but spent the most part of his life in Germany.

Wed 10:40 Hotel Terme room 2 History of acoustics

The Common Work of Johannes Kessel and Ernst Mach in Prague 1871 - 1874

Rüdiger Hoffmann[a] and Lutz-Peter Löbe[b]

[a] *TU Dresden, Professur für Systemtheorie und Sprachtechnologie;* [b] *BfA-Klinik Borkum*

Johannes Kessel (1839 - 1907) was a German otologist who contributed a lot to the theory and surgery of the middle ear. We are investigating his scientific biography in an historic project since some years. From 1871 to 1874, he worked with Ernst Mach in Prague, and a number of fundamental papers were published there. It is interesting to learn more about this cooperation. Unfortunately, we have very few information about the personal life of Kessel in Prague. We reported about that in our paper at the DAGA in 2008. For the recent paper, we tried to find out more about the scientific cooperation of Mach and Kessel. This was enabled mainly by some notes, which we found in the diaries of Ernst Mach which are stored in the archives of the Deutsches Museum München. In this way, we are able to show some new material and give an improved description of the Prague period of Kessel.

Wed 11:00 Hotel Terme room 2 History of acoustics

Optical Analyzing of Eardrum Vibrations on Living Man: Wolfgang Köhler 1909

Götz Corinth[a] and Rüdiger Hoffmann[b]

[a] *Arzt für öffentliches Gesundheitswesen, Mainz;* [b] *TU Dresden, Professur für Systemtheorie und Sprachtechnologie*

Long time ago the registration and analysis of original eardrum oscillations of living man was a ”persistant dream” for the audio scientists. Many experiments with prepared eardrums of animals and human heads were done - but all objects were not in ”natural conditions” with joined ossicles and innerved muscles. The first series of real experiments were executed in 1909 by a young student, Wolfgang Köhler, at the Berlin University for his doctorate under the supervision of the well-known Prof. Carl Stumpf. He cemented a very small galvanometer mirror (weight 17 milligrams) on his own eardrum and aimed a light beam via a condensor and slit on it and registrated the reflection through a second lens on a clock-moved photographic plate. For analyzing the recorded curves, he used the ”actual method of the time” - a Mader/Ott graphic analyzer. The announced lecture consists of two parts: The first one should give a description of the experimental method and their results. The second one will demonstrate the method of of analyzing some old and new recorded curves by graphic-mathematical methods.

Wed 11:20 Hotel Terme room 2 History of acoustics

Origin and development of physical acoustics in Italy

Andrea Bettucci

Università degli Studi 'Sapienza' di Roma

Stemming out from first radio transmission experiments, acoustical physics in Italy is somehow connected with German physics, since the roots of it can be traced back to the stage Giacomini spent at Heinrich Hertz Institute in Berlin in 1929. Radio frequencies were fed into piezoelectric plates and became ultrasound. Acousto-optics in liquids was the first topics of acoustical physics after the 2nd World War developed at the Institute of Acoustics in Rome, that lately extended to internal friction in solids, to transducer arrays and surface acoustic waves. Scientists at the Institute of Acoustics developed new fields in new places: acoustic cavitation and acoustic emission at Catania and Rome University, Lamb waves and Brillouin scattering at Perugia University. In the mean time, acoustical radars and surface acoustics waves developed in Florence at the Institute of Electromagnetic Waves, following the tradition of optics that was present there.

Wed 11:40 Hotel Terme room 2 History of acoustics

Environmental noise in Italy: A Historical Perspective

Carmine Ianniello

Univ. of Naples 'Federico II'

The sonic environment of inhabited areas in our country has evolved over time. Social phenomena have caused an increase of the environmental noise of a different nature. This resulted in a constant struggle between the noise makers and those who suffer the negative effects. This note tries to highlight briefly the major steps of the efforts made to mitigate the menace to the wealth and well being of population. To the knowledge of the author the awareness of the environmental noise in our country dates back to the ancient times when Greek colonists in Southern Italy and Romans issued ordinances and regulations against noisy activities. Little is known about this subject in medieval age. Awareness and public actions against environmental noise in Italy started concretely in the last part of the 20th century with an increasing rate up today.

Session "Physical acoustics"

Wed 15:30 Hotel Terme room 2 Physical acoustics

Ultrasonic Grain Scattering Noise Calculation in Polycrystalline Materials

Sigrun Hirsekorn
Fraunhofer IZFP, Saarbrücken

Scattering of ultrasound at grain boundaries in polycrystalline materials causes sound velocity dispersion and attenuation. These effects as well as the amplitudes of the scattered waves can be used for materials characterization, but concomitant hamper defect detection and evaluation because the so-called grain noise superposes the defect signals entailing the need to include grain scattering into ultrasonic nondestructive testing simulations. R.B. Thompson, F.J. Margetan, and co-workers calculate directional dependent ultrasonic grain scattering coefficients in polycrystals from a first order Born approximation of scattering at a single grain within a macroscopically averaged matrix, the ensemble average of the material. This approximation is valid only for low scattering in the Rayleigh regime (low frequency limit) and yields too low scattering amplitudes for materials with high single crystal anisotropy as e.g. most steels. This contribution presents results following from the ensemble averaged equation of motion in the Born and in the Keller approximation of second order. The exploitation of the underlying analytical formalism for sound velocity dispersion and attenuation calculations already described in the literature shows the power of this approach for large scattering and also for higher frequencies. Here, the calculation of the scattering waves, the grain noise, is presented.

Wed 15:50 Hotel Terme room 2 Physical acoustics

Auditory functional MRI of interaural time and phase differences

Stefan Uppenkamp and Paul Glad Mihai
University of Oldenburg, Medical Physics

Binaural hearing allows for the use of interaural level, time and phase differences, providing essential cues for sound localisation. This has been extensively explored in numerous psychoacoustic and neurophysiological studies. One possible mechanism for the extraction of interaural time differences (ITD) has been implemented in the sound localization model by Jeffres (1948). Recent physiological studies, however, suggest that the auditory system might actually be more sensitive to the corresponding interaural phase differences (IPD), rather than to the ITD cue itself. In this study, activation maps of the human auditory pathway in response to stimuli with different ITD and IPD were recorded by means of functional magnetic resonance imaging. The stimuli were either static sounds or dynamic stimuli with a varying ITD and IPD cues. Results indicate for both, ITD and IPD stimuli, that (1) dynamic stimuli produce more cortical activation than static stimuli, and (2), that Planum temporale is largely involved in the processing of dynamic stimuli, while the activation in response to static stimuli is more restricted to Heschl's gyrus. A systematic difference between ITD and IPD

cues could not be confirmed at the level of auditory cortex, probably due to the large perceptual similarity of the conditions.

Wed 16:10 Hotel Terme room 2 Physical acoustics

Bubble Pair Interaction

Werner Lauterborn[a], Bing Han[b], Robert Mettin[a] and Alfred Vogel[c]
[a] *Georg-August-Univ. Göttingen, 3. Physikalisches Institut;* [b] *Nanjing University of Science & Technology;* [c] *University of Lübeck, Institut für Biomedizinische Optik*

Bubbles in liquids are of common appearance in nature and technical equipment. When set into oscillation or translatory motion by acoustic or other forces they exhibit strange dynamics with the development of high speed liquid jets, shock waves and even light emission. For cleaning problems and in view of their erosion capabilities on solid surfaces the dynamics near interfaces of various kinds are investigated since long time. Less work is known on the interaction of bubbles. They can attract or repel each other, but also influence or evoke jet formation. In the present contribution bubble pair dynamics is investigated numerically with open source computational fluid dynamics software and compared with available experimental data. Special emphasis is given to the pressure distribution in the liquid and how it steers jet formation and bubble splitting of both bubbles. The cases of in-phase oscillating bubbles and of out-of-phase oscillating bubbles is considered. Bubbles are introduced numerically into the liquid either expanded or as a compressed volume of uncondensable gas mimicking laser induced bubbles. The parameters of extreme jet formation are sought for, as jets may be important for opto-injection of assorted material into cells.

Wed 16:30 Hotel Terme room 2 Physical acoustics

Acoustic signatures of fast micro-droplet impact

Philipp Frommhold and Robert Mettin
Georg-August-Univ. Göttingen, 3. Physikalisches Institut

The impact of very fast micro-droplets on solids and on deep water surfaces is investigated. From high-speed video recordings and acoustic emission measurements, the impact process is characterized. Peak pressures are estimated, and noise characteristics of multi-droplet impact are extracted. The findings are compared to results from erosion and noise caused by rain drops.

Wednesday Physical acoustics (Poster)

Wellenausbreitung im inhomogenen und anisotropen Festkörper
Oskar Bschorr
Aeroakustik Stuttgart
Aufgabe ist die Ausbreitung von longitudinalen und transversalen Planwellen im inhomogenen und anisotropen Festkörper. Dazu werden die Dyaden der Spannung und des Gradienten der elastischen Auslenkung auf die 3x3 kinematischen und sterischen Komponenten reduziert. Diese sind orthogonal und vereinfachen dadurch den Hookeschen Algorithmus. - In einem inhomogenen Körper erfährt eine longitudinale Welle eine Krümmung entsprechend der Snellius-Brechung und eine Auffächerung mit dem Divergenz-Radius. Bei einer Transversalwelle mit einem Gradienten des Schermoduls kommt es zusätzlich zu einer Drehung der Polarisationsebene. Beim anisotropen Körper liegen die Vektoren der longitudinalen und transversalen Wellengeschwindigkeit auf den von je 3 Hauptwerten aufgespannten Ellipsoiden.

Wednesday Physical acoustics (Poster)

Review of the use of metamaterials for acoustic scattering reduction
Marco Norambuena and Martin Ochmann
Beuth Hochschule für Technik Berlin
Metamaterials have opened a door with new possibilities to control wave propagation. In this field, cloaking has undoubtedly drawn the most attention due to its large potential. In more precise terms, cloaking refers to the capability of a metamaterial to reduce the acoustic scattering of an elastic body. The benefit of this is that for an observer the elastic body becomes invisible. This work presents a review of the cloaking devices found in the literature. Theoretical background of the cloaking is presented and discussed. The transformation media is illustrated to explain how the parameters of the metamaterials are obtained. Several examples of cloaking devices are summarized and presented. The final goal of this work is to serve as a stepping stone for future research in poroelastic metamaterials.

Wednesday Physical acoustics (Poster)

Acoustical properties of metal-ceramics composites in dependence on temperature of sintering
Andrew Abramovich
St. Petersburg State Techn. University of Plant Polymers (RUS)
In the work the results of studding of elastic moduli and absorption coefficient of longitude ultrasonic waves with frequency of 10 - 50 MHz in samples of metal-ceramics based on corundum and stainless steel are presented. The samples were produced by vacuum sintering of corundum and metal powders with different concentrations (5 -35 wt.%) at temperatures 1400 - 1700oC. The concentration dependences of elastic moduli and absorption coefficient for different sintering temperatures is discussed within setting of modern concepts about of micro-heterogeneous medium. It

is discussed also some possibilities of applications of the researched composites as technical ceramics.

Session "Acoustic measurements and instrumentation 1"

Wed 16:50 Hotel Terme room 2 Acoustic measurements 1

Measuring the angle-dependent sound absorption coefficient with a small microphone array

Erwin Kuipers, Ysbrand Wijnant and André de Boer
University of Twente, Enschede (NL)

Measurement of the angle-dependent sound absorption coefficient is problematic for non-locally reacting surfaces and/or surfaces with a complex geometry. The difficulty lies in the generation of overall sound field models for such surfaces, which is difficult or even impossible. This paper presents a novel method that does not rely on an overall sound field model, but is based on a purely local concept instead. It is therefore applicable to determine the angle-dependent sound absorption coefficient for the aforementioned surface types. In every measurement point, the incident and reflected sound intensity are determined, as well as the angle of incidence. The area-averaged sound absorption coefficient of a certain surface area is then calculated by spatial integration. The measurements are performed with a small, newly developed, three-dimensional microphone array, consisting of MEMS-microphones.

Wed 17:10 Hotel Terme room 2 Acoustic measurements 1

Measurement of Angle-dependent reflection coefficients with a microphone array and spatial Fourier transform post-processing

Rob Opdam, Sander Hoen, Diemer de Vries and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

In today's state of the art room acoustic simulation algorithms, based on a hybrid of ray tracing and mirror image sources, it is desirable to use a correct scattering coefficient to improve the accuracy of the simulated data. This scattering coefficient can be determined with full knowledge of the angle-dependent reflection coefficients of materials. Several methods exist, but have their individual advantages and disadvantages. One common disadvantage is the lack of speed. In this work Tamura's spatial Fourier- transform method [1,2] is implemented in combination with a microphone array to improve the speed of the angle-dependent reflection coefficient measurement. Simulated data will be compared with measurements and the influence of the array configuration and finite material sample size on the results will be discussed as well. [1] Tamura, J. Acoust. Soc. Am., Vol. 88, No. 5, November 1990; [2] Tamura et. al., J. Acoust. Soc. Am., Vol. 97, No. 4, April 1995.

Wed 17:30 Hotel Terme room 2 Acoustic measurements 1

Diffuse-field reciprocity calibration of measurement microphones

Simon Weihe[a], Volker Wittstock[b] and Matthias Blau[a]
[a] *Jade-Hochschule Oldenburg;* [b] *Physikalisch-Technische Bundesanstalt*

The primary calibration of measurement microphones is performed by reciprocity technique where microphones act as sound source and as receiver. The ratio between acoustic and electric quantities is identical in both directions. Therefore, the sensitivity of microphones can be determined by measuring the input current into the sending microphone and the output voltage of the receiving microphone. Additionally, the properties of the acoustic field must be known. The technique requires the use of three microphones where each microphone is used once as emitter and once as receiver. This method is standardised in pressure and in free-fields. The application in diffuse sound fields is more difficult to implement. The reason is that the source strength of a microphone is too small to excite a reverberation room of about 200 m^3 with a measurable sound pressure. Therefore, a scaled model of a reverberation room with a volume of 0.23 m^3 is used at PTB to implement the method. The diffuse field correction is of interest for frequencies above 1 kHz. The scaled reverberation room is expected to provide an approximate diffuse sound field in this frequency range. The measurement setup, measured sensitivities and comparisons to known random incidence sensitivities will be presented.

Wed 17:50 Hotel Terme room 2 Acoustic measurements 1

Free-Field Calibration of Measuring Microphones - A Method Providing Additional Value

Heinrich Neubauer, Hans-Günter Uszakiewicz and Michael Mende
SPEKTRA Schwingungstechnik und Akustik

The various concepts that are in practical use for the calibration of measuring microphones are based on different principles of applying a test signal to the device under test. This results not only in advantages and disadvantages with respect to the practical measurements, but also entails different information about the proper functioning and long-term stability of the test objects. Based on our long-term experience in the practical use of free-field calibration, we have come to the conclusion that this is the method of choice for a thorough characterisation of microphones. It provides valuable information about the frequency response as well as parameter shifts and a decline in performance. Free-field calibration can therefore be regarded as providing important additional information over and above other microphone calibration methods. Furthermore, we consider free-field calibration as the most appropriate method for calibrating microphones that are used outside of buildings, with a particular focus on microphones for monitoring aviation noise.

Wed 18:10 Hotel Terme room 2 Acoustic measurements 1

The New ISO 126101

Hans-Joachim Milz
G+H Schallschutz GmbH

The new standard ISO 26101 is based on the established standard ISO 3745 Annex A. It gives procedures for the qualification of acoustic free fields in chambers. While the ISO 3745 is limited to the free fields for precision measurements, the new ISO 26101 allows general qualifications of free fields not only for precision measurements. The new ISO 26101 will be discussed and the advantages, expansions and differemces to the ISO 3745 Annes A will be shown.

Session "Music acoustics 2"

Wed 8:40 Hotel Terme room 3 Music acoustics 2

Modal Analysis of the Tar Box Using Finite Element Method

Ferina Saati Khosroshahi
Tehran University, Iran

In this work, the subjective is to present a study of the modal characteristics of Tar, an Iranian musical instrument which is unrivaled among the other studied instruments due to the shape of its resonance box and is specific to Eastern musical culture. In our case of study, the geometry is far unreachable than a hundred hours of working by hand can reach, because Iranian instruments, specially Tar cling to no specific pattern except to some diameters and some general shapes; therefore, 3D laser scanning method is the best way to choose for describing the outside geometry of the box of Tar so that no single detail would be missed. Vibrations of the resonance box of the Tar have been studied by means of the modal analysis technique and the finite-element method. The final step in the study is to run a normal coupled mode analysis and also experiment an impact hammer modal test on the entire Tar and compare the results of the two tests. In this phase, we will only focus on the box and will study the vibrations both numerically and experimentally without considering the effects of air.

Wed 9:00 Hotel Terme room 3 Music acoustics 2

Feedback Control of Electric Guitar Strings: Collocated Control Using Physical Models

Edgar Berdahl
Audio Communication Group, TU Berlin

Properties of acoustic musical instruments can be altered using feedback control to create new hybrid digital-acoustic musical instruments. Consider collocated feedback control in the context of a vibrating string: a sensor measures the velocity of the string over a certain window along the string, a feedback controller computes a real-time force command as a function of the string velocity, and an actuator exerts the force command on the string over the window where velocity was measured. Assuming that the resonance frequencies are not known precisely, only feedback controllers that implement physical models are guaranteed to be stable. In summary, collocated control using physical models is the recommended approach.
The theory is tested in the context of a design for changing the physical properties of six strings on an electric guitar. Nonlinear and/or time-varying physical models can induce particularly intriguing dynamic behaviors. Practical advice is given for researchers interested in applying the concept to other instruments, including a design procedure. Finally, a proof is referred to explaining why changing the resonance frequency of a musical resonance requires much more control power than changing the decay time of the resonance.

Wed 9:20 Hotel Terme room 3 Music acoustics 2

The Impact of Music Preference on the Physiological Activation of the Human Body due to Music Reception

Fabian Greb and Jochen Steffens
University of Applied Sciences Düsseldorf

Music is calming, music is activating, music is enchanting, but what happens to our body when we are listening to our favorite music? For a long time many surveys in medical, psychological and neurobiological research have been dealing with the impact of music on the human body. Thereby the reactions to specific music pieces were mostly examined. Also most surveys assumed that the impact of music on the body can be generalized and is supra-individual. Just a view studies include the relationship between the subjects and the presented music. Also in the research field of music preference the correlation of subjective preferences and physiological activation has been barely studied yet. Listening to music undeniably leads to physiological reactions, but are these reactions affected by individual music preference?
In an experiment subjects listened to different pieces of music from a wide range of music genres. In the meantime their physiological reaction was captured. Thereafter the individual music preferences were estimated by using a questionnaire and a qualitative interview. This article deals with the relationship between music preference and physiological activation based on the results of the survey.

Session "In vivo acoustic measurements in musicians and music instruments"

Wed 9:40 Hotel Terme room 3 In vivo measurements

Application of Sound Shields in Orchestras - I. Acoustic Measurements

Cristina Zamorano[a], Malte Kob[a], Timo Grothe[a] and Heinz-Dieter Neumann[b]

[a] *Hochschule für Musik Detmold, ETI;* [b] *Unfallkasse Nordrhein-Westfalen*

The upper limit values for noise exposure of workers given by the "Noise and Vibrations Occupational Safety and Health Ordinance" and directive 2003/10/EC are LEX,8h = 85 dB(A) and LC,peak = 137 dB(C). Orchestra musicians sitting 3 m in front of brass or percussion sections are typically exposed to LA,eq values of up to 105 dB(A). Obtaining an appropriate sound attenuation in orchestras without disturbing the artistic performance is a challenging task. Given the variety of hearing protection solutions such as individual screens or earplugs, this in-vivo study investigates the acoustic effects of using wide sound shields between orchestral sections. Several shield configurations have been tested in four orchestras. Microphone recordings were carried out with and without shields at a distance of 10 cm from the musician's ear on both sides of the screens, at the conductor and in the audience. The Leq is calculated from paired samples of 10 seconds of music, and the measured levels are compared. During performances, Leq,125ms differences between both sides of screens reached values up to 15 dBSPL. Room acoustics and the positions of all orchestra instruments relative to the shields are potential reasons for significantly lower Leq that are measured over longer periods.

Wed 10:00 Hotel Terme room 3 In vivo measurements

Application of Sound Shields in Orchestras II - Survey

Verena Beatrix Schulte[a], Cristina Zamorano[a], Malte Kob[a], Maria Schuppert[b] and Heinz-Dieter Neumann[c]

[a] *Hochschule für Musik Detmold, ETI;* [b] *Hochschule für Musik Detmold;* [c] *Unfallkasse Nordrhein-Westfalen*

According to recent research (e.g. Neumann et al. DAGA 2010, Schuppert et al. DAGA 2011), professional orchestra musicians frequently suffer from noise-induced hearing loss caused by long time exposition to high sound levels. These are produced by loud instrument groups depending on several parameters such as repertoire, acoustics, and orchestra settings. One solution to reduce the sound level is the application of sound shields in front of the loudest orchestral sections as investigated by Unfallkasse NRW and PTB Braunschweig. Apart from the effect of sound reduction a lack of acceptance was observed in some groups of musicians. Aim of our study is a detailed knowledge of the origin of these observations and an approach for improvement of the acoustic conditions for orchestra musicians. Besides objective research we conducted a survey among the musicians to evaluate their comfort/discomfort while rehearsing with and without the shields. Surveys in four different orchestras indicate that by using the sound

shields most of the brass players behind the screens complained about the separation from their colleagues and modification of their own instrument's sound. However, all of the musicians in front of the screens experienced a lower sound level during rehearsals compared to playing without screens.

Wed 10:20 Hotel Terme room 3 In vivo measurements

A Physiologic Approach to Rate the Damage Risk of Impulse Noise

David Pazen and Martin Walger
HNO Uniklinik Köln

Short impulse sounds with high peak pressure levels are potentially harmful to the hearing organ, especially the sensitive hair cells of the inner ear. Only taking into account simple physical quantities like the peak level, etc. is not considered to be sufficient to quantify the damage risk of such sound exposures. A more promising approach to quantify the risk of auditory damage is the Auditory Hazard Assessment Algorithm for Humans (AHAAH), which is based on a physiological model. In addition to the AHAAH predictions, the change of otoacoustic emissions (OAEs) after a defined exposure to noise allows the individual detection of small physiological changes of the outer hair cells before any serious damages like threshold shifts may occur. In pilot experiments the combination of the AHAAH predictions and OAE measurements was applied to different impulse sounds of percussion instruments, artificial clicks from a loudspeaker, a clicking frog and a toy pistol. The OAEs did not change significantly after these exposures and the AHAAH rated them as harmless despite peak levels of about 140 dB. Therefore damage risk criteria should be based on physiological models and measurements to ensure the best protection of the auditory system against noise induced hearing loss.

Session "Demands on room acoustic criteria"

Wed 10:40 Hotel Terme room 3 Room acoustic criteria

On the Nature and Usability of Room-acoustical Parameters

Jens Blauert
Ruhr-Universität Bochum, Inst. of Communication Acoustics

It is an old dream of acousticians to identify parameters that represent the aural experience of performance spaces comprehensively but can, nevertheless, be assessed instrumentally, namely, with acoustical (physics-based) measuring instruments. A battery of such parameters are actually in use, such as those standardized in ISO 3382, but also more sophisticated ones like Clarity (C80), Center Time (Ts), Apparent Source Width (ASW), Interaural Cross Correlation (IACC), or even more complex indices like Perceived Audio Quality (PEAQ) - just to mention a few. The all have in common that they are derived from acoustic data, that is, properties of elasto-dynamic vibrations and waves, and not from aural data, that is, properties of auditory events. Consequently, they exhibit a very low amount of inter-individual variance ("objectivity"). This is appreciated by acoustical designers and consultants, but also poses a serious risk when incautiously applied to the prediction of aural experience - the latter being prone to

higher inter-individual variance (”subjectivity”). In this talk, epistemological foundations of aural experience of performance spaces will be discussed with the aim of fostering careful usage of room-acoustical parameters when describing and predicting the aural qualification of such spaces, that is, of what is colloquially termed their ”acoustics”.

Wed 11:00 Hotel Terme room 3 Room acoustic criteria

Room Acoustical Parameters in predictions of concert hall preference - about uncertainties, explanation and understanding

Magne Skålevik
Brekke & Strand, Spikkestad (NO)

Concert hall acoustics are very difficult and expensive to improve once the hall has been built. Thus there is high demand for safe methods to predict the public preference for the concert hall. After a hundred years of experience with room acoustical parameters, we still need to investigate by the main streem approach: Which set of physical quantities, i.e. parameters, are critical and relevant? What are the preferred values of these parameters? How can we predict the outcome in the planned hall? Each of these questions can only be answered with some degree of uncertainty, and the uncertainties add up. Not only do we deal with uncertainties in the physical measurements. There are of course the uncertainties in subjective data, in the ranking of halls. Improved predictions and reduced uncertainty in outcome may have the cost of reduced understanding of the details in the causal chain. This paper is a status report on this author’s ongoing investigations and some findings so far.

Wed 11:20 Hotel Terme room 3 Room acoustic criteria

Demands on Stage Acoustic Criteria

Margriet Lautenbach and Martijn Vercammen
Peutz bv, Mook (NL)

The ISO 3382 gives two specific parameters for stage measures. Earlier investigations indeed showed no correlation between the opinion of musicians in a symphonic orchestra and the other ISO parameters derived from impulse. This might have to do with the fact that on stage the distances between source and receiver are short, so the influence of the direct sound on the ”usual” parameters is large compared to the influences of stage environment. Nevertheless, musicians react strongly on different stage environments, so there must be something that can be measured which is in agreement with the opinion of musicians. Our investigation on stage acoustics started with the renovation of De Doelen in 2008, where was asked to investigate the re-introduction of stage reflectors. From a small tour with the orchestra we found that the subjective opinion for ëhearing each other’ did correlate with the G5-80, also the strength calculated without direct sound until 80 ms. In 2012 we followed to orchestras on tour to extend our investigation on stage acoustic. The musicians were individually asked to fill out a questionnaire, and extensive impulse response measurements were performed on all stages. This paper gives an overview of the results of this investigation.

Wed 11:40 Hotel Terme room 3 Room acoustic criteria

The importance of high frequencies for concert hall acoustics

Tapio Lokki, Jukka Pätynen and Sakari Tervo
Aalto University

Objective room acoustical parameters (ISO3382-1:2009) are usually calculated at octave bands between 125 Hz and 4 kHz. Moreover the values are often reported only at mid bands (500 and 1000 Hz octave bands). This paper discusses the importance of high frequencies, between 2 and 12 kHz, for acoustics of concert halls. At these frequencies air absorption attenuates sound, thus it is important to design walls that do not absorb high frequencies. The early decay times (EDT) and strength (G) values are reported from over 10 measured halls to show the importance of high frequencies. These values are reflected to subjective impressions that are gathered from listeners and literature. Furthermore, it is shown that the high frequencies are important for intimate sound, hall's dynamic responsiveness to music, and the perceived overall quality of concert hall acoustics.

Wed 15:30 Hotel Terme room 3 Room acoustic criteria

Acoustic Measurements of Bonci Theatre in 2012

Dario D'Orazio[a], Lisa Loreti[b], Simona De Cesaris[a] and Massimo Garai[a]
[a] *University of Bologna, Dep. of Industrial Engineering - DIN;* [b] *University of Bologna*

The Bonci Theatre in Cesena was built in 1843-46 with a project by the architect Vincenzo Ghinelli. The theatre has four floors of boxes and gallery and it has been used as case study in a series of measurements in the early 2000s made by different research groups. This paper presents the results of the new measurements conducted in september 2012. The values of monaural descriptors extracted from impulse responses are presented. While previous literature was focused on the measurements techniques and on the choice of positions of the sources and microphones, the present work is focused on the algorithms for the extraction of ISO 3382 descriptors and the related uncertainly expression.

Wed 15:50 Hotel Terme room 3 Room acoustic criteria

Requirements for Room Acoustical Parameters - a proposal for structuring the questions on how to define them

Uwe M. Stephenson
HafenCity Universität, Hamburg

Among room acousticians it is widely consensus that there are some room acoustical parameters (RAPs) physically described and highly correlated to subjective judgments on the 'acoustics' of auditoria. Some are defined in the ISO 3382 standard - but not their recommended limiting values. So, the aim should be to set up compulsory standards whose compliance could be claimed by the public. The questions are:
Which RAPs should be selected to sufficiently describe 'good acoustic'?
How many are really necessary?

Since RAP limits depend on the room purpose, to what extent should these purposes be distinguished? Also dependent on different musical styles?
Should RAP limits strictly depend only on psycho-acoustical results or should compromises be accepted depending on feasibility - or different cultures?
Should max&min values or mean values and maximum standard deviations be set up?
What's about deviations of parameters only on some places in a room? How many exceptions could be tolerated?
Which verification methods should be proposed: ray tracing and/or scale measurements?
The last question but the public mainly interesting one is: Could, by weighting the single RAPs, a single value be set up describing an overall acoustical quality? This paper aims solely to structure these and further questions.

Session "Room acoustics 1"

Wed 16:50 Hotel Terme room 3 Room acoustics 1

Damping of Modes in Small Rooms

Ingolf Bork[a] and Jannis Klaus[b]

[a] *Physikalisch-Technische Bundesanstalt;* [b] *Technische Universität Braunschweig*

In small rooms acoustical modes can reduce the quality of sound transmission considerably, especially in the low frequency range below 100 Hz. At resonance frequencies, the planes of sound pressure nodes and antinodes can increase as well as decrease the sound level depending on the position in the room. This is very annoying in such rooms which are intended to be used for critical hearing like control rooms in recording studios, rehearsing and teaching rooms for musicians particularly playing bass instruments. Measurements showed that applying frequency selective means are able to reduce the sound coloration in the low frequency range significantly. Further, single tonal components coinciding with a frequency of a room mode, e.g. a mains hum, can be reduced to a high degree in the whole room depending on the degree of coupling between sound field and absorber.

Wed 17:10 Hotel Terme room 3 Room acoustics 1

Measurement of Absorption Coefficients of Worshippers in Mosques by Reverberation Room Method

Tobias Behrens and Wolfgang Ahnert
ADA Acoustics & Media Consultants GmbH

For room acoustical and electro acoustical planning of mosque projects the knowledge of absorption coefficients of worshippers in typical postures and arrangements is desirable in order to have a proper data base for simulation. It was assumed that generally known absorption behavior of persons by guidelines and literature (persons standing or sitting on different kind of chairs) could lead to incorrect simulation results when used for mosque projects. Therefore measurements of absorption coefficients by reverberation room method according ISO 354 of persons in typical postures and arrangements for mosques have been done. As typical postures and arrangements 14 test dummy persons on a carpet as a 10 m^2 sample within a surrounding reflective barrier have been under test while standing, kneeing on floor or being in Muslim specific praying posture. The procedure and results are described and discussed.

Wed 17:30 Hotel Terme room 3 Room acoustics 1

Influence of the Distribution of Sound Absorbers on the Room Acoustic Properties of Sports Halls

Joachim Zander[a], Frank Schnelle[b] and Roland Kurz[a]
[a] *Kurz und Fischer GmbH, Winnenden;* [b] *Kurz und Fischer GmbH*

Standards as the German standard DIN 18041: 2004-05 contain requirements to the reverberation time for planning the acoustic design of sports halls. It is assumed that there are suitable room acoustic conditions for the use as sports hall in the case of meeting those specific requirements to the reverberation time. In this connection the reverberation time functions as an room acoustic indicator. In view of the practical use of sports halls direct room acoustic demands should be placed on a good speech intelligibility in short and middle distances and a sufficient noise reduction. As is known from earlier investigations, both, the extent of sound absorbers and the way in which sound absorbers are distributed on the principal axes of a room, influence the reverberation time in sports halls. With the use of computer simulations, these influencing factors were examined in dependence of the size of rectangular-shaped sports halls. Both, the effects on the demanding indicator reverberation time and those on the direct parameters speech intelligibility and noise reduction, were considered. The results are used to make recommendations for the acoustic design of sports halls in dependence of the room size.

Wed 17:50 Hotel Terme room 3 Room acoustics 1

Diffusivity Coefficients Caused by Edge Diffraction of Arbitrary Polygonal Reflectors

Stefan Drechsler and Uwe M. Stephenson
HafenCity Universität, Hamburg

In ray tracing, diffuse reflections are usually modeled interpolating simply between Lambert's law and geometrical reflection. Usually only the roughness of a surface is considered, but the edge effect contributes to the diffusivity coefficient as well. Since early estimations for reflectors made by Cremer in 1953, different derivations of scattering coefficents due to the edge effect have been made. A new derivation of these coefficients is based on an analytical formula for diffraction at arbitrarily shaped polygonal plane reflectors. By averaging over octave bands an analytical solution suitable for room acoustical ray tracing has been found. An overall diffusivity coefficient of the polygon could be derived. Different former approaches and the new one are compared. However, the direct use of the analytical scattering formula is suggested rather than the use of diffusivity coefficients.

Wed 18:10 Hotel Terme room 3 Room acoustics 1

Influence of a volume scale factor on the scattering coefficient effects on the prediction of room acoustic parameters

Louena Shtrepi[a], Arianna Astolfi[a] and Monika Rychtáriková[b]
[a] *Politecnico di Torino - Dipartimento Energia;* [b] *KU Leuven, Laboratory of Acoustics and Thermal Physics*

Surface scattering has become an important input parameter in the work on geometric models and in the research concerning the enhancement of auralized sound. This contribution deals with the comparison of four scaled prediction models of the same concert hall and studies the scattering coefficient prominence in simulations while the size of the concert hall increases by two, three and four times. The hall is a fan shaped hall with aspect ratios of around 4.5:2.8:1 and typical auditorium features such as stage and raked audience area. The influence of a volume scale factor on the scattered sound effects on the prediction of the objective room acoustic parameters like T30, EDT, C80, D50, LF and G, is investigated. Five different alternatives were simulated, where scattering coefficient values s = 10, 30, 50, 70 and 90% respectively, were applied separately and combined to the interior surfaces of the ceiling, side and rear walls. Analysis has been performed by studying the results of objective room acoustical parameters predicted by simulations done with software Odeon® 11.00 and Catt-Acoustic® v 8.0.

Wednesday Room acoustics (Poster)

A particular acoustical insulation in a restoration work
Alessandro Cocchi
University of Bologna , Prof. Re Emerito, Scuola di Ingegneri
The case history of restoration work in a particularly noisy site will be presented. A particular problem emerged in a room where it was foreseen to play classical piano music. The acoustical insulation from outside traffic noise was an opportunity to reach also good results in energy saving from the HEVAC plant.

Wednesday Room acoustics (Poster)

Architectural Acoustics and Electroacoustic in the Asisium Theatre: an Integrated Construction Work
Luca Quaranta
CP Progetti S.r.l., Roma
Designed in the 60s by the famous Italian Architect Michele Busiri Vici, the Asisium theater, with an airspace of approximately 2,100 m3 and a capacity of 250 seats, has been the object of an extensive renovation. Based on the multi-functional needs which it was designed for, from the conference room to the cinema with Dolby Surround sound effect, we performed an analysis of the room's acoustic response based on the model of a 3D simulation, referenced on acoustic parameters according to ISO-3382, thus directing the choices of architectural design. The combination of architectural and acoustic led to the integration of elements for the reflection of sound and the optimization of reverberation time, to obtain optimum acoustical conditions both on stage and in the audience for the various functions of the room. The design of the electro-acoustic, which provides various control technologies for the equalization and distribution of the amplified audio signal, has allowed to optimize acoustic passive elements also taking into account the presence of an amplified audio system. In this contribution we present choices and design criteria, materials and audio devices used to obtain the final result, to underline the key role of architectural acoustics and electro-acoustic integrated design.

Wednesday Room acoustics (Poster)

Acoustic characterization and numerical simulations of Rossini Theatre in Lugo and Masini Theatre in Faenza
Simona De Cesaris, Davide Spada, Dario D'Orazio and Massimo Garai
University of Bologna, Dep. of Industrial Engineering - DIN
The Rossini Theatre of Lugo (RA), was built in 1757-60, following the design of Ambrogio Petrocchi and completed in the stage, seating and balconies by Antonio Galli Bibiena. The Masini Theatre of Faenza (FC), was built in 1780-87, following the design of Giuseppe Pistocchi. The two theatres represent a case study to evaluate the reliability of the numerical simulations in architectural acoustics. Impulse responses with different combinations of source and receiver have been acquired, for a total amount of about 600 impulse responses for each theatre. The values of T30, EDT, C80 have

been extracted from the impulse responses. An hybrid ray-tracing software (Odeon) has been used in order to test the same monoaural parameters, following similar studies from literature. Considering that the two theatres have comparable general aspects (volume, number of seats, materials...) but they have different geometrical elements and surface treatments that influence the acoustic field, different hypotheses on the scattered field and different resolution of numerical simulation have been compared. Thanks to the multitude of measured positions, a point-to-point comparison between the simulated and measured parameters permitted the validation of both numerical models.

Wednesday Room acoustics (Poster)

From Historical Slaughterhouse to drama theater: example of acoustic renovation

Francesco Orsini[a], Marco Caniato[b] and Federica Bettarello[b]
[a] *Studio Ingegneria Orsini, Chiusi;* [b] *Studio Associato Acusticamente, Conegliano*

The project of recovery and reuse of a slaughterhouse to a cultural centre near Rome carried out many problems in terms of rehabilitation of many volumes. In the past, these volumes were used to meat processing and storing. The shape of these locals was a kind of high, tiny and very reflective shoe box, properties related to very poor speech intelligibility.
The aim of this building recovery was managed without modifying the actual inner rooms distribution. In fact this was not allowed in relation to the historic significance. Nowadays, renovation of historic buildings for different uses is a matter of fact. House comfort and energy saving have to be the principal aims of the design. It could be more complicated when renovation projects regard spaces for music or speech able to receive drama actors and people. With acoustic simulations, several solutions were analysed in order to verify the architectural proposals. See-through panels were added in order to both modify the inner acoustics and to preserve the historic architecture.

Wednesday Room acoustics (Poster)

Measurements and Room Acoustic Analysis with the ITA-Toolbox for MATLAB

Pascal Dietrich, Martin Guski, Johannes Klein, Markus Müller-Trapet, Martin Pollow, Roman Scharrer and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

During the last years, a MATLAB toolbox has been developed at the Institute of Technical Acoustics at RWTH Aachen University (e.g. Dietrich et al. 2012, DAGA). This toolbox handles common post-processing tasks in the field of acoustic research, including data import and export as well as different graphical representations of the data. Professional audio recording interfaces can be directly connected to enable data acquisition. Recently, two new applications have been released for measurements and room acoustical evaluation.

The measurement application includes basic features, such as signal recording, playback and deconvolution techniques for noise, sweep or MLS transfer function measurements. The possibility of simulating an entire measurement chain including convolution, filters, noise, quantization, clipping and nonlinear transfer characteristics helps to understand artifacts observed in real measurements. Using the room acoustics application monaural parameters can be evaluated according to ISO 3382 employing different evaluation methods. The routines help to understand the noise detection algorithms and the differences between the evaluation results.
The ITA-Toolbox including the two new applications is available online at www.ita-toolbox.org as OpenSource with a BSD license.

Wednesday Room acoustics (Poster)

Influence of Loudspeaker Distortion on Room Acoustic Parameters
Pascal Dietrich, Martin Guski and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University
The assessment of the range of uncertainty for room acoustic parameters is an ongoing research topic. The ISO 3382 demands the calculation of the uncertainty according to the GUM. However, the separation and determination of the main influence factors and their contribution is still not fully solved. Mainly the position of the sound source and the microphones, background noise and the loudspeaker directivity pattern are currently addressed due to strong deviations observed in the past.
In this contribution we explain an existing modeling technique of non-linear systems that is used to simulate the effect of loudspeaker distortion in impulse response measurements. Generic impulse responses are used to simulate a room acoustic measurement. We will analyze which room acoustic parameters are potentially affected. The evaluation of the room acoustic parameters leads to a scenario with controllable degree of loudspeaker distortion without the influence of the other uncertainty factors priorly addressed. This simulation approach is validated by measurement results with different amplifications in auditoria.

Wednesday Room acoustics (Poster)

Palacultura Messina: Acoustic characterization ante/post- operam for the placement of a Camera Acustica SuonoVivo®.
Basilio Mangano[a] and Roberto Furlan[b]
[a] *Studio Mangano, Spadafora;* [b] *Studio Furlan, Piove di Sacco*
This paper discusses the set of acoustic measurements conducted inside the Palacultura Messina, before and after the installation of a Camera Acustica SuonoVivo®, in order to verify the benefits achieved with this arrangement. The hall of Palacultura Messina and is suitable for various uses as conferences, meetings, but especially music performances, benefiting from acoustics that was already in origin very accurate, due to the shape of the room, both also due to the choice and arrangement of wall coatings. before building-up of the Camera Acustica, the entire area of the stage was not set up, in the crude state except for the wooden floor. In this state, musical performances were not satisfactorily possible as it lacked the

proper acoustic response from the stage area, hence the need to complete the aforesaid area with a Camera Acustica. This poster shows the results of acoustics characterization measurements of the hall, taken before and after works.

Session "Virtual acoustics 2"

Wed 9:00 Civic room Virtual acoustics 2

The relation between perceived apparent source width and interaural cross- correlation in sound reproduction spaces with low reverberation

Johannes Käsbach[a], Marton Marschall[a], Bastian Epp[a] and Torsten Dau[b]
[a] *Centre for Applied Hearing Research, DTU (DK);* [b] *Centre for Hearing and Speech Sciences, DTU (DK)*

The interaural cross-correlation (IACC) has been proposed as an objective measure of the apparent source width (ASW). This relation has been well-established in headphone-based experiments and IACC is commonly used to estimate ASW in reverberant spaces. However, in low-reverberation environments of sound reproduction systems, this relation is less clear. The present study investigates such a case in detail. The ASW of a band-limited noise signal with varying inter-loudspeaker cross-correlation was subjectively evaluated for a typical stereo-setup in a low-reverberation playback room. Consistent with results from earlier studies, the perceived ASW was found to increase monotonically with decreasing inter-loudspeaker correlation of the noise. The IACC, evaluated at the ear canals of a dummy head, however, predicted a saturation of the ASW from medium to low inter-loudspeaker correlation coefficients. These discrepancies resulted from the interaural cross-talk in the stereo-loudspeaker setup, leading to an ambiguity in the IACC calculation. Such ambiguities were absent in headphone presentation and have a negligible effect in reverberant environments. The results provide constraints for the applicability of the IACC as a measure of ASW in sound reproduction and synthesis systems, and in terms of computational models for the estimation of ASW in room acoustics.

Wed 9:20 Civic room Virtual acoustics 2

Subjective evaluations in virtual environments

Lamberto Tronchin[a], Angelo Farina[b] and Andrea Venturi[a]
[a] *University of Bologna;* [b] *University of Parma, Industrial Eng. Dept.*

The subjective perception of 3D sound distribution in rooms is still not completely analysed and fully evaluated, even if several experiments were conducted in the last ten years in this specific field. In this paper, the subjective evaluation of room acoustics perception have been analyzed by means or virtual reconstruction of 3D characteristics of ancient theatres, Italian-styled theatres and auditorium. The virtual acoustics of real enviromnents has been obtained both by means of Ambisonics based systems and by means of Stereo Dipole based systems, in the Arlecchino listening room at University of Bologna. The realisation of the properly measured filters will be discussed, and the preliminary results obtained gathering several

questionnaires about subjective perception will be shown. Afterwards, the most relevant results about the correlation betweeb subjective evaluation and measured, physical parameters, will be illustrated

Wed 9:40 Civic room Virtual acoustics 2

Just Noticeable Differences of Spatial Perception in Directly Manipulated Binaural Room Impulse Responses

Stefan Klockgether and Steven van de Par
University of Oldenburg

A Binaural Room Impulse Response (BRIR) contains all the acoustical information of a room that is relevant for perception. It is recorded with an artificial head to encode the spatial information of the impulse response. The BRIR can be separated in two parts. A diffuse tail that is important for the spatial impression and a first part which contains the information that determines the perceived location of a sound source. For this experiment the first and second part of the BRIR has been surveyed separately. Interaural time and level differences were directly manipulated in the first part of the impulse response. In addition, for the tail of the impulse response, the interaural correlation was manipulated. The BRIRs have been convolved with music signals and have then been used in a psychoacoustical experiment. The subjects had to distinguish between manipulated and none-manipulated signals in aforced choice experiment. The results of this experiment are interpreted as just noticeable differences (jnds) for interaural time difference, level difference and correlation in BRIRs. These jnds may be used to develop a model to predict room acoustical perception and may help to evaluate simulated acoustical scenes.

Wed 10:00 Civic room Virtual acoustics 2

Authenticity and Naturalness of Binaural Reproduction via Headphones regarding Different Equalization Methods

Josefa Oberem, Bruno Masiero and Janina Fels
Inst. of Technical Acoustics, RWTH Aachen University

Not only a suitable localization performance, but also the plausibility and authenticity of the played scene are major criteria for a successful reproduction. It is therefore important to examine whether the binaural reproduction can be perceptually distinguished from a real source. The aim of the presented investigation is to analyze the quality and reliability of binaural reproduction via headphones comparing two different microphone setups (miniature microphone in open dome and ear plug) used for individualized HRTF and headphone transfer function measurements. Listening tests with a total of 81 subjects have been carried out focusing on authenticity regarding naturalness and sound coloration. In a direct comparison between binaural reproduction and real sources more than half of the subjects could not distinguish a difference for speech or music. As a third stimulus, pink noise was played, which could be distinguished in a direct comparison due to colorations in higher frequencies. In the examination of indirect comparison between real sources and binaural reproduction pink noise is indistinguishable for all participants.

Wed 10:20 Civic room Virtual acoustics 2

Frequency domain filter exchange for DFT-based fast convolution

Frank Wefers and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

Real-time audio rendering is often implemented using FIR filtering. User interaction (e.g. head movement) and movement of objects make it necessary to exchange the filter impulse responses quickly in order to realize an instant system response. This exchange must be performed with a low latency (filter exchange latency) and should not produce audible artifacts. A variety of filter adaption concepts are known today, adapting the filter coefficients in different ways. FIR filters are usually implemented using a fast convolution technique, mostly within some transform domain (e.g. Discrete Fourier Domain). Many time-domain filter adaption concepts do not translate well in these transform domains. Realization is always possible but comes at a high computational costs. For this reason, audio rendering applications often found on time-domain filter exchange techniques (like cross-fading). This makes it necessary to partially filter the input data with two filters and combine the result in time-domain.

This paper presents a method to realize common filter exchange methods directly in the DFT domain, with a low computational cost. The technique is embedded into uniformly partitioned FFT-based convolution. The computational savings to conventional methods are examined.

Wed 10:40 Civic room Virtual acoustics 2

Using fast convolution for FIR filtering - Overview and guidelines for real-time audio rendering

Frank Wefers and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

The term 'fast convolution' summarizes methods that allows computing the discrete convolution efficiently. The term is mostly associated with block convolution using the Fast Fourier Transform (FFT). Actually, fast convolution stands for a variety of algorithms researched and developed from the early 1960s. Although they are all labelled '*fast*', the methods differ in their computational complexity. Moreover they have rather different properties and vary in several aspects. When it comes to realizing FIR filters by fast convolution in real-time, fast convolution techniques need furthermore to be adapted in order to realize low latencies. A multitude of methods evolved, suitable for different applications.

The focus of this paper lies on real-time FIR filtering for audio rendering. Current fast convolution methods are reviewed and classified with respect to this task. Afterwards several applications are regarded, varying in their requirements (number of channels, filter lengths, latencies, implementation) and suitable convolution techniques are discussed.

Wed 11:00 Civic room Virtual acoustics 2

Audio convolution on GPUs: a follow-up

Davide Andrea Mauro
Laboratorio di Informatica Musicale, UNIMI (Milano) and ParisTech TELECOM, CNRS-LTCI

This paper focuses on the use of GPGPU (General-Purpose computing on Graphics Processing Units) for audio processing. This is a promising approach to problems where a high parallelization of tasks is desirable. Previous work has examined the application of GPU to the generation of spatial audio. This work aims at extending previous results in view of the most recent technologies updates such as the adoption of PCIe 3.0 and NVIDIA CUDA 5.0 specifications. Within this context we will show a convolution engine having in mind both offline and real-time scenarios, and the support for multiple sound sources. Comparisons between this approach and typical CPU implementations will be presented as well as between frequency (FFT) and time-domain approaches. Results will show that benefits exist in terms of execution time for a number of situations.

Wed 11:20 Civic room Virtual acoustics 2

Inverse Ray Tracing for the Optimization of Acoustical Properties in Auralizations of Real Rooms

Fabian Knauber, Sönke Pelzer and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

Acoustic consultants are often in charge of changing room properties to fix problems or improve room acoustics. To assess the situation and come up with a solution, it is common practice to perform simulations. This technique is well established, cheap and effective. But it requires a CAD model of the room as well as properties of its boundaries, such as absorption and scattering coefficients. The CAD model is usually easy to obtain by asking the architect or measuring yourself, but quantifying the absorption coefficients of every single wall is a challenging task. This contribution presents a method that automatically matches absorption coefficients for every single wall by applying an inverse room acoustics model which bases on geometrical acoustics. The inversion is done numerically using a non-linear least-squares optimization process in MATLAB. The independent variables are all absorption coefficients and the goal is to minimize the error between measured and simulated impulse responses at all measured positions in the room. In addition to the acquisition of absorption and scattering coefficients, the goal after the optimization process is to perform interactive binaural auralizations that have a high perceptual congruence with the existing space.

Wed 11:40 Civic room Virtual acoustics 2

Localization experiments of reflections in virtual rooms

Ramona Bomhardt and Janina Fels
Inst. of Technical Acoustics, RWTH Aachen University

In the last decades virtual acoustics has become a powerful tool for psychoacoustic research. In comparison to experiments in real rooms the acoustics conditions in virtual rooms can be carefully controlled. Using virtual acoustics any desired scene can be created and psychoacoustic experiments can be carried out in one and the same scene for all participants. Furthermore, any kind of acoustics sources can be created easily and positioned precisely in virtual rooms, with full freedom of choosing source and receiver directivity. This way any acoustic scene can be virtually created for an arbitrary room. For research applications like localization of reflections on a wall, special room properties are required. At first a highly reflective wall is considered. The other walls should be sound absorbent to avoid their influence on the observed reflection. In case of reverberant walls, their reflected signals will superpose the observed signal. This paper provides a guide for virtual room design for localization experiments of reflections. It discusses the influence of the geometrical shape and the volume of a rectangular cubical room, which is given by the length, width and height. In addition the effect of the absorbent wall properties for one room shape is shown.

Wed 15:30 Civic room Virtual acoustics 2

Self-localisation in virtual environments

Monika Rychtáriková[a], Vojtech Chmelik[b], Greet Nuyts[a], Christ Glorieux[a]
[a] *KU Leuven, Lab. of Acoustics and Thermal Physics;* [b] *STU Bratislava*

For normally sighted people spatial orientation in buildings is typically based on visual cues. However, the building interior (walls, floor, ceiling, furniture etc.) can also supply acoustical information that might help in the spatial assessment of the place. One could wonder what can be said about the size and shape of a dark room. And, is it possible to design a room in order supply useful spatial information to those who can only rely on acoustical cues? This paper shows results from a preliminary study that deals with self-localisation of people in a virtual environment, in terms of recognizing the size of the room and their position in the room. Results based on listening test experiments are presented and discussed.

Wed 15:50 Civic room Virtual acoustics 2

3-D Sound Localization in Matched and Mismatched Crosstalk Cancellation Systems

Piotr Majdak[a], Bruno Masiero[b] and Janina Fels[b]

[a] *Austrian Academy of Sciences, Acoustics Research Institute;* [b] *Inst. of Technical Acoustics, RWTH Aachen University*

Binaural signal reproduction via loudspeakers requires crosstalk cancellation (CTC) filters to compensate for the crosstalk between the listener's ears. The localization performance depends on the CTC filters used in the system. In this study, the horizontal- and sagittal-plane localization performance was investigated in humans listening to individualized matched, individualized but mismatched, and non-individualized CTC systems. The systems were simulated via headphones in a binaural virtual environment with two virtual loudspeakers spatialized in front of the listener. The loudspeaker span was 90°. The individualized matched and individualized mismatched systems were based on two different sets of listener-individual head-related transfer functions (HRTFs). Both sets provided similar binaural localization performance in terms of quadrant errors (representing front-back confusions), polar and lateral errors. The individualized matched systems provided performance similar to that from the binaural listening. With the individualized mismatched systems, the performance deteriorated. With the non-individualized mismatched systems (based on HRTFs from other listeners), the polar and quadrant errors even further increased. The direction-dependent analysis showed that mismatch and lack of individualization yielded a degraded performance for targets placed outside of the loudspeaker span and behind the listeners, respectively, showing relevance of individualized CTC systems for those targets.

Wed 16:10 Civic room Virtual acoustics 2

Angle-dependent reflection factors applied in room acoustics simulation

Sönke Pelzer, Markus Müller-Trapet and Michael Vorländer

Inst. of Technical Acoustics, RWTH Aachen University

Due to the lack of input data, current room acoustic simulation algorithms commonly use diffuse-field absorption coefficients for the characterization of boundary conditions. So far it is not yet known how important it is to implement angle-dependent absorption and scattering coefficients in room acoustics simulations. Furthermore only few approaches exist for the successful measurement of these coefficients under free-field conditions.

This contribution presents the construction of a measurement system for the acquisition of free-field angle-dependent reflection factors. Furthermore the measured results are implemented into a room acoustics simulation tool that applies them for the popular image source method and scattering-enabled ray tracing.

Using a real room as a case study, the results of simulations using diffuse-field absorption coefficients and using angle-dependent absorption coefficients are compared with one another and against real measurements in that room.

Wed 16:30 Civic room Virtual acoustics 2

Predictive Auralization of Room Modifications by the Adaption of Measured Room Impulse Responses

Christoph Pörschmann and Sebastian Schmitter
Fachhochschule Köln

When optimizing the acoustics of an existing room it is helpful to auralize the implications of an intended constructional change in advance. Especially for the customer who is usually not an expert in room acoustics the possibility to hear the impact of a planned room modification is valuable. Even though room acoustic simulation tools applying geometrical models are available, they are for different reasons not commonly used for auralizing the expected results. On the one hand the quality of the auralization of room simulation systems is still poor and on the other hand the effort for geometrically modeling the room is comparably high.

Often the geometric structure is only slightly varied for an acoustic optimization process; the main modification affects the absorption of the walls. In such a case the fine structure of a room impulse response is sustained. Only the envelope is changed, which is typically described by a frequency-dependent reverberation time. An algorithm is presented which is capable of auralizing such room modifications applying an adaptation of the measured room impulse response. Furthermore, the results of a listening test are described which show to what extent perceptive plausible results can be obtained.

Wed 16:50 Civic room Virtual acoustics 2

Room Impulse Responses of Rectangular Rooms for Sources and Receivers of Arbitrary Directivity

Martin Pollow, Pascal Dietrich and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

For simple geometrical shapes, such as rectangular rooms, with simple boundary conditions analytical solutions exist. The room impulse response can be calculated by modal superposition for a specific transfer path. This result is valid for both perfectly omnidirectional sources and receivers. The derivation of the eigenfunctions describing the acoustical field allows to change the solution for the monopole sources and receivers by a solution for dipole sources and/or receivers, whereas multiple derivation yield multipoles of higher orders. This multipole description can then be converted to a representation in terms of spherical harmonic coefficients, allowing to derive the analytically computed room impulse response for arbitrary source and receiver directivities in rectangular rooms.

In this contribution, we give an overview of the modal superposition approach. A rectangular room with simple boundary conditions is used as an

example. We propose a method for the transformation of the multipole representation into spherical harmonics representation and compare results for a test room with numeric solutions.

Wed 17:10 Civic room Virtual acoustics 2

Room Impulse Response Measurements with Arbitrary Source Directivity

Johannes Klein, Martin Pollow, Pascal Dietrich and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

Room acoustical measurements in accordance with the ISO 3382 require a reasonably omni-directionally sound source. Any directivity of a real source is therefore neglected when using the result for auralizations. To obtain more realistic results it is desirable to employ a source with a particular directivity for the measurement of the room impulse response (RIR).
During previous research a measurement procedure using a specialized spherical loudspeaker has been developed. A large set of RIRs is obtained for different membrane orientations. In a subsequent post-processing this method then allows to generate RIRs for sources of arbitrary directivity up to a spherical harmonic order of 23, as long as the room can be regarded as LTI-system. The required factors for the superposition are derived from the measured directivity patterns of the target and the measurement source.
In this contribution, the entire measurement procedure, incorporating the specialized spherical source will be presented in detail. The special focus will be on the challenges and limitations of the method, such as the quality of the directivity data, the time-invariance of differently sized rooms and the parameters used for the post-processing.

Wed 17:30 Civic room Virtual acoustics 2

On the Impact of Noise Introduced by Spherical Beamforming Techniques on Data-Based Binaural Synthesis

Till Rettberg and Sascha Spors
Institute of Communications Engineering, Universität Rostock

The combination of sound field analysis techniques and binaural synthesis has been a subject of recent research. Typically, the acoustic scene is captured by a spherical microphone array and decomposed into plane waves employing modal or delay-and-sum beamforming. The sound field is subsequently auralized by the means of far-field head-related transfer functions (HRTFs). In practice however, not only is the spatial bandwidth limited due to finite sampling, but the microphone array will also introduce measurement noise into the resulting binaural room impulse responses. The robustness of beamforming techniques is usually quantified in terms of the white noise gain (WNG). Modal and delay-and-sum beamforming exhibit different frequency-dependent properties with respect to the WNG. This paper investigates the impact of array equipment noise on binaural synthesis using both beamforming approaches. Furthermore, the perceptual implications are discussed.

Wed 17:50 Civic room Virtual acoustics 2

Array modes of compact rigid microphone arrays with unconventional shapes

Fabio Kaiser[a], Franz Zotter[b] and Filippo Fazi[c]
[a] *Freelance, Salzburg (A);* [b] *IEM, KU Graz;* [c] *Univ. Southampton, ISVR (UK)*

Compact, rigid spherical microphone arrays and their advantages are well-known. Their signal processing employs a frequency-independent spherical harmonic decomposition of the microphone signals. A valid far field sound field description is obtained by individual equalization of the resulting signals by filtering. Any subsequent beamforming achieves an isotropic spatial resolution and is only a frequency-independent combination of signals. This is possible because the spherical harmonics are modes that separate the scattering problem imposed by the rigid sphere. An analytic separation of such modes for other, more complex array shapes (finite cylinder, finite cone, etc.) is not as easy to find. Nevertheless, these array shapes might be beneficial in applications that desire non-isotropic resolution. This work discusses the calculation of modes for rigid array shapes based on their scattering operator. This operator is numerically evaluated by the boundary element method. Subsequent singular value decomposition of the scattered surface sound pressure due to all plane waves yields the modes and their strength. The approach promises a similarly simple signal processing as employed with spherical arrays, after the quasi-continuous modes are used for array signal decomposition.

Session "Models of the hearing system and psychoacoustic quantities"

Wed 8:40 Civic exhibition room Models of hearing system

Analysis of the auditory system via sound texture synthesis

Torsten Dau and Richard McWalter
Centre for Hearing and Speech Sciences, DTU (DK)

Auditory scenes are often very dynamic and can be comprised of near silence to an overwhelming amount of information. The individual sources that make up the auditory scene are all processed by the auditory system. One category of sound common in natural environments is sound textures. Sound textures can range from a birds chirping or bee swarms to waterfalls or fires crackling. These sound textures are characterized by their temporal homogeneity, and may be processed by the brain using time-averaged statistics. To explore this concept, a system was designed to analyze natural sound textures using a biologically inspired auditory model and neurologically plausible statistics. The statistics gathered from an original sound texture were then imposed on a Gaussian noise input to synthesize a new sound texture that had the same perceptual qualities as the original. Convincing synthetic textures were created only when using a biologically inspired auditory model and a complete set of statistics. Any deviation from the auditory model or reduction in the statistical set would result in reduced realism of the synthetic texture. Analysis of sound texture perception

via synthesis is a novel approach for investigating peripheral and mid-level auditory process.

Wed 9:00 Civic exhibition room Models of hearing system

Extension and Evaluation of a Signal Processing and Perception Model

Carolin Iben and Stephan D. Ewert
University of Oldenburg, Medical Physics

In the computational auditory signal processing and perception model (CASP) by Jepsen et al. [J. Acoust. Soc. Am. 124, 422 (2008)] and its predecessor by Dau et al. [J. Acoust. Soc. Am. 102, 2892 (1997)] several experiment-dependent parameters are typically specified to account for various aspects of masking in human listeners. Here, one focus is to analyze the models behaviour with less prior specifications. Such a generalization, especially concerning frequency ranges of the auditory and modulation filterbank, is important if the model is used as front-end in, e.g. audio quality assessment. Based on the results of the analysis an extended version of the CASP model is suggested. The second focus of the study addresses the nonlinear processing of amplitude-modulation (AM) whereby two different approaches were pursued. In the first, the modulation filterbank was modified to account for AM depth discrimination as described in Ewert and Dau [J. Acoust. Soc. Am. 116, 478 (2004)]. In the second, the adaptation stage was extended to allow for an adaptation linked to the stimulus statistics. A toolbox was developed including an AFC framework, the models and a test battery of psychoacoustical experiments. The model versions are tested and compared to the data.

Wed 9:20 Civic exhibition room Models of hearing system

Roughness calculation for randomly modulated sounds

Arne Oetjen[a], Uwe Letens[b], Steven van de Par[a], Jesko Verhey[c] and Reinhard Weber[a]
[a] *University of Oldenburg;* [b] *Daimler AG;* [c] *Otto von Guericke Univ. Magdeburg, Dep. Experimental Audiology*

Many natural sounds show rapidly changing envelope variations caused by stochastic processes, for example the wind noise contained in vehicle interior noises. Although these variations may contain stochastic modulation frequencies in the domain of the psychoacoustic roughness sensation this sound characteristic is, in contrast to non-stochastic modulations, not perceived as being rough. Detecting these modulations via a short analysis window in a roughness calculation algorithm shows characteristics similar to regular, non-stochastic envelope fluctuations. From this analysis method it is not possible to distinguish between stochastic and regular amplitude modulations. A stochastic approach is proposed that is able to quantize the degree of randomness of modulation which is based on the Shannon entropy. It is used to optimize a calculation algorithm for roughness resulting in improved predictions for different environmental noises. Examples for the roughness of several different vehicle sounds including different operating conditions and vehicles will be presented.

Wed 9:40 Civic exhibition room Models of hearing system

Progresses in standardizing loudness of time-variant sounds

Roland Sottek and Klaus Genuit
HEAD acoustics GmbH

A new ISO standard for loudness of time-variant sounds will be proposed for the revision of ISO 532:1975 section 2 (method B), based on DIN 45631/A1:2010. Apart from being applicable to arbitrary sounds, this standard includes the well-proven and widely used standard DIN 45631:1991 for stationary sounds as a special case. This DIN 45631 standard differs slightly from the previous ISO 532:1975 method B by specifying corrections for low frequencies and by restricting the description of the approach to numerical instructions only, thus allowing a unique software description. The new proposal is also intended to reduce uncertainties of the existing standards by defining the mathematical facts of the algorithms, starting with the waveform of the time signal and ending with specific and total loudness vs. time functions. In addition to the loudness standard for stationary sounds, specifications of the third-octave filter bank, rectification, intensity averaging, non-linear temporal decay of the hearing system and the temporal weighting of total loudness are given not only by formulas and tables but also by program code. The proposed standard shall update the previous ISO 532:1975 method B and adapt it to proven new practice while preserving procedural and database continuity.

Session "Digital signal processing in audiology"

Wed 10:20 Civic exhibition room Signal proc. in audiology

Sound coding for Cochlear Implants based on electrophysiological measurements and models

Norbert Dillier and Wai Kong Lai
University of Zurich

Sound coding for cochlear implants usually relies on signal properties and concepts developed for communications systems. The detailed capacity of electrically stimulated neurons to convey spatio-temporal information on an individual basis, however, has rarely been considered in practical applications. One way of tackling this problem is to combine a signal processing strategy with a model of auditory nerve fiber population responses to electrical stimulation. A simulation model for auditory nerve responses to constant or time-varying electrical pulse train stimulation was implemented in MATLAB and used to reproduce animal (literature) and human (own measurements) data and to propose new test protocols with human subjects. The model includes refractory and stochastic membrane properties of neuronal excitation and allows varying the electric field distribution along the basilar membrane. Two variations of an excitability controlled processing model were integrated into a coding strategy and evaluated in pilot experiments with 10 subjects. Loudness perception for complex time-varying sounds turned out to be a critical aspect. Psychophysical tests using masking paradigms with various stimulation rates were inconclusive so far. Objective measures for amplitude growth, recovery functions, spread of excitation

and pulse train responses may help to further optimize the processing algorithms on a patient-by-patient basis.

Wed 10:40 Civic exhibition room Signal proc. in audiology

Personal Sound Amplifier Devices: Current Trends and Processing Options

Gabriella Tognola
CNR Inst. of Biomedical Engineering, Milano

This paper will give an overview of the current technologies in personal sound amplifier devices, on their utilization, current customer opinions and recommendations from medical/audiological societies. The basic characteristics that the technology implemented in these devices must fulfill will be identified and reviewed. Simulations and results from psychoacoustic tests will show how the signal quality (to specify better, the clearness of the processed speech) changes with the type of processing solutions implemented in these devices.

Wed 11:00 Civic exhibition room Signal proc. in audiology

Comparison of Transfer Functions in the Ear Canal for Open-Fitting Hearing Aids

Tobias Sankowsky-Rothe[a], Derya Dalga[b], Simon Doclo[c], Matthias Blau[a]
[a] *Jade-Hochschule Oldenburg;* [b] *University of Oldenburg, Medical Physics;* [c] *University of Oldenburg, Signal Processing Group*

Open fittings, which leave the ear canal as open as possible, are very popular, mostly because they avoid the occlusion effect. On the other hand, an open fitting possibly lets unwanted background noise pass into the ear canal and increases the risk of acoustic feedback.

One possibility to reduce the background noise in open-fitting hearing aids is the use of active-noise-cancellation-motivated techniques exploiting an ear canal microphone, which measures the sound pressure in the ear canal. In this context, a question is whether the sound pressure transfer function from the ear canal microphone of the hearing aid to the ear drum depends on the location of the sound source (outside at various positions versus inside from the hearing aid receiver). In this contribution, sound pressure transfer functions were measured on the ears of 10 subjects in an anechoic room for different external positions. The results will be presented and discussed.

Wed 11:20 Civic exhibition room Signal proc. in audiology

Combined Noise Reduction and Coherence Reshaping for Binaural Hearing Aids

Daniel Marquardt[a], Volker Hohmann[b] and Simon Doclo[a]

[a] *University of Oldenburg, Signal Processing Group;* [b] *University of Oldenburg, Medical Physics*

Besides noise reduction an important objective of binaural speech enhancement algorithms is the preservation of the binaural cues, i.e. the Interaural Level Difference (ILD) and the Interaural Time Difference (ITD) of both, the speech and the noise components. Recently, extensions of the binaural Multi-channel Wiener filter (MWF) have been presented which aim to preserve the binaural cues of the residual noise component. However, since these algorithms aim to preserve ILD and ITD they are well-suited only for directional noise sources but not for spatial isotropic noise fields which can not be fully described by the ILD and the ITD cues but rather by the Interaural Coherence (IC). In this contribution we present an extension of the binaural MWF, aiming to simultaneously suppress the noise component and reshaping the Interaural Coherence of the residual noise to a predefined value. In addition to noise reduction, this approach allows to control the Interaural Coherence based on psychoacoustic properties. Experimental results show that reshaping of the Interaural Coherence is possible without significantly degrading the output SNR compared to the binaural MWF.

Wed 11:40 Civic exhibition room Signal proc. in audiology

An Evaluation of Binaural Noise and Reverberation Reduction Algorithms

Rainer Martin[a], Masoumeh Azarpour[a], Dominic Schmid[a], Gerald Enzner[a] and Timo Gerkmann[b]

[a] *Ruhr-Universität Bochum, Inst. of Communication Acoustics;* [b] *University of Oldenburg, Faculty V - Speech Signal Processing*

In this contribution we will present recently proposed algorithms for binaural noise reduction and dereverberation and compare these algorithms in terms of their instrumental and auditive quality. The algorithms that we consider exploit the coherence of the two microphone signals but also implement several enhancements to this basic and well-known scheme. These enhancements include smoothing techniques in the cepstral domain as well as the estimation and the explicit use of the interaural impulse response in a matched-filter technique. In the evaluation part of this paper we assess the noise reduction, the speech distortions, the strength of the dereverberation effect, the intelligibility and the quality of the residual noise. The comparison will highlight properties of the considered methods and performance trade-offs of these methods in general.

Session "Auditory and multimodal scene analysis"

Wed 15:30 Civic exhibition room Auditory scene analysis

Acoustic Source Localization in Highly Reverberant Environments

Daniele Salvati
Università di Udine

Acoustic source localization (ASL) is an increasingly important aspect in a growing number of applications. The aim of an ASL system is at identifying the position of sound sources in space by analyzing the sound field with microphone arrays, a set of microphones arranged to capture the spatial information. Basically, the main task of an ASL system consists of estimating the time difference of arrival (TDOA) between a microphone pair. Blind system identification (BSI) focuses on the impulse responses between the source and the microphones to estimate the TDOA in reverberant environments. Considering the adaptive eigenvalue decomposition BSI method based on normalized multichannel frequency-domain least mean square (NMCFLMS) with sparse prior imposition, at the presentation it will be shown that the use of cepstrum analysis and maximum-TDOA constraints improves the performance of NMCFLMS filter, in order to successfully localize different sound types in different reverberant conditions. In fact, cepstrum and the filter length constraint allow the improvement of performance in case of sound periodicity and in case of high reverberation respectively. Experimental results show the efficiency of the proposed improvements up to a RT60 of 2 seconds. Application of this method include monitoring systems, musical interfaces, videogames and teleconferencing systems.

Wed 15:50 Civic exhibition room Auditory scene analysis

Modeling Human Localization Performance of Sound Sources in Sagittal Planes

Robert Baumgartner, Piotr Majdak and Bernhard Laback
Austrian Academy of Sciences, Acoustics Research Institute

Human sound-source localization in sagittal planes (SPs), including front-back discrimination, relies on monaural spectral features, which result from acoustic filtering of incoming sounds by the torso, head, and pinna. While the spectral features are well-described by head-related transfer functions (HRTFs), models for SP localization performance have received little attention so far. In this study, we describe a template- based model aimed at predicting SP localization performance of human listeners. The model contains a peripheral-processing stage modeling human physiology and resulting in the internal representation of an incoming sound. The internal representation is compared with an internal template yielding a distance metric as a function of the polar angle in the SP. The distance metric is mapped to a probability distribution representing the prediction for the listener's polar response angle. Models for 17 listeners have been calibrated to listener-specific performance in a baseline localization condition for broadband stationary noise bursts. The predictions of the listener-specific model have been evaluated under two experimental conditions, showing a good correspondence with the experimental data, and thus validating the model.

Results of the model for exemplary applications like localization with non-individualized HRTFs and localization in spatial reproduction systems with loudspeakers are presented.

Wed 16:10 Civic exhibition room Auditory scene analysis

Sound Predictability as a Higher-Order Cue in Auditory Scene Analysis

Alexandra Bendixen[a], Susan Denham[b] and István Winkler[c]
[a] *Institute of Psychology, University of Leipzig;* [b] *School of Psychology, University of Plymouth (UK);* [c] *Hungarian Academy of Sciences*

A major challenge for the auditory system is to disentangle signals emitted by concurrently active sound sources. Besides characteristics of the individual signals (e.g., location, pitch), one important cue for distinguishing sound sources is how their emitted signals unfold over time. In a series of experiments, we show that sounds unfolding in a predictable manner are more readily perceived as originating from one sound source, which helps to isolate them from a sound mixture. Participants were asked to indicate whether they perceived a given tone sequence as one coherent stream of sounds or as two concurrent sound streams. Unknown to participants, tone predictability in one or both putative streams was manipulated. Results show that predictability separately within each of the two streams specifically prolongs the mean duration of two-stream percepts. An additional manipulation of the acoustic similarity of the two streams (in terms of frequency separation) revealed that predictability and feature similarity affect perception of the tone sequence with markedly different characteristics. We suggest that feature similarity acts as a primary cue, influencing the initial formation of sound groupings, while predictability acts as a higher-order cue, stabilizing streams once they have been formed on the basis of simpler acoustic cues.

Wed 16:30 Civic exhibition room Auditory scene analysis

EyesWeb XMI: a platform for real-time analysis of multimodal data streams

Gualtiero Volpe
DIBRIS - University of Genova

This talk introduces recent advances in the EyesWeb XMI platform (www.eyesweb.org). EyesWeb was originally conceived as a hardware and software research platform for fast prototyping of interactive systems and for supporting real-time analysis of multimodal data streams, based on a visual programming language. The platform includes libraries for image and video processing (e.g., background segmentation and motion tracking), for audio processing, for analysis of full-body movement and gesture of single and multiple users, and for analysis of social interaction within groups of users. It supports a broad range of input and output devices. Recently, EyesWeb has been extended with support to novel commercially available devices, such as Microsoft Kinect, and with a collection of new modules for

capturing and analyzing 3D data. Moreover, a further layer (the MetaEyesWeb) for real-time coordination of multiple EyesWeb applications has been integrated in the platform. EyesWeb is freely available on the Internet. It is being used in several application areas, such as active experience of cultural heritage and networked media, performing arts, education and technology-enhanced learning, therapy and rehabilitation, and it was adopted as research and development platform in several EU projects. It may provide significant research and development tools for multimodal scene analysis.

Wed 16:50 Civic exhibition room Auditory scene analysis

Using Tactile Semantic Information for the Synthesis of Plausible Whole-Body Vibrations

Robert Rosenkranz and Ercan Altinsoy
TU Dresden, Chair of Communication Acoustics

In the last decade, there has been a remarkable progress in audio-, video- and tracking technology. This stimulated the development of virtual environments (VE) and has resulted in a multitude of new applications like vehicle- or aircraft simulators. However, in contrast to the technical side of VEs the perceptual side has received minor attention. Generating content for VEs that is perceived as realistic is difficult. Recording scenes is a tedious task and allows for only a limited variety of scenes for presentation in the VE, therefore creating the need for general rules of generating plausible scenes. The goal of this work is to find said general rules for the synthesis of plausible whole-body vibrations in VE. When subjects are exposed to whole-body vibrations that are occurring in common daily life situations a certain perceptual object is formed which can be verbalized by the subject. These verbal descriptions contain semantic information about the occurring scene and span a semantic space. If each element of that space is correlated with basic vibration signals it is possible to create a map. By combining this semantic space and this map a general model for the synthesis of plausible whole-body vibrations can be created.

Wed 17:10 Civic exhibition room Auditory scene analysis

Influence of vibration on physiological and subjective reactions to vibro-acoustic stimuli

Christina Imbery[a], Thomas Biberger[b], Steven van de Par[a] and Reinhard Weber[a]
[a] *University of Oldenburg;* [b] *University of Oldenburg, Medical Physics*

Whole-body vibrations and strong sound exposures can have a negative impact on health and may lead to neck and back injuries. In contrast, this study shows that sound and vibration can also have a positive impact on the well-being by stress relaxation. Physiological and psychological data have been captured for different sound and vibration stimuli, produced by a Tibetan singing bowl. One stimulus configuration is a combination of acoustic sound and vibration (physical contact between bowl and body) and another stimulus configuration consists of acoustic sound only (no physical contact between bowl and body). During all presentation configurations

physiological parameters as skin conductance, skin temperature, EKG and breathing were recorded. Subsequent to the stimuli presentation phase the subjective reactions were collected by a guided interview. Unlike the collected psychological variables from the interview the physiological reactions do not always provide a clear response pattern to a given stimulus condition.

Wed 17:30 Civic exhibition room Auditory scene analysis

Design and Perceptual Investigations of Audio-Tactile Interactions.

Stefano Papetti
ICST, Zurich University of the Arts

An overview of my recent and current research on the development of interfaces offering audio or audio-tactile feedback is given. Such interfaces are regarded with great attention by the HCI community, since they promise to provide alternative or additional modalities to those based on the vision. Possible applications range from contexts where visual feedback is not possible or practical, to scenarios where particular accuracy or expressivity is demanded. The potential of these interfaces is currently under-utilized, as on the one hand a comprehensive knowledge of the role of auditory and tactile feedback in the action-perception loop is still missing, whereas on the other hand there is still need for research on optimized hardware solutions for haptic and vibrotactile rendering. Several scenarios and interfaces that have been developed in the context of human-computer interaction and musical performance are described, and the results of some preliminary cross-modal perceptual investigations are shown. From a technological perspective, special emphasis is put on the synthesis of sound and haptic feedback by means of real-time physics-based algorithms, which offer the advantage of dynamic, gesture-consistent behavior, but pose some issues in terms of numerical stability, versatility and mapping.

Wed 17:50 Civic exhibition room Auditory scene analysis

Modeling of Speech Localization in a Multitalker Environment using Binaural and Harmonic Cues.

Angela Josupeit[a], Steven van de Par[b], Norbert Kopčo[c] and Volker Hohmann[a]
[a] *University of Oldenburg, Medical Physics;* [b] *University of Oldenburg;* [c] *Inst. of Computer Science, Fac. of Science, Safarik Univ. Košice (SK)*

This study presents a model of the psychoacoustic study of Kopčo et al. [J. Acoust. Soc. Am. 127(3), March 2010] that measured detection and localization performance for a female voice target among four male maskers, distributed in the horizontal plane in a reverberant room. All voices simultaneously uttered one monosyllabic word, leading to a complete temporal overlap of target and masker signals. The target utterance was fixed throughout the experiment, whereas its azimuth was randomized across trials. Several spatial configurations of the random masker utterances were tested in two conditions: Either the masker configuration was fixed throughout a run, or it varied randomly from trial to trial. The proposed model integrates binaural and harmonic cues extracted using existing auditory

peripheral models of binaural and harmonicity processing. A template of the time course of the harmonic cues from the target voice alone was used to identify the target in the mixture. Thus, the harmonic cues can be seen as a prior guiding the readout of binaural features related to the target. Additionally, the model integrates cues across frequency bands. Model results show a reliable localization ability of the target voice in the multitalker mixture that is comparable to the psychoacoustic data.

Wed 18:10 Civic exhibition room Auditory scene analysis

Vibrations and Music - The Influence of Whole-Body Vibrations on the Concert Experience

Sebastian Merchel and Ercan Altinsoy
TU Dresden, Chair of Communication Acoustics

The perception of music is not solely an auditive phenomenon. For example, visual aspects may play an important role during a concert. This article examines the influence of vibrations on the perceived quality of the concert experience. At rock or organ concerts, clearly perceivable vibrations at the body surface occur. The body surface is stimulated directly via air-borne or indirectly via structure-borne sound. Even in a classical opera house vibrations above the threshold of perception can be measured during music performances. Nevertheless, in many cases the concert visitor may not recognize the vibrations separately, because the tactile percept is integrated with the other senses into one multi-modal percept. However, even if the listener is unaware of vibrations, they can have an influence on the perceived features, e.g. presence or envelopment. If these vibrations are missing, e.g. if a recording is reproduced using a hi-fi system, the perceived quality of the concert experience can be influenced. To investigate this influence, sound and vibrations have been controlled separately in a perceptual experiment. The results show that vibrations, which can be generated from the audio signal using different approaches, have to be considered when evaluating the quality of the concert experience.

Session "Intake and exhaust noise"

Wed 8:40 Cult. centre movie theatre Intake and exhaust noise

Turbocharged IC-Engine Intake Noise Prediction Based on Linear Acoustics

Yasser Elnemr, Ying Guo and Rafael Veloso
Virtual Vehicle Competence Center

1D linear acoustic or gas-dynamics modeling of an intake system is typically done during the early development stages of a vehicle in order to do quick sound design assessments. 1D gas-dynamics models of the compressor and the intercooler of turbocharged IC-engines which are currently available are primarily developed for performance calculation purposes. However, these models are usually not sufficient for acoustic analysis purposes. Thus an efficient and precise tool for the acoustic analysis of the complete intake system for a turbocharged IC-engine including advanced

acoustic models of the compressor, intercooler and air-filter box is proposed. Linear acoustic multiport models of the compressor, intercooler and air-filter box were developed and then reduced to their respective equivalent transfer matrix formulation. These transfer matrix elements are then arranged in series from the engine towards the orifice. The acoustic excitation from the engine is then obtained through the acoustic source characterization of a 1D gas-dynamics engine model. A monopole radiation from the orifice to an observation point was then assumed in order to obtain not only the sound pressure levels but also to assess the sound quality.

Wed 9:00 Cult. centre movie theatre Intake and exhaust noise

In-duct Source Characterization of Automotive Intake Systems on the Chassis-Dynamometer

Carlo Ubertino[a], Eugène Nijman[b], Flavio Faccioli[a], Luca Marini[a], Claudia Tremonti[a] and Klaus Pfaffelhuber[a]
[a] *Röchling Automotive AG & Co. KG;* [b] *Nijman Acoustics & Vibrations, Costigliole d'Asti (AT)*

Accurate IC-engine intake orifice noise simulation is not only needed to ensure compliance with legal pass-by limit values, but also plays a more and more important role when specific brand sound design targets have to be fulfilled. A precise prediction and realistic reproduction of the radiated intake orifice noise requires the accurate knowledge of the Thévenin source parameters, i.e. the in-duct source strength and impedance, under relevant operational conditions like a full load engine run-up. Today such acoustic source data are obtained either using non-linear one-dimensional time domain CFD codes or else by measurements on engine test rigs. Unfortunately these artificially obtained source data still prove insufficiently accurate either because they are unable to faithfully reproduce "real life" engine operation and flow conditions or else because they fail to include relevant details such as the frequency dependent acoustical losses in plastic ducts, flexible hoses and other complex components like turbocharger compressors. In this paper it is shown that fast and reliable source and component data may be obtained in-situ, that is, with the vehicle on the chassis dynamometer under realistic operational conditions and that these data can be used for high quality orifice noise prediction and optimization.

Wed 9:20 Cult. centre movie theatre Intake and exhaust noise

Development Methodology for Active Exhaust Systems

Dennis Bönnen, Hoi-Jeon Kim, Gerhard Zintel and Hannes Steinkilberg
Faurecia Emissions Control Techn., Augsburg

In recent years, the demand to develop an active noise system for automotive exhaust lines has increased significantly due to new engine development and the constant request for size and weight reduction. Especially downsized gasoline engines with strong low-frequency content would benefit from an ANC (Active Noise Cancellation) system, whereas an ASD (Active Sound Design) system could increase the sound performance if needed, e.g. for diesel engines. In order to predict the performance of such a system beforehand and to optimize the function within the development

process using a reliable acoustic simulation tool can be of a high advantage. The challenge within such a development process is the fine-tuning between the optimized passive and the added active part of exhaust line. In the following, the development methodology for the implementation of such a system is shown, exemplary for a vehicle with a high-power turbocharged gasoline 4-Cyl. engine. Major development steps are the assessment of speaker performance, the estimation of the acoustic behavior of the passive exhaust system and the optimization of the transfer function between loudspeaker and error sensor position. For all these steps the linear acoustic simulation tool AMELI, developed by Faurecia, has been applied.

Wed 9:40 Cult. centre movie theatre Intake and exhaust noise

Progress on Active Exhaust Silencers for Gasoline Engines

Jan Krüger, Matthias Conrath and Michael Pommerer
Eberspächer GmbH

In recent years, the active control of sound and vibration has been introduced in au-tomotive series and several premium vehicle manufacturers debuted cars with actively enhanced interior sounds. Moreover, also the exhaust sound of some diesel propelled vehicles was improved utilizing active means thus mastering the inherent tasks of modern mass production, quality requirements and longtime durability. For gasoline engine applications in modern passenger cars the active control of the sound field is by far more challenging due to higher noise levels and extreme ex-haust gas temperatures. On the other hand, current and future restrictions in vehicle CO2-emission result in a constant trend to further engine downsizing, turbocharging and downspeeding which inevitably will lead to higher noise levels in a lower fre-quency range where they are more difficult to handle with conventional muffler de-sign. After an overview of the current state of the ANC-technology with respect to automo-tive exhaust systems its benefits will be explained in detail for a 4-cylinder-engine. In this case study, the conventional dual exhaust system could be replaced by an active single exhaust line without compromising on the acoustic targets but saving design space and weight significantly.

Wed 10:00 Cult. centre movie theatre Intake and exhaust noise

Active Sound Design for Diesel Exhaust Systems

Michael Pommerer, Viktor Koch and Jan Krüger
Eberspächer GmbH

Modern diesel engine applications in passenger cars show good market acceptance due to impressive torque values in combination with low fuel consumption. In addition, in recent years the diesel noise signature has improved considerably by more sophisticated NVH refinement. However, for passenger cars with a dynamic or sporty character an adequate acoustic feedback is required by many customers. One possibility to enhance the acoustic behavior of diesel engine passenger cars is the application of ActiveSound. This exhaust technology influences the exhaust note significantly from typical diesel character to a sporty or dynamic sound character which can easily be adapted to all driving conditions. Contribution to the

exterior and interior sound quality is analyzed. Application examples of ActiveSound technology are shown and tuning possibilities are described.

Wed 10:20 Cult. centre movie theatre Intake and exhaust noise

The application of an active Helmholtz resonator to an intake system.
Lars Hansson
Chalmers Univ. of Technology, Göteborg (S)
Active control of sound and vibration can be utilised for tailoring the interior or exterior sound of vehicles. In contrary to passive systems it allows a high flexibility and eventually less space, especially when focusing on low frequencies. This paper deals with the application of an active Helmholtz resonator for the intake system of a two-cylinder engine. A loudspeaker is added to a Helmholtz resonator allowing for modifying the stiffness of the air volume of the resonator. The application is tested in an experimental set-up where an adaptive harmonic feed-forward controller is designed. The reference signal is obtained from the tacho-signal of the engine. Different approaches for the decoder are discussed together with performance of the controller in different situations.

Wed 10:40 Cult. centre movie theatre Intake and exhaust noise

Numerical calculations of dissipative mufflers
Liubov Vorobeva and Alexandr Komkin
Bauman Moscow State Technical University (RUS)
This paper discusses optimization of dissipative mufflers configuration under certain restrictions such as geometrical parameters for instance. The overall transmission loss (OTL) is used as objective function for optimization process, which values are defined not only by the muffler configuration, but also by the shape of the initial (non reduced) noise spectrum. The goal of optimization is to maximize overall transmission loss value. The studies were conducted with the help of numerical calculations based on finite element method. The acoustic characteristics of fibrous absorbent material were derived from experimental studies for further implementing in the finite element model of the dissipative muffler. Verification of the developed finite element model was performed by comparing the numerical calculation results with the results of the experimental measurements of dissipative mufflers characteristics in stand conditions. The approach of optimization of dissipative mufflers configuration with dimensionless parameters is presented and its efficiency is proofed.

Session "Numerical simulation in vehicle acoustics"

Wed 11:00 Cult. centre movie theatre Simulation in vehicle acoustics

Latest Developments in Solving Large Simulation Models in View of Pass-By Noise

Koen Vansant
LMS, Leuven (B)

Recently the debate on pass-by noise has been revived as regulations are targeting lower sound pressure levels for future cars. It will thus be valuable to use simulation models to evaluate different sound proofing layouts, for instance in the engine bay or around the muffler area, and to see how these affect the noise transfer functions from the vehicle sources to the receiver microphones 7.5 meters away from the car. As the results should typically be available up to 4 or 5 kHz, the challenge in such simulations is the model size. This paper will give an update and comparison of modeling and solver technologies that can be used to tackle such problems. A BEM approach using Fast Multipole BEM as solver will be compared with direct (MUMPS) or iterative (Krylov subspace QMR) solving approaches for FEM models. Furthermore, for the acoustic FEM models, this paper will elaborate on the AML technology which is used as anechoic condition at the FEM model's boundary, as it is of key importance in enabling the use of relatively small FEM models and therefore reasonable computation times.

Wed 11:20 Cult. centre movie theatre Simulation in vehicle acoustics

Comparative Analysis of Different Deterministic Methods for the Simulation of Exterior Noise Acoustic Transfer Functions

Giuseppe Miccoli[a], Claudio Bertolini[b] and Abdelkader Bihhadi[c]
[a] *CNR-IMAMOTER, Ferrara;* [b] *Autoneum Management AG, Winterthur (CH);* [c] *Autoneum France SASU*

The relevance of simulation methods for the analysis of exterior noise in the automotive industry is likely to increase for several reasons in the coming years. In the past, the high computational resources needed prevented the application of deterministic simulation methods to exterior noise. Today, this difficulty is partially overcome, thanks to the increase of the available computational power. So now it can be useful to re-assess the capabilities of deterministic simulation methods in relation to exterior noise. This article describes a comparison between different deterministic methods in relation to the simulation of the exterior ATFs of a simplified - but not trivial - vehicle engine bay mock-up up to 3.5 kHz. The BE method, the PML method and the IE method have been considered. The performance of these three methods is analyzed in terms of results quality and computational power needed. In previously published articles, only results obtained by BE and PML methods had been compared. Here the results obtained by the Infinite Elements method enrich the simulation database. Special attention is devoted to this method and its advantages and drawbacks in comparison with the other two.

Wed 11:40 Cult. centre movie theatre Simulation in vehicle acoustics

Vehicle noise and vibration numerical simulation with Abaqus

Mikhail Belyi
Dassault Systemes Simulia Corp, Providence (USA)

Abaqus provides state-of-the-art capabilities for vehicle noise and vibration simulation including very efficient modal analysis procedures for the coupled structural-acoustic systems. The high performance implementation of these procedures is based on the AMS (Automatic Multilevel Substructuring) technology. Parallel performance of the Abaqus modal procedures is sufficient for large-scale automotive noise and vibration simulation with millions of physical degrees of freedom in the so-called, ”low-frequency” and ”mid-frequency” ranges using traditional finite element approach. If the structural-acoustic system is fully coupled (response of the structure is strongly affected by response of the acoustic media, and vice versa), convergence of the modal solution based on uncoupled structural and acoustic eigenmodes can be extremely slow. For this case, Abaqus offers efficient modal analysis capabilities based on fully coupled structural-acoustic eigenmodes. Noise and vibration simulations with Abaqus can include advanced mechanical features such as effects of nonlinear pre-loading, unsymmetric effects for example, gyroscopic effects of rolling tiers, and frequency-dependent materials for example, visco-elastic and porous materials. Abaqus substructuring capabilities allow generating dynamic substructures for coupled structural-acoustic subsystems. The substructure generation algorithm based on the AMS technology demonstrates unique performance and scalability.

Wed 15:30 Cult. centre movie theatre Simulation in vehicle acoustics

Simulation of the Acoustical Behaviour of Thin Structures with Transient Excitation

Wolfgang Foken and Marleen Koch
Westsaechsische Hochschule Zwickau

Thin structures made of different materials such as steel, aluminium or composites are widely used in the industry especially for body parts in the automotive industry. The paper presents the numerical calculation of the acoustical behaviour from the transient force excitation by the structure born noise transfer path to the radiated noise from the surface measured at any position of a microphone. The difficulties of the numerical simulation because of the transient excitation and the complex body parts combined with different materials are discussed. By means of an example a universally valid approach for those numerical simulations combined with an experimental validation process will be presented.

Wed 15:50 Cult. centre movie theatre Simulation in vehicle acoustics

Noise radiated by an electrical automotive powertrain: numerical simulation

Pascal Bouvet and Jean-Baptiste Dupont
VIBRATEC France

The noise radiated by an electrical motor is very different from that radiated by a combustion engine. It is characterized by high frequency pure tones that can be annoying, even if the overall noise level is lower than that of a combustion engine. To evaluate sound perception of future users during the design phase, it is necessary to simulate the noise radiated by the electrical machine and listen it.

This paper describes a complete approach to simulate the noise radiated by electric motors. The principle of this multiphysical method is first to calculate the excitation due to electromagnetic phenomena using an electromagnetic finite element solver. This excitation is projected onto the structure mesh of the stator to calculate the dynamic response. Finally, radiated sound power is calculated with the aid of a finite element method. The calculation methodology assumes a weak coupling between the different physical domains.

This 3-step procedure is applied to an automotive electric motor and the calculation is performed for a run-up, resulting in deflection shapes and in a radiated power spectrogram. The noise radiated by the electric motor can be submitted to auditors in order to assess its perception by the driver and the passengers.

Wed 16:10 Cult. centre movie theatre Simulation in vehicle acoustics

The dynamic analysis of an engine catalytic converter

Constantin Onescu, Ionel Vieru and Sebastian Parlac
University of Pitesti (RO)

The paper shows the modal analysis of analytic converter used in the engine exhaust system. For calculus is used a catalytic converter modeled by surfaces, using CATIA V5 application. On computes comparatively the vibration eigenmodes for the catalytic converter housing, with and without taking into consideration the ceramic monolith influence. The results obtained by numerical calculus are compared with experimental data achieved at the University of Pitesti.

Wed 16:30 Cult. centre movie theatre Simulation in vehicle acoustics

Particle velocity measurements for validating vehicle acoustic simulations, theory and practicality

Daniel Fernandez Comesaña, Iban Cereijo and Andrea Grosso
Microflown Technologies

Numerical simulations are often required in the automotive industry for optimizing not only the acoustic performance but also durability and crash behavior of cars. Therefore validating the model when a prototype is built has remarkable importance in improving the current design. Most conventional updating techniques for adjusting the acoustic numerical models inside the cabin use microphones located at different reference positions for comparing predictions with real measurements. However, sound pressure is a scalar quantity which does not give information about the often unknown excitation distribution across the structure. This problem can also be addressed by using particle velocity sensors close to the radiating surfaces due to their vector nature. In this paper the main theoretical and practical considerations for using particle velocity sensors in the validation stage are presented. It is concluded that the use of solutions which combine both sensors, such as a P-U intensity probe, have strong potential for optimizing numerical models more accurately.

Wed 16:50 Cult. centre movie theatre Simulation in vehicle acoustics

Boundary Element Energy Method for the Acoustic Prediction of Automotive External Noise - Industrial Application.

Pascal Bouvet[a], Thierry Lambert[b], Benjamin Betgen[a] and Michael Thivant[a]
[a] *VIBRATEC France;* [b] *PSA Peugeot Citroen*

Regarding the new exterior noise regulation, acoustic shields packages become essential for a wide range of vehicles. Due to reduced development times, the acoustic design must start in the early stage of industrial projects and follow the whole development phase, requiring precise and reactive prediction tools. Classical FE methods are efficient in the low frequency range, but they reach their limits at higher frequencies, due to high computational cost, very precise mesh required, and high sensitivity to geometry and frequency. The method proposed here is based on view factors computation between Boundary Elements and local acoustic power balance resolution. Absorbing materials are characterized by diffuse absorption and transmission coefficients. The frequency based meshing criterion is relaxed: only the description of the geometry must be considered. Meshing and computation time are dramatically reduced. This energy method is dedicated to acoustic issues in the mid and high frequency range, preferably with complex geometries, broadband and distributed sources. The acoustic resolution is carried out by recently developed software SONOR. Successful comparisons with measurements are presented, concerning external noise prediction for an automotive engine bay.

Wed 17:10 Cult. centre movie theatre Simulation in vehicle acoustics

Numerical Investigations on Structure-Borne and Air-Borne Insertion Loss of Acoustical Multilayers used in the automotive industry

Claudio Bertolini and Theophane Courtois
Autoneum Management AG, Winterthur (CH)

The physical mechanisms thanks to which an acoustical multilayer can reduce the sound radiation of an automotive panel are different for the case of Structure-Borne (SB) excitation and for the case of Air-Borne (AB) excitation. As a consequence, SB Insertion Loss and AB Insertion Loss (IL) can, in principle, be different. In the automotive industry, it is common to use AB Insertion Loss to assess the performance of an acoustical multilayer, while SB IL is generally not used because its measurement is much more elaborate. Also as a consequence of this, the use of AB IL is often extended to the case of SB excitation, without a real confidence that this extension makes really sense. In this article, Finite Elements (FE) are used to investigate the difference between SB and AB Insertion Loss of acoustical multilayers normally used in the automotive industry for the construction of sound package parts. It is evidenced that, in general at least, the 2 quantities are substantially different and that the relationship between them depends on the type of multilayer considered. Care should be taken in using AB Insertion Loss to assess the effect of acoustical multilayers on structurally excited panels.

Wed 17:30 Cult. centre movie theatre Simulation in vehicle acoustics

FEA Computation of an Equivalent Structural Damping Loss Factor of Multilayer System using the Power Input Method

Thomas Semerak[a], Volker Rathje[a] and Otto von Estorff[b]
[a] *Volkswagen AG;* [b] *Hamburg Univ. of Technology, Inst. of Modelling and Computation*

Multilayered sound absorbing and damping materials (trim) are frequently used in a wide spectrum of industrial branches as a straight-forward way to improve the noise control treatment. The increase of the effective structural damping coefficient of a certain base material due to the multilayered Trim depends on the layer combination, its thickness and corresponding structural parameters. Particular structural material parameters of each layer influence the damped system in such a way, that its mobility changes leading to a different acoustical performance. A characterization of such a system in terms of its frequency-dependent equivalent loss factor can be performed by measurement using the Power Injection Method (PIM). A modified analytical PIM based on the results of finite element calculations can be used in order to avoid the often cumbersome and inexact measurements. A description of this method is presented in this paper. Its advantage is that a complicated multilayer FEM trim including large DOF numbers is represented by a simple single layer model. The base material together with an equivalent damping loss factor are substituting the trimmed system in a very convenient way, leading to good match of measured and computed FRFs.

Wed 17:50 Cult. centre movie theatre Simulation in vehicle acoustics

On the Use of Frequency Dependent Mechanical Properties for the Transmission Loss Prediction of Multilayer Panels

Paolo Bonfiglio[a], Francesco Pompoli[a], Maurizio Tarello[b] and Massimiliano Tiengo[b]

[a] *MechLav, Tecnopolo dell'Università di Ferrara;* [b] *ADLER EVO s.r.l., Villastellone*

Multilayer panels made of steel sheet, poroelastic layer and impervious mass are widely used on cars for increasing sound insulation in the cabin; a complete description of the vibro-acoustical behavior of the poroelastic material used in those panels requires the knowledge of mechanical parameters (i.e. Young's Modulus, Poisson ratio and loss factor) in order to model the wave propagation through the elastic structure constituting its skeleton. Although many of the materials used for noise and vibration control exhibit a viscoelastic behavior, at the present prediction models make use of the linear elasticity theory. As a consequence acoustical quantities, as for example sound transmission loss, can be predicted by using quasi-static values of the mechanical properties. In the present research several multilayer panels have been experimentally investigated and their sound transmission loss have been compared to results from a transfer matrix model with frequency dependent mechanical properties for the core materials (polyurethane foams and felts). Dynamic Young's modulus and loss factor have been measured using a method based on Rayleigh-type surface waves prompted by mechanical excitation. Results show a significant increase of the accuracy in the calculation for the materials that present a strong frequency dependency of the mechanical parameters.

Wed 18:10 Cult. centre movie theatre Simulation in vehicle acoustics

Sound Insulation of Structured Double Walls

Carsten Langhof and Ennes Sarradj

BTU Cottbus, Chair of Technical Acoustics

Structured sheet metal has embossed bumps that increase its bending stiffness compared to flat sheet metal. Thus, it offers great potential in lightweight construction especially for vehicles. However, the increased stiffness has an adverse effect on the sound insulation that could be already demonstrated for single wall constructions made of structured sheet metal. One option to increase the sound insulation of lightweight and stiff structures is to use double wall constructions. In this contribution, the effect of using structured sheet metals for double walls is analyzed. To this end, FEM and analytical modeling of the sound insulation for a wide frequency range is used. The results are benchmarked using practical measurements of different single and double wall configurations made of both flat and structured sheet metal. It is shown that the double wall constructions are one possibility to apply structured sheet metal when high sound insulation is required.

Session "Electroacoustics and sound reinforcement 2"

Wed 8:40 Cult. centre music room Electroacoustics 2

Virtual Microphones: Solving the Technical Difficulties for a Practical Device

Tobias Merkel[a], H.-G. Lühmann[b] and Tom Ritter[a]
[a] *Beuth Hochschule für Technik Berlin;* [b] *Lütronic Elektroakustik GmbH*

If a focussed ultrasonic wave crosses the wave field of an audio source, it will be modulated in its speed of sound. The modulation is proportional to the audio pressure. If the ultrasonic wave is received with an ultrasonic microphone its phase shift contains the audio information. In last DAGAs this phenomenon was discussed with the aim to use the ultrasonic beam itself as a so called "Virtual Microphone": at the place of sound reception no technical devices like membranes or similar are necessary.
Unfortunately the physical mechanism, which is responsible for the observed effects, is very small. To get a usable practical device some very hard technical difficulties remain to be solved. Our practical experiments have shown that there is a minimum requirement of 125-130 decibel dynamic range for all levels of the signal processing: starting with generating the electrical sine signal and transmit it into acoustical ultrasonic sound, receiving it again with ultrasonic microphones and processing it through all analog and digital units.
The presentation will show how we solved the technical difficulties to get the first Virtual Microphone for practical use.

Wed 9:00 Cult. centre music room Electroacoustics 2

Electret microphones with stiff plates as membranes

Joachim Hillenbrand, Sebastian Haberzettl and Gerhard M. Sessler
TU Darmstadt, Institut für Nachrichtentechnik

Common electret microphones are based on thin polymer membranes, approximately 10 to 30 μm thick and covered with conducting layers. These membranes are deflected by the sound pressure in such a way, that the maximum variation of the air gap thickness is located in the center of the membrane, while closer to the border of the membrane the air gap variation fades away. Recently, electret accelerometers were developed, in which the stiff seismic mass and the backplate are separated by an elastic polymer ring and the air gap thickness variation is thus independent of location. These accelerometers were taken as the basis of a new type of electret microphone with stiff plates. The height of the seismic masses was reduced to values below 200 μm. Thus, stiff plates were obtained and it was ensured, e.g. by openings in the housing of the sensor, that the sound pressure can reach the free surface of the plate. Various such microphones with different materials, thicknesses, and diameters of the plates were built. Sensitivities up to 10 mV/Pa and resonance frequencies between 4 and 10 kHz were measured. Better protection against environmental influences and lower harmonic distortion are potential benefits of the new microphones.

Wed 9:20 Cult. centre music room Electroacoustics 2

Spatial sound pick-up with a low number of microphones

Julian Palacino and Rozenn Nicol
Orange Labs - Université du Maine

Portable audio devices have become more and more popular during the last decade. Recent advances in audio compression and electronic miniaturization allow people to keep all their music and movies at hand, at all times. Nowadays people are using their smartphones everywhere as photo or video cameras. In order to provide a consumer possibility of 3D audio recording adapted to these kinds of devices, we developed a compact microphone array able to pick-up a full 3D sound scene, using less than four microphones. To compensate for the low number of microphones which results in poor spatial selectivity, spatial post processing is applied to the microphone signals and improves the sound source localization. Another advantage is that the post processing makes the sound reproduction flexible. The 3D audio scene can be converted into any format to be rendered to any equipment and any device. The paper will describe various recording set-ups in combination with the associated post processing. As a first assessment, their performances in terms of sound localization accuracy will be compared using a new set of objective criteria descriptors.

Session "Hydroacoustics: Source identification, sound propagation, and communication"

Wed 9:40 Cult. centre music room Hydroacoustics

Data Evaluation of Underwater Radiated Noise of Ships in Relation with Directivity

Anton Homm
Bundeswehr Techn. Centre WTD 71

The shallow water range Aschau of the German Bundeswehr Technical Centre for Ships and Naval Weapons is located in Eckernförde Bay in the Baltic Sea. The water depth in the area is around 20 m. Due to special properties of the seabed in the Bay two different sites with varying underground are used. At each site, 5 hydrophones, respectively, are available for the measurements. They are located below the keel and in 40 m and 80 m distance at portside and starboard side of the track. The investigations will show if this configuration, along with a special developed evaluation method, is suited to reveal information about the directivity of the radiated underwater sound of the ranged ship. In comparison, data of a towed reference source will be investigated in the same way.

Wed 10:00 Cult. centre music room Hydroacoustics

Predicting Underwater Sound Radiation: Modeling the Vibro-Acoustic Paths from Airborne and Structureborne Sources to Virtual Hydrophones in Shallow Water

Denis Blanchet and Arnaud Caillet
ESI, München

Noise and vibration simulation using classical methods such as Finite Element Method (FEM), Boundary Element Method (BEM) and Statistical Energy Analysis (SEA) are well integrated into standard design processes in the automotive, aerospace and train industry. In the marine industry, simulation starts to occupy a key role in product design as vibro-acoustics and environmental requirements are becoming increasingly demanding. This paper discusses new advances in marine vibro-acoustic predictions and in particular the modeling of airborne and structureborne source responsible for vibration generation on hull panels. To model the effect of water loading of hull panels a wavelet based sound radiation formulation is used to load hull panels with sea water allowing the computation of the ship's water loaded natural frequencies and modal damping. This paper also presents the use of Fast Multipole Boundary Element Method (FMM-BEM) to predict underwater sound radiation of vibrating hull panels in shallow waters. Several application examples using a 70 m luxury yacht model are presented.

Wed 10:20 Cult. centre music room Hydroacoustics

Underwater noise pollution by merchant ships

Stefan Schael
Bundeswehr Techn. Centre WTD 71

The contributions of underwater noise emissions of merchant ships into the marine environment are progressively drawing the interest of different national and international groups and organizations. Especially the increasing worldwide trade and the relocation of production lines are dependent on shipping traffic which inevitably influences the underwater world. For members of the European Navy, it is important to distinguish between the underwater emission of civilian and navy ships with all its consequences. Therefore, a common R&D project was initiated to establish a data base of the measurement results of underwater signatures produced by all kinds of merchant ships. This paper will present information on this SIRA-MIS (Signature Response Analysis on Multi Influence Mines) project within the European Defense Agency. It will provide the procedures for measurements along with first results performed at the fixed underwater signatures range of the Bundeswehr Technical Center for Ships and Naval Weapons, Naval Technology and Research in Germany. Ship configurations, environmental properties as well as the procedure of measurement, have a huge influence on the measurement results. Some of the strong distinctions will be shown.

Wed 10:40 Cult. centre music room Hydroacoustics

Free-Field Measurements of RV PLANET - Further Investigation

Volkmar Nejedl, Jan Abshagen and Rainer Kühl
Bundeswehr Techn. Centre WTD 71, Research Dep. FWG

The basic idea of ship noise measurements under freefield conditions, the experimental configuration and first results are described in [1,2]. A comprehensive evaluation of the measured data is still in progress. The presentation will focus on the radiated sound measured by an vertical hydrophone array. Such an array offers a large variety of possible analysis methods. Single channels evaluation, correlations between them and beam forming was done in order to inverstigate the ratiated ship noise, especially the dependency on machinary states, on the aspect angle and swell induced effects. Selected results will be presented in order to gather some insights from effects, which may interesting for a better understanding of radiated ship noise.

[1] V. Nejedl, A. Stoltenberg, J. Karstens: ”Freifeldmessungen zur Geräuschabstrahlung von Schiffen”, DAGA 2012, Conference proceedings, Darmstadt 2012

[2] V. Nejedl, A. Stoltenberg, J. Schulz: ”Free-Field Measurements of the Radiated and Structure Borne Sound of RV PLANET”, ECUA 2012, Conference proceedings, Edinburgh 2012

Wed 11:00 Cult. centre music room Hydroacoustics

Investigations on diver detection

Dietmar Stiller
Bundeswehr Techn. Centre WTD 71, Research Dep. FWG

In this paper detection of divers with an active sonar is considered. For surveillance of areas for protection of ships against divers in the underwater domain acoustic methods are often used. The detection results are influenced among others by the target strength of the diving devices and by the diving suits. Investigations regarding the estimation of the target strength out of the detection data are presented. The estimation is based on contacts of the detection data which were used in extracted tracks from different experiments.

Wed 11:20 Cult. centre music room Hydroacoustics

Experiments on Fluid-Structure Interaction for Underwater Sonar Applications

Jan Abshagen and Dennis Küter
Bundeswehr Techn. Centre WTD 71, Research Dep. FWG

Flow noise plays an important role in underwater sonar applications as it limits the performance of sonar antennas mounted onto or towed behind a moving platform. Pressure fluctuations inside the turbulent boundary layer which surrounds the antenna during operation act onto the outer wall of the sonar hull. The wall pressure fluctuations interact with the elastic wall structure and this fluid-structure interaction contributes substantially to the flow noise that is received at a hydrophone in the interior of the sonar system. Experimental results on the interaction of wall pressure fluctuations, flow-induced, and vibrational noise obtained in different types of systems will be presented and compared. Measurements were performed in laboratory, water-tunnel, and underwater free-field experiments.

Wed 11:40 Cult. centre music room Hydroacoustics

Low wave-number analysis of wall pressure fluctuation spectra

Elena Ciappi and Massimo Miozzi
CNR-INSEAN, Roma

Turbulent flow about the ship hull can be a relevant source of underwater and on board noise. In general, the direct sound radiation into the water of a turbulent boundary layer (TBL) is considered rather inefficient whereas, the radiation due to the induced structural vibration may be significant. Furthermore TBL excitation has relevant effect on the comfort on board high speed, small and medium size vessels and on the performance of the on board sensors and towed array used for underwater measurements. In the last years model and full scale experimental campaign have been performed to characterize wall pressure fluctuations (WPF) and the mechanism of the fluid structure interaction through direct measurements of the fluctuating pressure and of the induced structural response. On the basis of this database some theoretical models of different complexity for the space/wavenumber-frequency characterization of WPP has been developed. The validity of the different approximation introduced to describe WPP spectra with particular reference to the low wave-number domain are here investigated by comparisons between the measured and the simulated response of simple and ribbed panels.

Session "Computational aero-acoustics in industrial applications"

Wed 15:30 Cult. centre music room CAA in industrial applications

Acoustic Assessment of Car HVAC Components using CFD-CAA

Johannes Kreuzinger[a], Florian Schwertfirm[a] and Nikolaus Peller[b]

[a] *KM-Turbulenz GmbH, München;* [b] *AUDI AG*

Car HVAC systems are characterized by low Mach number M=O(0.03), moderate Reynolds number Re=O(50000), short distance between sound sources and listener d=O(1m) and complex geometries. A suited CFD-CAA method is the hybrid approach implemented in the code MGLET. Both, flow (LES) and acoustics (perturbation equations), are computed using the same grid and numerics. With Cartesian grids, local refinement, multi-grid technique, immersed boundaries to represent arbitrary geometries and being parallelized it is able to compute accurate results in an short turnover time, a prerequisite for industrial applications. Different applications will be shown: A LES alone predicts the differences in SPL between similar duct / exhaust nozzle configurations by quantitative analysis of computed source terms. Pure acoustic simulations are used to compute resonances in duct systems and track the paths of sound energy flux through a multi-branched system. The combined flow and acoustic simulation is able to predict the sound field of exhaust nozzles and to characterize SPL, scaling with flow rate, the precise shape of the spectra and directivity. In contrast to experiments the complete flow and sound fields can be analyzed without restrictions in number and location of probes.

Wed 15:50 Cult. centre music room CAA in industrial applications

Zonal LES for axial fan broadband noise prediction: Part 2 - Computational Test-Case

Michele De Gennaro[a], Alessandro Zanon[a], Helmut Kuehnelt[a] and Domenico Caridi[b]

[a] *AIT - Austrian Institute of Technology;* [b] *ANSYS Italia S.r.l., Milano*

Broadband noise prediction is a major challenge in computational aeroacoustics for many industrial applications. The objective of this paper is to provide to the scientific community a reference test-case for turbomachinery noise, assessing the potentialities of a novel breakthrough approach for CFD: the zonal LES. The test- case chosen is a 5-bladed axial fan in free field conditions with an outer diameter of 350 mm and an operating point at 1400 rpm whose aerodynamic and aeroacoustic performance have been investigated both from the experimental side (Part 1) as well as from the computational side (Part 2).

The computational approach combines of a fully resolved LES in the acoustic generation region with a RANS solution in the outer region, while the acoustic propagation is performed applying the Ffowcs Williams-Hawkings acoustic analogy. Results show very good agreement with experiments for aerodynamics and far-field sound power in a frequency range up to 10 kHz. A deep analysis of computational issues as mesh and subgrid-scale model sensitivity as well as physical quantification of the aerodynamic performance, noise sources location, noise level and noise pattern directivity

was performed, providing a wide, reliable and complete test-case for further studies and benchmarks.

Wed 16:10 Cult. centre music room CAA in industrial applications

Numerical Investigation of acoustic noise generated by turbulent flow through the application of a hybrid CFD - CAA Approach

Aaron Reppenhagen[a], Gerhard Dutzler[a], Andreas Hüppe[b] and Manfred Kaltenbacher[b]

[a] *VIRTUAL VEHICLE Research & Test Center;* [b] *Vienna University of Technology*

This contribution focuses on the numerical simulation of sound generated by turbulent flow. Numerical methods such as computational aero acoustics (CAA) are very capable of locating the sources of sound generation and also predict the propagation of sound. The prediction and visualization of the occurring phenomena can contribute to a better understanding of the generation mechanisms and help to minimize unwanted noise and optimize entire components. Our approach is based on a hybrid Computational Fluid Dynamics (CFD) - Computational Aeroacoustics (CAA) scheme. The unsteady CFD simulations were carried out with ICON FOAMpro® which is based on the OpenFOAM® open source CFD code. Based on the data of a transient flow simulation, the acoustic source terms are calculated on a fine CFD grid. These source terms are then interpolated in a conservative way onto a coarser acoustic grid and serve as input for the subsequent CAA simulation with CFS++ (Coupled Field Simulation). The acoustic sound field is obtained by solving the variational formulation of the Lighthill's acoustic analogy with an advanced Finite Element (FE) method allowing for non-matching grids and a PML (Perfectly Matched Layer) technique to accurately model free radiation conditions.

Wed 16:30 Cult. centre music room CAA in industrial applications

Hybrid Methods in Aeroacoustic Simulations of Climatronic Systems

Stefan Becker, Matthias Tautz, Sebastian Willmitzer, Kerstin Altenhein and Thomas Biermeier

Inst. für Prozessmaschinen und Anl.-technik, FAU Erlangen-Nürnb.

Numerical methods are gaining increasing importance in the analysis of the acoustic behavior of fluid systems. Hybrid methods, in which flow field and acoustic calculations are carried out in separate software packages, are commonly used. The coupling, which usually involves interpolation of data between two or even three distinct grids, is a critical step in such methods regarding both the quality of the results as well as their applicability.

In the present work, the coupling between a Large Eddy finite volume CFD simulation and a finite element sound propagation calculation was studied. The acoustic source terms were calculated according to the Lighthill analogy. Several approaches employing different grid types and interpolation strategies were investigated, including a novel approach based on a dual grid generated directly from the flow simulation mesh.

The geometry under consideration consists of a plate in a rectangular channel where both broadband noise as well as tonal frequencies is generated. Experimental measurements and an analytical solution of the occurring Parker modes were obtained as data base for the validation of the results from the acoustic simulation. This allows to evaluate the different approaches in terms of computational costs and achievable accuracy.

Wed 16:50 Cult. centre music room CAA in industrial applications

Simulation approaches for the prediction of the acoustic excitation on a passenger car vehicle.

Martin Maihöfer, Alexander Schell, Volker Schwarz, Hironori Tokuno and Reinier Toppinga
Daimler AG

In order to increase the passenger comfort, the prediction of driving noise is an important task in automotive industry. Due to significant improvements in the area of engine and tire noise, wind noise optimization becomes more and more important. The objective is the optimization of the interior noise level already in the early stage of the development. The aim is to predict the noise levels by simulation. In addition to the structural behavior of the vehicle, the knowledge of the wind noise excitation is important. As the vehicle structure and especially the side windows are highly receptive for acoustic excitations, the prediction of the near field acoustic of the vehicle plays an important role. For the investigation of the different physical effects a full vehicle model will be used. Based on measurements, the importance of the exterior acoustic for the interior noise prediction will be discussed. For the prediction of the hydrodynamic excitation on the side window, CFD simulations with StarCCM+ are carried out. The results will be compared with measurements. For the acoustic, two different simulation approaches are presented, a hybrid CFD-/CAA approach and a method based on a compressible CFD-solution. Based on the measurements, the approaches are discussed.

Wed 17:10 Cult. centre music room CAA in industrial applications

Accuracy of Aeroacoustic Analogies Inside the Flow Region

Andreas Hüppe[a], Aaron Reppenhagen[b], Manfred Kaltenbacher[a] and Gerhard Dutzler[b]
[a] *Vienna University of Technology;* [b] *VIRTUAL VEHICLE Research & Test Center*

In computational aeroacoustics (CAA), it is necessary to utilize an analogy to compute acoustic sources based on a given flow field simulation. Most commonly used in the field of CAA is Lighthill's acoustic analogy resulting in an inhomogeneous wave equation due to its simplicity and accuracy in the far field. However, within the source region the accuracy of the acoustic results is questionable. Other approaches based on a perturbation ansatz such as the acoustic perturbation equations (APE) allow an alternative description which enables a better differentiation between flow and acoustic quantities within the source region. Within our contribution, we utilize a stabilized finite element scheme to compute the acoustic field generated by

the flow past a generic side mirror based on perturbation equations similar to APE. Furthermore, we apply Lighthill's wave equation for the computation of the generated sound. Especially inside the flow region, we identify significant differences within the source terms as well as the resulting acoustic fields when comparing the two approaches. The accuracy obtained by Lighthill's wave equation as well as the perturbation equations will be evaluated with the help of measured data, and a detailed discussion of the both approaches will be provided.

Wed 17:30 Cult. centre music room CAA in industrial applications

Front-Rotor Trailing-Edge-Blowing for the Reduction of Open Rotor Noise

Rinie Akkermans, Arne Stuermer and Jan Delfs
German Aerospace Center (DLR), Braunschweig

A possible way to decrease the noise contribution of the interaction tones of a contra-rotating open rotor (CROR) is thought to be the application of trailing edge blowing, with the aim of reducing the momentum deficit of the front-rotor wake and therefore its interaction with the aft rotor. In this contribution, we present an assessment of front rotor trailing edge blowing for the reduction of CROR noise. For this purpose, the Airbus-designed generic AI-PX7 CROR configuration has been modified to include trailing edge blowing at the front rotor blades. With the DLR CFD-code TAU, uRANS simulations have been made of the baseline and the trailing edge blowing configuration. Subsequently, an aeroacoustic analysis has been performed with the Ffowcs-Williams/Hawkings tool APSIM+ for both configurations. The aerodynamic analysis shows a negligible degradation of the performance, with slightly higher unsteady loading of the aft rotor. On the aeroacoustics side, interaction tones are most affected showing the expected decrease in sound pressure level. Rotor-alone tones show slightly elevated sound pressure levels near the rotor plane. An interpretation of the front rotor trailing edge blowing as an additional aeroacoustic source will be discussed, explaining the increased rotor-alone tone noise.

Wed 17:50 Cult. centre music room CAA in industrial applications

CAA Estimation of Noise Radiated from a 2D Airfoil Profile with Leading Edge High-Lift Devices

Seiji Adachi[a], Peter Brandstätt[a] and John C. Simpson[b]
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High-lift devices at the leading edge (LE) of the airfoil are used to increase aerodynamic performance in addition to deploying the trailing edge (TE) flap when the aircraft is in approaching and landing phases. In developing a quieter aircraft, it is very important to reduce noise radiated from these devices. In this study, we estimated aeroacoustic noise from a 2D baseline airfoil, which has a double-slotted Fowler flap at the TE, with a few LE high-lift devices such as a droop nose, small and large Krueger flaps. The hybrid two-step method was used for computation. In the first step, a transient flow around the airfoil was simulated using computational fluid

dynamics with a model of large eddy simulation and time-varying pressure fluctuation on the airfoil was estimated. In the second step, sound radiation was simulated using computational aeroacoustics, where the wave equation was solved with the estimated surface pressure as a boundary condition. It was found that the droop-nose configuration is about 4 dB quieter than the conventional Krueger flap configuration over the entire frequency range examined in the analysis.

Wed 18:10 Cult. centre music room CAA in industrial applications

Prediction of acoustic behaviour of microperforated plates in High-lift configuration

Katherina Rurkowska and Sabine Langer
Institut für Angewandte Mechanik, TU Braunschweig

Porous materials are widely used in noise reduction applications. To minimize the external noise produced by aicraft propeller drives, microperforated plates are implemented. As a part of the project Sonderforschungsbereich 880 ”Fundamentals of High Lift for Future Civil Aircraft”, porous surfaces are used in the High-lift conguration to mitigate the flow noise and influence the structure-borne sound. In order to model the performance of the these microperforated plates, an approach based in the Johson-Allard for ridig frame porous media proposed by Atalla and Sgard is used. In this model an equivalent tortuosity is used and Biots parameters for cylindrical pores are assumed. The aim of this work is to predict the behavior and acoustic effect of the used microperforated plates during its operation lifetime. The sound absorption of the porous materials is carried on with our in-house Code using the transfermatrix method.

Session ”Noise and vibration at the working place 2”

Wed 8:40 Cult. centre exhib. room Noise at working place 2

Practical experience with hearing aids with hearing protection function

Peter Sickert
SG ’Hearing Protection’ of DGUV, Nürnberg

Hearing aids with hearing protection function are available on the market since 2011 as certified products. At the type examination as PPE it has been verified that the hearing aid when used at a work place in a noise area doesn’t produce damaging sound pressure levels at the ear. Sufficient ability of communication is however not checked at the type examination. This regards especially the speech intelligibility in noise, hearing of warning signals and relevant machinery sound. After introduction of two types of hearing aids with different performance parameters (number of frequency channels) on the market experiences regarding acceptance and usability have been collected. This has been done under consideration of different hearing losses and noise situations. The following aspects are important for the usability of the hearing aids with hearing protection function: Ï the objectively measurable speech intelligibility Ï the audibility of signals Ï the

recognition of relevant working sound e.g. informative machinery sound Ï the subjective hearing impression Ï the handling of a hearing aid.
With the implementation of hearing aids with hearing protection function persons with hearing impairment or hearing loss can keep their work places in noise areas also if a high amount of communication is required.

Wed 9:00 Cult. centre exhib. room Noise at working place 2

Individual Sound Attenuation of Ear-Plugs Measured with Audiometric Methods

Sandra Dantscher
IFA - Institut für Arbeitsschutz der DGUV, St. Augustin

Sound attenuation of hearing protectors measured according to ISO 4869-1 with a sample of 16 test subjects is used for selection of suitable products. But this selection method only gives statistical information on the effective attenuation. The individual attenuation values can differ significantly.
From the point of view of the European noise directive (2003/10/EEC) the individual performance of a hearing protector is important because the exposure limit values under the hearing protector have to be observed for every worker.
For custom moulded ear-plugs there is a second aspect. Due to their fabrication it has to be individually verified that the sound attenuation of the ear-plug conforms to the values from the type examination. For this reason fitting checks are necessary.
One of the test methods that are applied by manufacturers for measuring the individual sound attenuation is the use of an audiometer. The sound attenuation is calculated from the difference of two hearing thresholds - with and without hearing protector. At IFA the suitability of audiometric methods for individual sound attenuation measurements was investigated. Important aspects are the difference between individual attenuation values and the results from the type examination and the reliability of the subjective audiometric test procedure.

Wed 9:20 Cult. centre exhib. room Noise at working place 2

Vibrations on Buses

Alessandro Peretti[a], Francesco Bonomini[b], Anita Pasqua Di Bisceglie[b] and Giovanni Battista Bartolucci[c]
[a] *University of Padova, Post-Grad School in Occupational Medicine;* [b] *Consultant, Padua;* [c] *University of Padova, Department of Molecular Medicine*

Accelerations at the driver's seat in 49 urban buses have been measured under normal working conditions, from terminal to terminal. Longitudinal, transverse and vertical frequency-weighted accelerations were simultaneously detected both on the plane and on the base of the driver's seat. Vertical vibrations are dominant (average value 0.33 m/s2; standard deviation 0.06 m/s2) but they should not create a risk to the health of workers considering the Directive 2002/44/CE. The resonance frequency of the buses is typically equal to 1.25 Hz. The seat attenuates the vibrations in 84% of cases, whereas in 16% it amplifies them. Generally, the seat produces

amplification at 2-3.15 Hz; above these frequency values the attenuation of the seat is gradually increasing. From the tests carried out on 9 buses under controlled conditions (at constant speed and on straight paved paths in optimal conditions) it has been shown that there is correlation between speed and vertical acceleration. Accelerations on the backrest, on the steering wheel and the pedals, as well as in correspondence of the mouth and the head of the driver have been obtained. Data are compared with those previously obtained with different instrumentation and technique.

Wed 9:40 Cult. centre exhib. room Noise at working place 2

Vibrations on Forklifts

Alessandro Peretti[a], Francesco Bonomini[b] and Anita Pasqua Di Bisceglie[b]
[a] *University of Padova, Post-Grad School in Occupational Medicine;* [b] *Consultant, Padua*

In 14 companies of different types 131 forklift with electric and diesel engine have been examined under normal working conditions. Longitudinal, transverse and vertical frequency-weighted accelerations were simultaneously detected both on the plane and on the base of the driver's seat. The duration of each measurement was 10 minutes. The collected data show that the vertical vibrations are dominant (average value 0.47 m/s2; standard deviation 0.20 m/s2) and may create a risk to the health of workers. The resonance frequency of the forklifts is typically equal to 6.3 Hz. The seat attenuates the vibrations in 71% of cases, whereas in 29% it amplifies them. Generally, the seat determines amplification at 2.5-4 Hz; above these frequency values, the attenuation of the seat is gradually increasing. From tests carried out on 3 forklifts under controlled conditions (at constant speed and on straight paths with uniform surfaces) it has been shown that there is correlation between speed and vertical acceleration; also the type of pavement on which the forklift moves and the irregularities of the pavement greatly influence the vibrations. In conclusion, the critical aspects of the forklifts and the interventions that can reduce vibration are discussed.

Wed 10:00 Cult. centre exhib. room Noise at working place 2

New advances in the active noise control technology at workplace

Pietro Nataletti[a], Lindoro Del Duca[b], Diego Annesi[a], Luigi Cerini[a], Simone Marra[c], Antonio Moschetto[a], Filippo Sanjust[a] and Maurizio Serra[c]
[a] *INAIL, Dipartimento Igiene del Lavoro, Monte Porzio Catone;* [b] *Active Ltd, Roma;* [c] *Udito Farm Più SrL, Roma*

Introduction: The drivers of ambulances of emergency service 118 and of agricultural tractors are exposed to noise generated primarily, respectively, by the siren and the engine. Measurements in some Italian provinces indicate the possibility for drivers to exceed the lower action value of 80 dB (A) of the daily noise exposure LEX established by the Legislative Decree 81/2008 European Union noise Directive 2003/10/EC.
Methods: We have developed a prototype of a special active noise control earplug device, based on two-channel system ATH311 developed by Active Ltd, which can track the fundamental frequencies generated by the siren of an ambulance and by the tractor engine, and drop them in real time in the

driver's ear canal. The system was tested in the acoustics laboratory of the Department of Occupational Hygiene of INAIL (formerly ISPESL), via the use of a B&K 4128 dummy head and torso simulator equipped and a test ambulance and a test tractor.
Results: The Active Insertion Loss, the difference between the sound level in the ear canal with the ANC system OFF and ON, was greater than 10 dB in both ears of the dummy inside the ambulance and the tractor cabin in real conditions of operation.

Session "Machinery noise"

Wed 10:40 Cult. centre exhib. room Machinery noise

Diagnostic of rotating machinery based on their acoustic signature
Enrico Primo Tomasini[a], Milena Martarelli[b] and Paolo Chiariotti[a]
[a] *Università Politecnica delle Marche, Ancona;* [b] *Università degli Studi e-Campus, Novedrate*
The exploitation of acoustic data for the diagnostic of damages in rotating machinery will be shown in this paper. A diagnostic algorithm has been developed based on envelope analysis for the identification of amplitude and phase modulation, symptom of defects in rolling bearings components and rotation speed variation due to stick-slip phenomena. A methodology for the determination of optimal filter limits will be described exploiting the spectral kurtosis, to be applied in the pre-processing phase of the time histories on which the envelope analysis will be applied. Two case studies will be considered: the diagnostic of rolling bearings and the damage identification on electrical motors with a three stage epicyclical gear.

Wed 11:00 Cult. centre exhib. room Machinery noise

Vibro-acoustic Design of a Low Noise Hopper for Refuse Collection Vehicles
Sebastien Dalle
CETIM, Senlis (F)
According to Directive 2000/14/EC, refuse collection vehicle are equipment subject to noise marking and the acoustic tests shall be performed in a stationary position for 4 different operating conditions. The test phase where material is falling into the refuse collection vehicle is highly contributing to the global weighted sound power. Noise reduction on the refuses impact noise, and particularly enhancement of the hopper damping rate can significantly influence the declared noise emission values. To achieve a target of 14 dB reduction on the refuses impact noise, an experimental vibro-acoustic study on a vehicle was conducted.
The redesign process consists firstly in a measurement campaign including vibro-acoustic test on the refuse collection vehicle under real or artificial excitation. Results issuing this step are used to set a target on the vibratory behaviour of the hopper under real load. The integration of a noise reduction solution on the refuse collection vehicle has to reach the defined vibro-acoustic performance while taking into account the severe environmental conditions relative to waste collection.

Wed 11:20 Cult. centre exhib. room Machinery noise

Application of the Inversion Method for Testing Noise Emitted by Machines Used in Opencast Mines

Dariusz Pleban and Krzysztof Kosala
Central Institute for Labour Protection, Warsaw

The acoustic models of machines are important factors both in the design of low-noise machines and in the reduction and prediction of machine noise. In recent years, inversion methods have become more and more applied in various fields of science, including vibroacoustics. In vibroacoustics, inversion methods are used for testing processes in machines. When this method is used, the tested machine is replaced with a set of omnidirectional substitute sources. The acoustic parameters of the substitute sources are calculated on the basis of sound pressure levels and phase shift angles, measured around the machine with an array of 24 microphones. This paper presents test results of a combine unit (used in an opencast mine), for which an acoustic model was determined with the inversion method.

Wed 11:40 Cult. centre exhib. room Machinery noise

New Perspectives for the Noise Control of Mobile Machines

Eleonora Carletti
CNR-IMAMOTER, Ferrara

This paper starts presenting an overview of the noise control methodologies currently applied to mobile machines and the main results till now reached. Thanks to the EU noise limits in force for more than 30 years, many efforts have been addressed to a deeper knowledge on the main noise sources and the related noise transmission paths. As a result, the emitted sound power levels and the sound pressure levels at the operator station fully meet the limits currently in force. Despite this compliance, however, the noise by these machines keeps adversely affecting both people in the surrounding areas and the operators. Some results of studies by the author aimed at overcoming this limitation are then presented. They mainly concern the tailoring of the Sound Quality approach to this specific field. The shift from criteria based on energy parameters to hearing-related criteria assures new remarkable opportunities for the noise control of these machines. Noise solutions can be found able not only to assure lower noise levels and reduced perceived annoyance, but also able to take into account the main expectations of operators referring to the noise signals as carriers of information about the state of operation of the machine

Wed 15:30 Cult. centre exhib. room Machinery noise

Determination of Rigid Body Inertia Properties of Combustion Engines based on measured Frequency Response Functions

Christoph Tamm and Matthias Kurch
Fraunhofer Inst. for Struct. Durability and System Reliability LBF

The prediction of the vibro-acoustic behavior of vessels at every stage of the design process helps to identify acoustic problems and to optimize ship designs. In order to simulate the sound, noise and vibration transfer into ship structures, the sources of excitation need to be modeled. On board a vessel combustion engines are relevant sources of structure-borne noise, which introduce vibrations into the foundation as a result of the combustion process. For simulations in an early phase of design the engine can approximately be modeled as a rigid body with six degrees of freedom that is excited by an oscillating torque.
The calculation of the rigid body inertia properties, consisting of the moments of inertia and the center of gravity, can only be calculated with the exact knowledge of mass distribution, which is generally unavailable. In this paper an approach for the determination of rigid body inertia properties based on measured frequency response functions is described. The proposed technique is applied to estimate the inertia properties of two combustion engines. First numerical simulations of the engine vibrations are performed and the results are presented.

Wed 15:50 Cult. centre exhib. room Machinery noise

Steam Turbine Exhaust casing - Determination of Sound Reduction Index by Measurement and Calculation

Werner Schirmer
SCHIRMER Beratende Ingenieure, Dresden

The exhaust casing is the main sound transmission path from the inside sound generation by interaction steam flow / turbine blades to the sound field outside the turbine. Thus its frequency dependent sound reduction index R is of interest for analysing the sound generation of steam turbines. The paper deals with the measurement of R of an exhaust casing. Its free volume is 16 m^3. All holes are closed. The measurements took place in a normal industrial hall with low background noise. Inside the exhaust casing a Dodekaeder loudspeaker produces a total sound pressure level of 120 dB. The sound radiated from the exhaust casing was measured by the intensity scanning method in 150 mm distance from the surface at 11 partial areas. The calculation of R by help of construction parameters of the exhaust casing is carried out with an excel calculation program. Both results are corresponding quite well. Finally, it will be pointed out, that for a working turbine R is higher than measured and calculated for normal condition pressure outside and inside the exhaust casing. For typical turbine working parameters this correction is about +15 dB for all frequencies.

Wed 16:10 Cult. centre exhib. room Machinery noise

Simulation of the Sound Radiation of an Air Conditioning Unit from a Railway Vehicle using Transfermatrix Techniques

Moritz Linke[a], Rüdiger Starobinski[b], Welf-Guntram Drossel[a], Jan Troge[a], Holger Kunze[a] and Björn Knöfel[a]

[a] *Fraunhofer IWU, Chemnitz;* [b] *Silencers. Consulting and Engineering, Hamburg*

The air conditioning unit of a railway vehicle is one of the major sound sources for exterior and interior noise. The design of such devices is a compromise between major functions like efficiency, fluid mechanics, thermodynamics and acoustics. The acoustical behavior of an air conditioning unit needs to be quantified in every state of the development process, starting in an early design phase. Therefore preferably simple and fast calculation tools are needed, which can be easily built up and adapted in a short time. Within a research project at the Fraunhofer Institute for Machine Tools and Forming Technology IWU an acoustical calculation model, based on transfer matrices of the different components, has been created to give a sufficiently accurate description of the sound power radiated by the AC-unit. In a first step the sound power of important sources has been characterized by measurement data. Furthermore the acoustical transfer behavior of ducts and additional components like condensers or evaporators has been individually investigated and implemented in the model using transfer elements. Finally, the sources and transfer components were combined to give a complete representation of the acoustical properties of the air conditioning unit, which can be used for parameter variation studies.

Wed 16:30 Cult. centre exhib. room Machinery noise

Qualification of Laboratories for Sound Power Determinations

Christian Bethke and Volker Wittstock

Physikalisch-Technische Bundesanstalt

The sound emission from technical equipment and household appliances is characterised by the sound power. Sound powers can be determined by various methods, e.g. by enveloping surface methods using sound intensity or sound pressure. Especially for the latter method, special laboratory rooms are required which provide an essentially free-field over a reflecting plane. Within a cooperation with BSH Bosch und Siemens Hausgeräte GmbH, PTB performed qualification measurements in three similar rooms. The qualification procedure according to annex A of ISO 3745 was applied and the measurement results could be compared to results from another testing institute obtained for one room. Additionally, the room correction K2 according to ISO 3744 was determined on several box-shaped surfaces. The results of the different qualification procedures are compared and recommendations are given how to handle the room correction K2 in such rooms.

Wed 16:50 Cult. centre exhib. room Machinery noise

Application of Psychoacoustics on the Machinery Noise Emission of Gear Transmissions

Christian Carl, Christian Brecher and Markus Brumm
WZL of RWTH Aachen University

Acoustic quality of powertrains becomes increasingly important for the customers' acceptance. The gear transmission remains a main functional and acoustic component in stationary (e.g. wind turbines) or mobile (e.g. vehicles) machinery, which is confronted with developments like lightweight design or the reduction of masking noises. Therefore, high acoustic quality of the gear transmission is strongly demanded in order to meet the acoustic requirements of the machinery system. A complete avoidance of gearbox noise can often not be achieved by reasonable means. Consequently, increased acoustic quality needs to be achieved by reduction of perception related annoyance, which can be determined by psychoacoustic metrics. But there is only insufficient knowledge about the correlation between the physical excitation in the gear mesh and the psychoacoustic rating of the radiated noise. This paper discusses the application of psychoacoustics on three different machineacoustic signals of gearbox noise: excitation, surface vibration and air-borne noise. Several different gearsets, which differ in their excitation, are investigated experimentally regarding the psychoacoustic evaluation. Furthermore, the application of FRFs is discussed to predict the noise emission theoretically. Finally, correlation analyses show possibilities of transfer psychoacoustics to the gear set excitation that represents a foundation for the gear transmission design process.

Wednesday Machinery noise (Poster)

A procedure for measuring electric motor noise in noisy environments

Rosario Romano[a], Raffaele Dragonetti[a] and Francesco Mercogliano[b]
[a] *Univ. of Naples 'Federico II';* [b] *DENSO Thermal System SpA, Poirino (TO)*

This work reports a method to obtain the noise spectrum emitted by electric motors carrying out acoustic measurements in a noisy environment. Such a method was the main goal within the framework of an agreement drawn up between DETEC and DENSO Thermal System. The latter needs, during the production of air cooling systems, to assess the acoustical quality of the used electric motors. In particular there are specific regulations and guidelines that require tonal components of electric motor noise below a fixed threshold so that motors are suitable. A solution for the above-mentioned need could be a shielding of the measurement apparatus and tested electric motors against the external noisy environment by means of a box. At low frequencies (e.g. < 200 Hz) a suitable passive sound insulation results in a quite heavy structure. Therefore the proposed technique is based on a noise insulation at low frequencies based on noise compensation. Numerical simulations were performed to investigate about capabilities of the proposed method and to choose the more suitable geometric configuration of the box. Then preliminary tests were carried out in an anechoic environment with artificial noise to verify the accuracy of the method.

Wednesday Machinery noise (Poster)

Parameters influencing the vibration excitation in elliptically deformed ball bearings

Adam Skowronek, Steffen Kuhl, Joachim Bös and Holger Hanselka
TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

Ball bearings can have a major influence on the acoustical behavior of rotating machines, both as a transfer element for vibrations between the shaft and the outer machine parts and as a source of vibration excitation itself. This also enables the assessment of the bearings' condition by means of vibration diagnosis. This paper deals with the vibration excitation caused by not circular shaped ball bearings in special gearings. Due to the operation mode of these gearings the bearings undergo a revolving elliptic deformation, causing other loads and deformations than those known from classical bearing applications. To determine how these values change in the course of time, a simulation model in the time domain has been developed. It is used to analyze the effects of bearing failures and parameter variations on the forces within the bearings and on the excited vibrations. Simulation results of certain parameter analyses are presented and compared with measured data. The study aims at gaining a better understanding of the parameters that influence the vibration excitations in elliptically deformed bearings to reduce the bearings' excitation. Additionally, it is of interest to compare the effects of failures on the vibration signals in circular and elliptically deformed bearings.

Wednesday Machinery noise (Poster)

Acoustic Emission Sensors on the Basis of Piezo-electric Composite Materials for Machinery Engineering Applications

Peter Holstein[a], Christian Probst[a], Dominik Surek[b] and Andreas Tharandt[c]
[a] *SONOTEC Ultraschallsensorik Halle GmbH;* [b] *An-Institut Fluid- und Pumpentechnik Merseburg;* [c] *Steinbeis Transferzentrum 'Technische Akustik u. angew. Numerik'*

Vibrational analysis and technical acoustic investigations are predominantly done in the frequency range up to 20 kHz. However, many technical and physical processes produce sounds at higher frequencies. Therefore, an approach has been developed for the simultaneous investigation of frequencies of very slow vibrations up to about 200 kHz (and even higher) by means of new sensors for acoustic emission. The sensors have been developed on the basis of piezo-electric composite material. Commonly, the spectral-sensitivity characteristics of the sensors exhibit several resonances caused by the construction principles. The piezo-composite sensors show only weak unwanted resonances due to the specific internal construction principle. Therefore, the frequency characteristics of the sensors can be linearized to a certain extent. It will be demonstrated, that the highly sensitive sensors can be used for the simultaneous investigation of vibrational effects at low frequencies and for high frequency processes as well. Examples are given for the diagnostics of bearing damage, for cavitation in pumps and for the monitoring of structures.

Session "Structure-borne sound and vibration 1"

Wed 17:30 Cult. centre exhib. room Structure-borne sound 1

Calculation of Transmission-Loss and Noise-Reduction-Indices Using a Random Finite Element Simulation

Martin Abele and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

The calculation of the acoustical transmission-loss (TL) in the case of diffuse excitation fields and the identification of noise-reduction-indices (NR) for excitation fields, which arise on surfaces beneath a turbulent boundary layer, are of great interest in many areas of mechanical engineering.
The excitation caused by a diffuse field or a turbulent boundary layer can be considered as a random pressure field. This is characterized by its auto power spectral density (Auto PSD) and its cross power spectral density (Cross PSD).
If the structural response can be determined in an analytical way, the calculation of a TL or a NR can be executed quite efficiently. Analytical solutions for complex structures, however, are commonly not available. Therefore, the structural response must be determined numerically, e.g. by using the finite element method. The resulting calculation time strongly depends on the frequency and the associated grade of spatial discretization.
In the current contribution three different methods for the determination of the excitation-vectors for the FE-Simulation are critically discussed: The conventional method, which utilizes a singular value decomposition of the Cross PSD Matrix, a plane wave sampling procedure and a Cholesky sampling procedure.

Wed 17:50 Cult. centre exhib. room Structure-borne sound 1

Effects of locale property changing of hardable sheetmetals to transmission of sound

Rico Schmelter and Armin Lohrengel
TU-Clausthal, Institut für Maschinenwesen

Plain structures of sheet metal often constitute a main source of sound emission without being the source of sound excitation. Emission of sound generally is influenced by the modes and total deflection of the structure, while the transmission from source to the emitting structure is denoted by material impedance and reflections. To decrease this emission of sound, three main methods exist: damping the modes, insulation of the structure or isolation of the emitting structure from the source. Damping of the structure and insulation are state of the art. Regardless, these methods are either material or money intensive or come ahead with an increase of weight. A new approach for reducing sound emissions can be acoustic isolation of the plain structure from the source by locale changing of material properties with laser. To specify acoustic properties of this local changes, at the Institute of Mechanical Engineering (IMW) at Clausthal University of Technology experiments on plain sheet metal plates were done. This proceeding will suggest the latest results from the experiments and FE-modelling of the sound transmission through local material changes.

Wed 18:10 Cult. centre exhib. room Structure-borne sound 1

Identification of structural parameters based on acoustic measurements

Thomas Kletschkowski
Hamburg University of Applied Sciences

Modal quantities (natural frequencies and mode shapes) of vibrating structures can be used to identify associated structural parameters (generalized mass- and stiffness-matrices). This usually requires vibration measurements with structural sensors (accelerometers) attached to the vibrating surface. As a consequence, the structural response is modified. This effect can be corrected during data processing, or avoided, if vibration measurements are replaced by acoustic measurements. For this purpose, it is advantageous to use particle velocity probes to distinguish between in-plane and normal components. In the present study, the response of a simplified test rig that consists of three mass points (610g) attached to a simply supported elastic beam (150g) has been measured with a pu-probe (provided by Microflown). Based on conventional modal analysis and considering the first three mode shapes, it has been possible to identify both physical and generalized mass- and stiffness-matrices. The physical parameters have been identified for a discrete model (mass points, massless elastic beam-elements). The results have been confirmed using vibration measurements as input for the identification procedure and improved by the application of an LMS-algorithm. Furthermore, it has been possible to validate a Finite Element Model of the test structure using both data sets with the same accuracy.

Wednesday Structure-borne sound (Poster)

Acoustic Radiation Characteristics of the Vibrating Plate Structures with Arbitrary Boundary and Environmental Conditions

Lukasz Nowak and Tomasz Zielinski
IPPT PAN, Warsaw

Acoustic radiation beam patterns of the vibrating plate structures with arbitrary boundary and environmental conditions are considered. It is assumed, that the plate is surrounded by air and the structural and acoustic domain can be decoupled. The eigenfrequencies and the corresponding eigenmodes of the plate are determined using the Finite Element Method. The amplitude of the acoustic pressure in any point of the surrounding space is computed as a linear combination of the modal amplitudes. Three different cases of the environmental conditions are considered, for which different algorithms of determining the coefficients of the combination are introduced. The first case concerns the far field radiation of the baffled plate, for which the Rayleigh's integral can be applied. The second case includes the free field conditions and the near or the far field radiation. The coefficients are computed using indirect variational Boundary Element Method. The third - most general case - concerns complex environments which cannot be described exactly enough with the numerical models. The empirical method of determining the radiation coefficients is introduced in

this case. The results of the simulations are compared to the results of the experiments performed in an anechoic chamber and in the complex, reverberant environments.

Wednesday Structure-borne sound (Poster)

Modification of Flat Plates to Decrease Radiation Efficiency and Increase Transmission Loss

S. S. Pathan and Dhanesh N. Manik
Indian Institute of Technology, Bombay

Flat plates are used in machines as an outer cover but they become sounding boards in many cases. It becomes difficult to objectively determine whether the sound from the machine is due to higher radiation efficiency or lower transmission loss. Sometimes this problem can be overcome by providing constrained layered damping or using a double walled construction to increase the transmission loss. However, both these approaches cannot be used in cases where heat dissipation is important; for example, in case of transformers. The present investigation therefore attempts to change the nature of flat surface of the plates to reduce radiation efficiency and to increase transmission loss. The modification is in terms of attaching stiffeners that not only increase the stiffness but also decrease the efficiency at which vibration of the structure gets coupled with the surrounding air. The effect of these modifications are predicted and verified through experiments based on SEA and BEM modeling.

Wednesday Structure-borne sound (Poster)

Piping fatigue failures by acoustically induced vibration: when design optimization may sacrifice mechanical integrity and safety

Rosario Romano[a], Giuseppe Squadrone[b] and Raffaele Dragonetti[a]
[a] *Univ. of Naples 'Federico II';* [b] *DESIGN HSE Noise Control Group - TECNIMONT S.p.A.*

In industrial plants, process piping subjected to the vibrations induced by high frequency acoustic excitation of high pressure letdown devices, associated with large-flow gas systems, may led to fatigue failures within few minutes or hours. This mechanism, well known as Acoustically Induced Vibration (AIV), has been formerly recognized, documented and analyzed by Carucci-Müller at early 80's and a safe design limit curve, plotted as theoretical sound power level inside pipe (Lw) versus pipe diameter, was proposed. In the late 90's the Marine Technology Directorate encouraged a deep investigation on this subject and as outcome, a guideline had been published containing most accurate risk assessment criterion, based on the mechanical parameter Likelihood Of Failure. This paper reports on AIV risk assessment performed by means of either Carucci-Müller or MTD method and based on the analysis of data provided by TECNIMONT through a series of activities carried out during the design of industrial plants in recent years.

Session "Numerical acoustics 2"

Wed 8:40 Urania Alton Numerical acoustics 2

On the Accuracy of finite Elements compared to experimental Results and the Influence of distorted Elements

Marcus Guettler and Steffen Marburg
Universität der Bundeswehr München

Different element types can be chosen in modern commercial finite element tools. Usually, their specific selection depends on the problem to solve. Benchmark tests are a common method to prove the elements' performance against analytical solutions. However these tests are often realized only for single elements. When investigating the complete mesh of a structure the comparison of the element's performance is quite challenging due to the lack of closed or, at least, fully converged solutions. The main goal is to simulate the behavior of a real structure as good as possible because a closed solution only represents the behavior of the underlying mathematical model. In this paper, we will present element performance investigations using the commercial code ABAQUS. Performance of finite element types is investigated by testing convergence of the numerical solution and, at the same time, comparing these numerical results with experimental results. In addition the authors will present the effect of distorted elements on the quality of the analysis.

Wed 9:00 Urania Alton Numerical acoustics 2

Flexible Discretization for Computational Acoustics

Manfred Kaltenbacher[a], Andreas Hüppe[a] and Barbara Wohlmuth[b]
[a] *Vienna University of Technology;* [b] *TU München*

Flexible discretization techniques for the approximative solution of coupled wave propagation problems are investigated. In order to keep as much flexibility as possible, we use independently generated grids which are well suited for approximating the solution of decoupled local sub-problems in each subdomain. Therefore, we have to deal with the situation of non-conforming grids appearing at the common interface of two subdomains. Special care has to be taken in order to define and implement the appropriate discrete coupling operators. We apply the Finite Element (FE) method and use two approaches to handle non-conforming grids: (1) Mortar coupling; (2) Nitsche type coupling. In the first approach we guarantee the strong coupling of the numerical flux (normal derivative of the acoustic pressure) by introducing a Lagrange multiplier and coupling of the acoustic pressure in a weak sense. The Nitsche type coupling does not need the additional Lagrange multiplier and handles the coupling by symmetrising the bilinear form and adding a special jump term. We will compare both methods, discuss their advantages and disadvantages and will apply them to practical examples in computational acoustics.

Wed 9:20 Urania Alton Numerical acoustics 2

Transmission loss modelling of double wall structures using hybrid simulation

Alexander Peiffer
EADS Innovation Works, München

The major part of the acoustic mid-frequency power into cabins of aircraft, trains or cars is transmitted via double wall systems. Especially the double wall effect is a typical example for hybrid theory because of the deterministic nature of the double wall resonance. In hybrid theory implementations deterministic subsystems are modelled using the finite element method. In contrast to this, the acoustic treatment of primary structures consisting of fibre blankets and the interior lining is modelled by analytical models that do not perfectly describe the radiation stiffness of the structure into the cabin cavity. This paper deals analytical models, full finite element approaches of the double wall and tries to establish a hybrid double wall formulation using complex modes of the coupled fluid structure system. Finally, the different approaches will be compared for different type of exterior excitations and regarding numerical efficiency and precision.

Wed 9:40 Urania Alton Numerical acoustics 2

Numerical Simulations of a Supersonic Impulsively Starting Jet and its Acoustics

Juan Jose Pena Fernandez and Jörn Sesterhenn
TU Berlin

Numerical simulations of a supersonic impulsively starting jet are performed, analyzing the main acoustic properties. The supersonic jet aeroacoustic is mainly analyzed in the statistically steady regime, in which there are three main noise sources, called screech, turbulent mixing and shock associated broadband noise. The screech noise is generated due to the closing of a cycle that involves the nozzle exit, the position in which the eddies are detached from the shear layer and the acoustic waves travelling in the subsonic region backwards to the nozzle. The starting of the jet resolves from the initial condition until this cycle is created and the Sound Pressure Level spectrum and the noise radiation diagram in this time interval are deeply analyzed. The acoustics of the jet starting is a challenging problem with shockwaves and a complex acoustic feld. In order to resolve this acoustic feld, pressure fluctuations of order 2×10^{-5} [Pa] must be resolved in a feld where the average value is 10^5 [Pa].

Wed 10:00 Urania Alton Numerical acoustics 2

Application and analysis of a boundary error indicator based adaptive Wave Based Technique

Tamás Mócsai and Fülöp Augusztinovicz
Budapest University of Technology

In recent years, the Wave Based Technique (WBT) has become a new alternative of the element based acoustic simulation methods (e.g. Finite Element and Boundary Element Methods). WBT is based on the indirect Trefftz approach, in which exact solutions of the governing differential equation are used, requiring a less fine element discretization. The resulted numerical models exhibit an enhanced computational efficiency, which can extend the frequency range of the calculation. Recently, a novel boundary error controlled adaptive strategy has been applied and investigated to provide a-posteriori error indication and control of accuracy. Practical application of the strategy is presented on numerical examples.

Wed 10:20 Urania Alton Numerical acoustics 2

Modeling absorption by implementing boundary conditions for the time domain boundary element method

Carsten Marter and Martin Ochmann
Beuth Hochschule für Technik Berlin

The boundary element method (BEM) is well known in frequency domain. This method is capable of predicting sound fields for several applications. In contrast to the harmonic case a transient problem can only be solved in the time domain. Additionally it can be beneficial to calculate the impulse response function in the time domain. The response for several frequencies can be obtained by applying Fourier transform as kind of a post process. Therefore only one calculation is needed in opposite to evaluate the response for each investigated frequency. However, the boundary condition values depend on the frequency. This is the case for absorbing walls in building acoustics, or real and imaginary part of impedance for other applications. This paper presents a solution to implement frequency depending boundary conditions for transient simulations. A BEM was programmed which uses constant shape functions on each boundary element and different shape functions with respect to time. Especially the behavior of the method related to stability, as it is known from finite difference applications, was investigated. Methods to improve stability are shown. Finally, results for special examples of application are presented and compared to analytical solutions.

Wed 10:40 Urania Alton Numerical acoustics 2

Iterative approach for transmission loss simulations

Rafael Piscoya, Ralf Burgschweiger and Martin Ochmann
Beuth Hochschule für Technik Berlin

In a previous work, the transmission loss of plates in a Kundt's tube was simulated using a coupled BEM-Rayleigh-Ritz approach. The Helmholtz integral equations were used to describe the sound field in the tube and the Rayleigh-Ritz method was applied to the equation of motion of the plate. By solving the coupled system of equations, the sound pressure in front and behind the plate was calculated and the transmission loss obtained. In the present work, we apply the method to simulate TL test facilities. Due to the size of real test facilities, the number of elements even for middle frequencies can be very large. To reduce the size of the system to be solved, an iterative scheme is incorporated in the method. With the iterative approach, the acoustic and elastic calculations can be decoupled so that three smaller systems, i.e. source room, plate and receiver room are solved instead of the bigger total system. However, the three systems need to be solved several times until convergence is obtained. Still, each room may require large number of elements for sufficiently high frequencies. Therefore, a Fast Multipole BEM will be incorporated to speed up the calculations and avoid the enormous memory requirements.

Wed 11:00 Urania Alton Numerical acoustics 2

Dynamic load in a layered soil with anisotropic material

Holger Waubke and Wolfgang Kreuzer
Austrian Academy of Sciences, Acoustics Research Institute

The differential equation for an anisotropic soil can be solved in the Fourier-domain about time t and orthogonal coordinates x,y,z. The result are six generalized eigenvalues kz,i for the vertical direction and eigenvectors Ψi. The inverse transformation of the homogenous solution can be done analytically for every horizontal layer. A half space can be added and inclining waves are neglected. The result are three eigenvalues for the half-space. The amplitude of the waves described by the eigenvalues and eigenvectors are unknown and have to be determined form the boundary conditions at the interfaces. So far loads are allowed only at the interfaces. A load within a layer can only be handled, if the layer is split into two sub-layers with an interface at the height of the load. By some mathematical operations a solution was derived that allows to melt the two sub-layers into one layer again with special boundary conditions at the upper or lower interface. The solution works for the determination fairly well, if the interface of the sub-layer is near to the loaded interface. But no stable solution for stresses and displacements in the loaded layer was found.

Wed 11:20 Urania Alton Numerical acoustics 2

The Combination of a Multi-Level Fast Multipole Algorithm with a Source-Clustering Method for higher expansion orders

Ralf Burgschweiger[a], Ingo Schäfer[b], Martin Ochmann[a] and Bodo Nolte[b]

[a] *Beuth Hochschule für Technik Berlin;* [b] *Bundeswehr Techn. Centre WTD 71, Research Dep. FWG*

The Multi-Level Fast Multipole Method (MLFMM) allows the computation of acoustical problems based on the Boundary Element Method (BEM) where the discretized models of the corresponding structures may consist of a huge number of elements.

The required multipole expansion order of the so-called translation operator increases significantly with higher frequency and larger dimensions of the model considered. If this order reaches a value of about 80-90, depending on the cluster distance, one can hardly achieve reasonable results due to numerical inaccuracies of the Hankel functions and high memory requirements for the unit sphere integrations.

This problem can be avoided by combining the MLFMM with a so-called source clustering method (SCM) that replaces the translation operator at these high orders or large cluster distances by a summation method, which considers the interactions between the relevant points of the source - and target cluster.

The article explains the basic principles of both methods and presents the first results obtained, taking into account quality and solution time.

Wed 11:40 Urania Alton Numerical acoustics 2

Numerical optimization of the distribution of damping layers based on structural intensity

Clarissa Schaal, Joachim Bös and Holger Hanselka

TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

Damping layers are often used to reduce noise levels of mechanical structures by reducing sound radiation since they dissipate structure-borne sound. The energy flow of structure-borne sound in solids between a source (such as an excitation point) and a sink (for instance, a damping layer) is characterized by the structural intensity (STI). Hence, the analysis of the STI identifies all energy paths within a mechanical structure, which are frequency-dependent, and can be used to derive design measures for noise reduction. The STI is usually visualized as a vector field. By defining a control volume, the STI can be used to calculate the input power or the dissipated power within this volume by means of the energy flow across its boundaries. This method is used to numerically optimize the distribution of damping layers in a finite element model. Damping layers with varying thickness are applied to an undercarriage model of a car. The thickness parameters serve as design variables to maximize the dissipated power based on the STI with numerical optimization algorithms implemented in OptiY. The results will be discussed and compared to conventional methods of the distribution of damping layers.

Session "Numerical acoustics 3"

Wed 15:30 Urania Alton Numerical acoustics 3

A Hybrid Method to Assess the Sound Field of Moving Sources

Michael Rescheleit and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

A combined calculation procedure is presented which is able to assess the sound radiated from arbitrarily shaped moving sources. The method is divided into two major steps. Initially the sound radiation of the moving source under free-field conditions is determined. This is done by means of a Hybrid Element Method that uses analytical multipole solutions as ansatz functions in the far field. The analytical convective solution is found by applying the Lorentz transformation to the non-convective solution. It is then possible to consider that the disturbed airflow influences the sound radiation of the source in the discretized near field.

The second step involves the calculation of the resulting sound field in a more complex environment. Referring to the multipole ansatz of the first step, the sound source is modelled as a multipole point source in the far field. The effects of reflecting objects are assessed by the image source method. While the direct use of image sources makes it necessary to recalculate the positions of all image sources after each time step, the reciprocity can be exploited to save computation time. Since the receiver point is fixed, a superposition of image receivers in the direct field is used instead.

Wed 15:50 Urania Alton Numerical acoustics 3

Parallel Sound Particle Radiosity: Reunification of Diffracted and Scattered Sound Particles on Parallel Computers

Alexander Pohl, Jan Winkelmann and Uwe M. Stephenson
HafenCity Universität, Hamburg

For the simulation of sound propagation in room and urban acoustics, simulation methods based on Geometrical Acoustics are widely used. Such methods can be extended to include diffraction by using the uncertainty based diffraction model. Here, sound particles are split up whenever they pass by a room edge, which causes an exponential growth of computation time. Sound Particle Radiosity compensates this split-up by reunifying similar sound particles and, thus, tracing them simultaneously. To achieve a reasonable accuracy, Sound Particle Radiosity utilizes a reunification buffer that, unfortunately, requires a very large amount of memory.

In this work, Sound Particle Radiosity is extended with data parallelism. The reunification buffer, along with the workload, is distributed among multiple machines, which effectively increases the amount of available RAM. Runtime efficiency strongly depends on the distribution of the buffer among the available computers. We present an advanced preprocessing method

that models the data dependencies within the buffer and uses graph partitioning to reduce the communication between the linked computers. Although this method requires intensive preprocessing, measurements indicate that the overall performance scales much better than a naive decomposition of the buffer.

Wed 16:10 Urania Alton Numerical acoustics 3

A strategy to implement volume sources into Galbrun's equaion

Stefanie Retka and Steffen Marburg
Universität der Bundeswehr München

When considering noise propagation in flow in frequency domain computations, the standard Helmholtz equation is not sufficient to describe these effects. Therefore, using the linearized Euler equations (LEE) is common practice to describe sound propagation based on displacement perturbation. Galbrun reformulated the LEE in terms of an arbitrary Eulerian-Lagrangian desciption, which resulted in the displacement based Galbrun equation.

We want to include sources (monopoles, dipoles and quadrupoles) in this Galbrun formulation when a constant volume flow is present. One possibility is the formulation of the source on one finite element. The influence of the source on the computational domain is then passed on from this element to the entire finite element domain via the nodes. The analytic solution of the source only has to be known on one element and not in the entire domain, as would be necessary in other formulations.

In a first step, our goal is to solve the source problem with a monopole in case of a constant volume flow analytically. Later on, this solution has to be solved numerically and varyfied by other formulations.

Wed 16:30 Urania Alton Numerical acoustics 3

Obtaining dispersion curves of lined ducts as a solution of transcendental eigenvalue problems

Bernhard Karl Bachner
ANDRITZ HYDRO GmbH, Braunschweig

For the computational prediction of sound propagation in lined ducts, a number of different approaches can be found in the literature. Although purely numerical methods offer a great flexibility with respect to complex shaped ducts, an analytical solution permits an easy extension to high frequencies. Especially for ducts of circular cross-section containing coaxial perforated pipes or bulk-reacting layers of sound absorbing material or a combination of both, a modal expansion leads to such a solution. Usually the dispersion relation is achieved by a summary of all radial boundary conditions of the central passage and the annular layers to a single transcendental equation for the wave numbers by an elimination of the unknown modal amplitudes. Indeed the numerical solution of this equation can be a quite challenging task in case of nearby eigenvalues of different modes. A smart possibility to eliminate these difficulties is the notion of the boundary conditions as a transcendental eigenvalue problem. Using the method of numerical continuation, the dispersion curves of different modes described

by their eigenvalues (wave numbers) and eigenvectors (modal amplitudes) can be obtained in a robust manner. The proposed method is verified by means of a comparison of numerical results with experimental data.

Wed 16:50 Urania Alton Numerical acoustics 3

On the Applicability of Interval Arithmetics to Uncertain Vibro-acoustic FE-models

Lydia Mayer and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

Due to shortened development periods and product life cycles, computational methods and simulations gain greater importance in the field of vibro-acoustic design and optimization. To obtain reliable results and to use these methods in real life industrial applications, however, numerical models should be able to consider parameter uncertainties.
Practice-oriented methods that are widely spread to analyse the effect of parameter uncertainties, like the Monte Carlo method or the fuzzy transformation method, are often based on the multiple evaluation of the same numerical model with different values for the scattering parameters. This results in high calculation cost. Since in early design stages usually data of material properties are incompletely and inaccurately known, it might be advantageous to use intervals instead in order to describe the uncertain parameters.
An analysis on the applicability of the interval arithmethics to uncertain vibro-acoustic FE-models will be presented. It will be investigated whether the overestimation, which is usually claimed as a great disadvantage of this method, could be accepted due to the much lower calculation effort.

Wed 17:10 Urania Alton Numerical acoustics 3

On vibro-acoustic analysis with BEM Hierarchical Matrix approach

Boris Dilba[a], Otto von Estorff[b] and Olgierd Zaleski[a]
[a] *Novicos GmbH;* [b] *Hamburg Univ. of Technology, Inst. of Modelling and Computation*

Sound radiation of vibrating structures is of interest in many engineering disciplines. When considering structures under free field conditions the sound radiation can be calculated by means of the Boundary-Element-Method (BEM). Compared to the Finite-Element-Method (FEM) the standard BEM has the drawback of fully populated system matrices. Fast Boundary Element Methods like the Fast Multipole Method or the Hierarchical Matrix approach are effectively reduce this drawback. The general vibro-acoustic simulation model leads to a coupled system matrix, which comprises structural as well as acoustical degrees of freedom. Due to the fully populated acoustic system matrix direct methods are used to solve the coupled system of equations. This leads to high memory requirements and long computation times especially when dealing with large scale structures and acoustic models, respectively. In this paper an alternative coupling method for the BEM Hierarchical Matrix approach is presented, where the structure solver and the acoustic solver are coupled in a partioned way. Thus the particular validated solvers for fluid and structure can be used

in order to solve the coupled vibro-acoustic problem. The efficiency of the proposed approach will be discussed on principal examples.

Wed 17:30 Urania Alton Numerical acoustics 3

FMBEM Simulation of scattered wave fields excited by multiple moving sources

Peter Fiala and Péter Rucz
Budapest University of Technology

Environmental and traffic induced noise contains remarkable contribution from complex moving sources. In the assessment and prediction of the radiated and perceived noise, simulation of the binaural receiver's acoustic behaviour is of high importance.
Even harmonic moving sources imply broad band scattered wave fields. At the same time, high frequency resolution is needed in order to follow the rapidly oscillating spectrum near the Doppler limits. Therefore, numerical reproduction of the binaural response is computationally demanding.
We introduce an effective FMBEM algorithm to compute the wave fields excited by harmonic moving sources and scattered from a dummy head. Our method is able to effectively incorporate sources travelling in various directions, resulting in the optimal computation of head related transfer functions applied to moving sources. The incident sound spectra of moving sources are decomposed into a set of orthogonal excitations by means of SVD. The accuracy of the FMBEM solver is adjusted according to the importance (singular value) of the orthogonal excitations. This results in a computationally optimal setup. Computations are run on a supercomputer exploiting parallelisation.
Results of the simulations can be applied to auralise binaural pass-by noise by taking moving source HRTFs into account.

Wed 17:50 Urania Alton Numerical acoustics 3

Comparison of two different halfspace formulations for the investigation of acoustical problems via the 2D fast multipole boundary element method

Malte Gehlken, Sören Keuchel and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

For the numerical simulation of acoustical problems often the boundary element method (BEM) is used. While in the conventional BE approach iterative solution procedures can be applied to reach a quadratic dependence of the calculation time on the number of degrees of freedom, methods like the fast multipole BEM (FMBEM) provide a quasi linear complexity. Thereby even larger systems in the higher frequency domain can be investigated in reasonable time and with an additional decrease of memory. If sound emitting bodies over a reflecting surface have to be investigated there exist different possibilities, which are known from the 3D case and can be adapted to 2D. One approach is the application of a modified fundamental solution in which the mirror sound sources are included implicitly, while another approach demands mirroring of the whole discretization on the reflecting plane. Both possibilities yield specific advantages and drawbacks which

make them applicable for different problems. In the actual contribution the two different algorithms are presented with the help of a 2D example. They are analyzed with respect to their efficiency and their dependence on the chosen simulation parameters. Thereby recommendations for the fields of application of the different approaches are derived and discussed.

Wed 18:10 Urania Alton Numerical acoustics 3

Validation of the Rayleigh model in FDTD models to predict low-frequency sound fields in small volumes that are subdivided by porous materials

Nuno Ferreira and Carl Hopkins
University of Liverpool

This paper concerns validation of Finite Difference Time Domain (FDTD) models to predict sound fields at low-frequencies in small volume spaces using transient excitation from a loudspeaker. In particular, spaces that contain porous materials which subdivide the volume that can be modelled using a Rayleigh model. A novel feature that arises in this situation is a spring-mass-spring resonance below the fundamental acoustic mode of the space. This required implementation of a simple harmonic oscillator that was coupled to the FDTD update equations to model the lumped mass behaviour of the panel formed by a porous material. The porous material was modelled using a low number of elements to keep the calculation times within reasonable limits. Results from the FDTD model have been compared against grid measurements taken in a small reverberation chamber in three different conditions: empty, with a mineral fibre partition that partially divided the room volume, and the same type of partition the completely divided the room volume. A frequency-independent boundary condition was assumed where the specific acoustic impedance was obtained from the average of the measured room modal damping constants within the frequency range of interest. Close agreement was obtained between the FDTD model and the measurements.

Wednesday Numerical acoustics 3 (Poster)

2-layer Piezoelements - The Impact of Shape and Material Properties on Their Effectiveness

Roman Trojanowski and Jerzy Wiciak
AGH University of Science and Technology, Krakow (PL)

This work presents the results of numerical studies on efficiency of different element shapes and material properties of inner layer of 2-layer piezo elements used as actuators. For this purpose numerical models were created with ANSYS software that contained steel plate clamped on all sides with piezo elements attached. 5 of them are always homogeneous piezo elements with square shaped base (4 were used as sensors, 1 for vibration excitation). Additional element is a 2-layer piezo element used as actuator. Proposed 2-layer elements are have layers with different material properties. The inner layer has the same shape as the whole element, but with its base area being a fragment of the whole base. The outer layer is a ”frame” that envelops the inner layer. There are 4 possible shapes of the base this

actuator: square, disc, triangle and parallelogram. For each shape harmonic analyses were made with different material properties for the inner layer of actuators. Analyses were performed with the use of ANSYS software.

Wednesday Numerical acoustics 3 (Poster)

FEM Approach for Calculation of Acoustic Parameters in a Regular Lattice of Rigid Metallic Spheres

Francesco Bianco[a], Gaetano Licitra[b], Mauro Cerchiai[c] and Luca Teti[a]
[a] *Università di Siena;* [b] *CNR-IPCF, Pisa;* [c] *ARPAT - Area Vasta Costa - Settore Agenti Fisici*

Acoustic properties of porous materials are tipically described with semi-phenomenological models such as Johnson-Champoux-Allard (JCA) that describes characteristic impedance and wavenumber in a sample using parameters determined by the geometry of the pores.
This work will show a new approach to obtain acoustic parameters, like tortuosity and characteristic lenghts, using a FEM approach: a fluidodynamic simulation is performed for the fluid in the rigid reticular structure.
Two cases of Bravais lattice of rigid metallic spheres will be studied, simple cubic and esagonal: their periodic structure allows to perform the simulation in a single cell, exploiting its symmetries to further simplify calculations. The solution for the velocity field will then be used to calculate the parameters that will allow, with a JCA model, to predict acoustic energy absorption for the samples described. Theorical predictions will allow a comparison with experimental measures obtained from an impedance tube device.
Acoustical parameters can also be derived directly from experimental characteristic impedance and wavenumber, derived for the samples with a new two measures approach in the impedance tube.

Session "Active acoustic systems (Poster)"

Wednesday Active acoustic systems (Poster)

Active Control of a Fluid-Loaded Smart Structure

Dariusz Iwanski and Jerzy Wiciak
AGH University of Science and Technology, Krakow (PL)

Results of active control of structural noise in fluid are taken under consideration. Resonant frequencies of circular fluid-loaded plate were measured using swept sine technique on laboratory stand. The other side of the plate contains piezo elements used both as sensors and actuators. Actuators were used to generate vibrations of the plate and other to reduce sound pressure level in fluid, i.e. water and air. Results were compared with numerical and analytical calculations. Final results reveal reduction of sound pressure level in fluid by more than 25 dB using only one piezo element.

Session "Environmental noise: Noise mapping (Poster)"

Wednesday Environmental noise: Mapping (Poster)

Auralisation of Environmental Noise Maps

Adam Craig, Don Knox and David Moore
Glasgow Caledonian University

Noise maps represent environmental noise levels and how they vary by geographical location, and are used for communicating information on environmental noise to the public. As such they are a potential quality of life indicator for those living in areas where noise pollution could be a detrimental factor. However this potential is not currently being exploited by noise maps produced by government bodies, which are based on traffic data and environmental variables rather than actual recordings of environmental noise at a given location. The aim of this research is to create an interactive audio tool using 3D environmental noise maps based on binaural recordings. This has the potential to communicate more meaningful information on environmental noise to the public, in that it will allow them to experience the noise levels present in a particular location. Another benefit of this approach is the potential to examine how subjectively annoying or disturbing the noise is to the listener by building a measure of human perception into the model. Therefore this research has the potential to create ësubjective' environmental sound maps which communicate both location-specific noise information, and the subjective effect of noise upon the listener.

Wednesday Environmental noise: Mapping (Poster)

Quality-Assured Noise Mapping - Part II: Resolution

Karl-Wilhelm Hirsch[a], Frank Hammelmann[a] and Berthold Vogelsang[b]
[a] *Cervus Consult, Willich;* [b] *Niedersächs. Ministerium für Umwelt, Energie Klimaschutz*

Noise maps are a popular tool to document and present noise loads, noise indices and other information related to the assessment of noise situations. If such data are shown as layers together with geo-referenced topographical layers, all layers (1) need to be referenced to the coordinate system of the resulting map and (2) must have the same resolution. Part II discusses rules to provide the same resolution for quality-assured mapping. Today, maps are often shown dynamically on computer screens offering all features of adding layers with different information from different data sources. This composite map can be continuously zoomed in and out. On the screen the color rendering and the way lines are drawn is normally controlled by the computer software or the graphic hardware. Zooming does not mean true scaling and the number of screen pixels does not mean resolution. To find a clear presentation mode for maps the type of information in each layer needs to be considered while matching the resolutions in a quality controlled way. Part II proposes clear rules to fulfill this task in a quality assured way.

Session "Environmental noise: Action planning (Poster)"

Wednesday Env. noise: Action planning (Poster)

HUSH Project: noise reduction measurements in two pilot cases to evaluate the effectiveness of the planned actions

Tamara Verdolini[a], David Casini[a], Andrea Carmagnini[a] and Marco Ranoisio[b]

[a] *ARPAT - AVC - Settore Agenti Fisici;* [b] *Università di Pisa*

HUSH is a LIFE+ project financed by the European Union in order to give indications for harmonisation of urban noise reduction strategies to perform homogeneous action plans among the Member States. Within the Action Plan of Florence, two different areas of intervention have been located to evaluate effectiveness of strategies and remedies. In each selected area specific noise measurement campaigns (long and short period measures) have been carried out, before the realisation of the intervention, following national and international good practice rules and standards. An accurate definition of the measurement protocols for acoustic data has been defined and controlled. Moreover, in the two areas, the noise measurements have been carried out under controlled traffic conditions. To verify the effectiveness of actions, after each intervention a detailed noise measurement campaign has been carried out, in the same conditions of the ante-operam measurements. The present work shows the methods and the results of such measurement campaigns and an estimation of the noise abatement achieved by the actions is given.

Wednesday Env. noise: Action planning (Poster)

The acoustical characterization of special pavements with rubber: some results in four different sites and the problem of their comparison.

Mauro Cerchiai[a], Luca Teti[b] and Gaetano Licitra[c]

[a] *ARPAT - Area Vasta Costa - Settore Agenti Fisici;* [b] *Università di Siena;* [c] *CNR-IPCF, Pisa*

In the recent past it was possible to monitor over time and acoustically characterize four special surfaces with rubber inside laid in two different conditions: urban and extra-urban roads. This was carried out using data coming from: the activities planned by the "LEOPOLDO" Project (funded by Tuscany Region and Tuscany provinces); the controls over special asphalts used for acoustical mitigations actions (planned in several regional main roads); some studies carried out by CNR-IPCF along a road in Merano (BZ). The analysis was carried out using the Close Proximity Index method, (ISO/CD 11819-2) and the ADRIENNE method (ISO 13472). In the present work, for each site, two different point of view for data comparison are shown: a qualitative view, by absorption and normalized emission spectra comparison and a quantitative view, through the evaluation of the reduction of sound pressure level gained by the pavements with rubber in comparison with the standard usual surfaces used on the same context and analyzed during the same measurement session. Moreover this work describes the time evolution of two of these investigated surfaces and tests the possibility to compare the results obtained among different sites.

Working Group Noise EUROCITIES

Henk Wolfert

DCMR EPA, Schiedam (NL)

EUROCITIES is the network of major European cities. Founded in 1986, the network brings together the local governments of more than 140 large cities in over 30 European countries. EUROCITIES provides a platform for its member cities to share knowledge and ideas, to exchange experiences, to analyze common problems and develop innovative solutions, through a wide range of forums, working groups, projects, activities and events. EUROCITIES gives cities a voice in Europe, by engaging in dialogue with the European institutions on all aspects of EU legislation, policies and programs that have an impact on cities and their citizens. Within the EUROCITIES network Working Group Noise (WGN) is established in 2006. The objectives of the WGN are (a) exchange of experiences and knowledge on Noise, Noise Effects and Noise Abatement, (b) influencing the European legislation and requirements, (c) execute projects to gain more knowledge about noise and noise effects and last but not least (d) gaining awareness among public, policymakers and politicians on all levels. Currently the WGN is presided by the city of Rotterdam. The poster presentation will raise more understanding of the mission, vision and activities of the WGN.

An Example Of Noise Mitigation Plan In Tuscany

Federica Bettarello[a], Marco Caniato[a], Vincenzo Baccan[b] and Francesco Orsini[c]

[a] *Studio Associato Acusticamente, Conegliano;* [b] *Studio Associato Acusticamente, Rovigo;* [c] *Studio Ingegneria Orsini, Chiusi*

In the last few years the noise mitigation plans become a need for a lot of towns in Italy, moreover where noise from road or rail traffic represent the most disturbing sources for residential areas or sensitive receptors (as school, hospital, etc...). Tuscany Region has been the leader in terms of noise mitigation planning, demonstrating how the aim of acoustic performances in town is a matter of fact. This paper presents an example of noise mitigation plan project recently carried out for a city with 21600 residential people in a territory of about 92 Km. The principal acoustic problems where represented by schools near very busy roads, protected park areas bordered with noisy activities, urban areas affected by intense productive activity neighbourhood and arteries of great traffic. The amount of acoustic measurements , simulation and the proposed solutions are then presented.

Session "Flow acoustics (Poster)"

Wednesday Flow acoustics (Poster)

Radial Mode Analysis in an Aero-Acoustic Wind Tunnel

Juan D. Laguna, Michael Bartelt and Joerg R Seume
Leibniz Univ. Hannover, Inst of Turbomachinery & Fluid Dynamics

Turbomachinery-related noise measurements are up to the present time a mandatory requirement for the study and consequent understanding of sound propagation mechanisms. For this kind of studies, the Radial Mode Analysis (RMA) is applied. This method decomposes the transmitted sound field in dominant acoustical modes at specific frequencies. Before an experimental campaign is carried out in a single- stage air turbine, the RMA is tested in an aeroacoustic wind tunnel (AWT). The AWT allows the test of such measurement technique under turbine-like flow conditions. This facility provides internal flow at high mass-flow rate. The flow enters a settling chamber lined with noise absorber elements. Immediately after, the air flows into a test section equipped with a sound generator able to synthetically reproduce turbine-like noise patterns.

The current investigation presents the results of measurements performed in the AWT. For this purpose, an in-duct microphone array consisting of two fixed axially spaced sensor-rings flush with the outer duct wall is implemented. Each ring consists of ten 1/4" high temperature pressure field microphones located at equidistant circumferential positions. Results of the mode amplitudes are presented for low azimuthal as well as for low radial-mode orders under no flow and uniform flow conditions.

Session "Noise control for machinery and domestic environment (Poster)"

Wednesday Noise control for machinery (Poster)

Optimization of the Acoustic Emission of Blenders

Martin Fischer, Bruno Spessert and Bernhard Kühn
Ernst-Abbe-Fachhochschule Jena, Fachbereich Maschinenbau

Beside functionality, durability and purchase price, other criteria such as energy consumption and noise emission have become increasingly important and as such influence the purchasing decision of high-quality household appliances (like dishwashers or cooling appliances). It is expected that in the future the level of noise emission will play an important role in the purchasing decision of small household appliances like grinders or blenders, too. Regarding noise emission, beneath the "objective" sound power level the noise quality, the so called "sound" will be important. First approaches to noise emission development, which deal with the introduction of sound labels for household appliances, were presented in the DAGA 2011. The research activities focused on blender, which is a prime example of extremely noisy kitchen appliance. Besides broadband noise stimuli, narrowband stimuli especially appear. These are generated by the rotary frequency and their harmonics and are substantially caused by the imbalance of the rotary components. Significant gain reductions could be realized with

a decrease of the imbalance and through a full or partial encapsulation, damping and decoupling. Beside the gain reductions, optimizations of the ”sound” are both possible and necessary. Psychoacoustic parameters were applied to validity the noise quality.

Session ”Sandwich materials (Poster)”

Wednesday Sandwich materials (Poster)

The Effects of Physical Material Properties on Acoustic Attractiveness of Objects

Peter Holstein[a], Bader Bader[b], Andreas Tharandt[b] and Christian Probst[a]
[a] *SONOTEC Ultraschallsensorik Halle GmbH;* [b] *Steinbeis Transferzentrum ’Technische Akustik u. angew. Numerik’*

In the design of lightweight structures, the acoustic criteria are often considered only in terms of noise reduction and avoidance. However, since characteristic noise forms in conjunction with the context of new acoustic patterns, sound characteristics and impressions as well. It is useful to examine them in terms of user uptake. Therefore, a specific approach has been developed for a unified discussion of acoustic material effect from the point of view of design and usage. The article is focused on reviewing the acceptability of damage noise in lightweight materials and structures. Lightweight structures sound basically different caused by the specific material combinations and the reduced weight. The emitted noises differ from other than those from comparable structures of conventional constructions of similar shape and size. The acceptance of relevant issues has been investigated only partially until now. Furthermore, the acoustic emission events are also important indicators of the condition of the material, damage and damage dynamics.

Session ”Soundscaping: Creating and designing (Poster)”

Wednesday Soundscaping: Creating (Poster)

Effects of landscape factors on soundscape perception in city parks

Jiang Liu[a] and Jian Kang[b]
[a] *University of Rostock;* [b] *University of Sheffield, School of Architecture (UK)*

The main objective of this study was to analyse the effect of landscape factors on soundscape perception in city parks. This is based on a survey of 580 users in 5 city parks in Xiamen, China. Two aspects of landscape characteristics in terms of visual and functional were analysed in relation to soundscape perception. The results suggested that, visual satisfaction is significantly correlated with the frequency of sounds perceived by the users, more than functional satisfaction, while they are almost equally related with the user’s preference of different sounds. Both visual and functional satisfaction could affect the evaluation of aural satisfaction. However, visual aspect shows a higher degree of effectiveness. The results showed the close relationship between visual and aural perception in real contexts.

The aural satisfaction was evaluated as the second important factor following the visual aspect in terms of overall satisfaction, indicating the importance to consider about the soundscape in park design and management. The analysis of users' social and demographical factors and behaviour factors such as frequency of use, expectations and main activity areas, has also been proved to be vital in the study.

Wednesday Soundscaping: Creating (Poster)

Simplified Soundscapes Analysis Method, The Case of the New York High Line

Mohammed Boubezari
CAPS-IST, Lisbon

The NYC High Line was designed, on a disabled railway line, as a landscaped itinerary spreading over 1,5 km from Gansevoort street until the W 30th street. Obviously, the concept plays on vegetation in the foreground and the city as background decor. Even if the urban designer said to not have thought about the soundscape aspect of the project, it appears clearly that this sonic dimension was considered, maybe intuitively; evidenced by the quality and diversity of the soundscapes combined with other visual aspects. A sound analysis of method of filtering/measuring some fragments of soundscapes of the course was conducted using an audiovisual capture device.The composition of the soundscape was represented from the point of view of the listener. This paper describes the method applied to the soundwalk of the High Line and shows some relevant results.

Wednesday Soundscaping: Creating (Poster)

Vibrating Bracelet for Signaling in Place of Sonic Information

Dorota Czopek and Jerzy Wiciak
AGH University of Science and Technology, Krakow (PL)

Sense of hearing is a key sense for the blind when moving. Excessive noise causes that some places are inaccessible for people with visual impaired. Therefore auxiliary device for the blind should not be relating to audible signals. In return researchers proposed vibration signals which was applied to the wrist. At first scientists compared the sensitivity of various areas on the wrist skin for two tactile stimuli acting simultaneously. Then the smallest distance between two simultaneous stings that is recognized in more than 95% of cases was determine and vibration perception threshold (VPT) on the wrist was measured. Results have been useful to choose parameters for signals matched with situation in the city which are dangerous for the visually impaired people. For every situation a few different sequence of vibrations were composed. In the paper there are presented results of the researches how burdensome, distinguishable and easy to learn and memorize this signals are. Tests were carried out on group of blind and partially sighted people. Perception of signals was evaluated using ICBEN scale. Based on results the best signals were selected.

Session "Signal processing (Poster)"

Wednesday Signal processing (Poster)

Automatic subtitle synchronization of theater and tv performances

Guntram Strecha[a], Ulrich Kordon[b] and Karlheinz Mayer[c]

[a] *TU Dresden, Professur für Systemtheorie und Sprachtechnologie;* [b] *TU Dresden, Institut für Akustik und Sprachkommunikation;* [c] *TV Text International Fernsehtext-Produktion GmbH*

This contribution deals with the suitability of pattern recognition methods for the automatic subtitling of theater and TV performances. In practice, the goal is to reduce the manual work, which is necessary for multiple performances and to reduce the timing differences caused by the manual subtitling. Based on pattern recognition methods, the manually annotated start times and durations of a reference performance subtitles should be synchronized with the actual performance. The variations between the actual and the reference performance could occur due to different conditions like other date and location of presentation, variation of the production and so on. Because, the optical information (video signals) of the performances are possibly too varying, the pattern recognition algorithm uses only the acoustical informations, which are in most cases more appropriate to compare. The subtitling synchronization of the reference and the actual performance is based on a Dynamic Time Warping approach processing the audio signals directly in real time. For musical performances, like classical operas having lesser rhythmic parts of singing and orchestra, the algorithm supplies a synchronization accuracy error of about 0.2 to 0.5 s. Depending on the performance character, bigger differences are possible.

Wednesday Signal processing (Poster)

Effect of Secondary Path Estimation Errors on the Performance of ANC-Motivated Noise Reduction Algorithms for Open-Fitting Hearing Aids

Derya Dalga[a] and Simon Doclo[b]

[a] *University of Oldenburg, Medical Physics;* [b] *University of Oldenburg, Signal Processing Group*

Current noise reduction (NR) techniques for open-fitting hearing aids that only use the external microphones on the hearing aid largely ignore the occurrence of signal leakage through the vent, typically leading to a degraded noise reduction performance. Recent miniaturization advances however enable to incorporate an internal microphone in the ear mould, which provides information about the signal leakage and hence enables to improve the performance of NR algorithms. Recently both feedforward and combined feedforward-feedback active-noise-control-motivated algorithms for noise reduction have been introduced for open-fitting hearing aids. Since the performance of these NR algorithms is affected by secondary path estimation errors, in this paper the effect of estimation errors on the performance of ANC-motivated NR algorithms for open-fitting hearing aids is

investigated. The performance of the algorithms is analyzed both for phase and amplitude errors by means of Monte Carlo simulations and limiting values for amplitude and phase errors of the secondary path are provided.

Wednesday Signal processing (Poster)

A Perfectly Invertible Perception-Based Time-Frequency Transform for Audio Representation, Analysis and Synthesis

Thibaud Necciari, Peter Balazs, Peter L. Soendergaard and Nicki Holighaus
Austrian Academy of Sciences, Acoustics Research Institute

Time-frequency representations are widely used in audio applications involving sound analysis-synthesis. For such applications, obtaining an invertible time-frequency transform that accounts for some aspects of human auditory perception is of high interest. To that end, we exploit the theory of non-stationary Gabor frames to obtain a perception-based, linear, and perfectly invertible time-frequency transform. Our goal is to design a non-stationary Gabor transform (NSGT) whose time-frequency resolution best matches the time-frequency analysis properties by the ear. The peripheral auditory system can be modeled in a first approximation as a bank of bandpass filters whose bandwidth increases with increasing center frequency. These so-called “auditory filters” are characterized by their equivalent rectangular bandwidths (ERB) that follow the ERB scale. Here, we use a NSGT with resolution evolving across frequency to mimic the ERB scale, thereby naming the resulting paradigm “ERBlet transform”. The ERBlet is implemented as a filterbank that counts one filter per ERB and leads to perfect reconstruction while minimizing redundancy. Therefore, it can be useful to both auditory modeling and signal processing applications. The ERBlet design and implementation will be presented. Its performance will be compared to invertible linear gammatone filterbanks.

Wednesday Signal processing (Poster)

Automated Sequence Clustering of Audio Signals using Conditional Random Fields

Dierck Matern, Alexandru Condurache and Alfred Mertins
University of Lübeck, Institute for Signal Processing

In this paper, we propose a new Conditional Random Field (CRF) based algorithm for automated sequence clustering of audio signals, similar to the known sequence clustering in biomedical signals. Usual CRF based methods are trained in an observed manner, that is, for the training data, we need a corresponding state sequence. For automated sequence clustering, we have no such known state sequence in the beginning. We therefore adapt the training of the CRFs to the case of an unknown state sequence and apply the trained model for classification of new instances of the audio signals. This analysis of the acoustical signals can be used, for example, for scene analysis or novelty detection, where we use abstract states regularly and therefore manual prelabeling is not reasonably. In the experiments, we successfully have applied the trained model for sequence clustering on audio signals and were able to detect the significant clusters.

Wednesday Signal processing (Poster)

Improvement of Speech Intelligibility in Telephone-Systems by adaptive gain maximization

René Asendorf[a], Dirk Oetting[a] and Jörg Bitzer[b]
[a] *Fraunhofer IDMT - HSA, Oldenburg;* [b] *Jade-Hochschule Oldenburg*

Telephone communication can be quite difficult in loud environments and for hearing-impaired people. A quite common example is a presentation level below the listener's expectation although the maximum gain of the telephone system is already reached. Digital signal processing algorithms can improve this situation by modifying the incoming speech signal. To address this problem, a system was developed which increases the loudness of the signal with respect to sound quality and speech intelligibility. The system consists of an automatic level control algorithm that ensures that the incoming speech signal is well adjusted to the internal dynamic range. A fast acting look-ahead limiter eliminates sections where peak-clipping would occur due to the additional amplification. The loudness of the signal can further be increased by dynamic range compression in several frequency bands with different frequency characteristics.
The system has been evaluated in terms of speech-intelligibility with normal-hearing and hearing-impaired subjects. For the evaluation, the speech material of the Oldenburg Sentence Test (OLSA) has been modified to simulate the typical frequency characteristics of telephones. Stationary speech-shaped noise and babble noise was used to quantify the Speech Reception Threshold (SRT) for the different settings of the algorithms.

Session "Speech processing (Poster)"

Wednesday Speech processing (Poster)

Glottal Stop Detection in German Accented English Using ASR

Maria Paola Bissiri, Ivan Kraljevski and Rüdiger Hoffmann
TU Dresden, Professur für Systemtheorie und Sprachtechnologie

Glottal stops (GS) are sounds produced by the closing and abrupt opening of the vocal folds. In German, GS are frequent before word-initial vowels and are a salient word-linking technique. Therefore, German speakers can transfer this word-linking habit to their English productions. Neither in English nor in German GS are phonemes, i.e. they cannot differentiate word meaning. However, GS should be acoustic modeled since a) they are good indicators of word and morpheme boundaries and can improve ASR performance, b) automatic pre-segmentation of GS is quite useful in basic phonetic research. We investigated GS detection in German accented English using the UASR (Unified Approach for Speech Synthesis and Recognition) system. The acoustic models trained on German Verbmobil database include GS. A corpus of BBC news bulletins read by German speakers was recorded and automatically segmented. The lexicon of English words with German phoneme inventory was created using the multilingual TTS system DRESS, indicating optional GS before word-initial vowels. In order to

assess GS recognition accuracy, the phoneme confusion matrix was analyzed and GS localizations were manually checked on a random sample of recordings. Results show that the proposed framework can be successfully used for GS detection in German accented English.

Wednesday Speech processing (Poster)

Age Effects During Selective and Divided Attention of Speech in a Working Memory Task

Silvia Carmen Lipski
University of Cologne, Jean-Uhrmacher-Inst., ENT-Research

Selectively attending to one speaker among others requires enhancement of the source of interest and inhibition of interferences. In order to monitor messages from multiple speakers simultaneously (i.e. divided attention) the listener has to swiftly rotate the focus of attention as well as process and reconstruct parts of the signal that is momentarily unattended. In both situations, active maintenance of verbal working memory is essential. Older age can lead to a decline in working memory, especially for longer messages whereas the maintenance of short messages is less affected by age. Furthermore, divided attention of speech can be demanding for older listeners. This study investigated the effects of age, message size, and attentional focus using a delayed response working memory task. Normal-hearing younger and older listeners concentrated on one of two simultaneously spoken lists of digits or on both lists. After a short delay participants decided whether a written number had been part of the attended list of items. Reaction time was measured for sub- and supracapacity sized lists.

Session "Thermoacoustics (Poster)"

Wednesday Thermoacoustics (Poster)

Determination of the stability limit of a standing wave thermoacoustic engine by means of finite elements

Anne de Jong, Ysbrand Wijnant and André de Boer
University of Twente, Enschede (NL)

A finite element model is presented to obtain the stability limit of, as an example, 2D standing wave thermoacoustic engine. The stability limit is the required heating to obtain self-sustained (thermo)acoustic oscillations. The method used to obtain the stability limit is not restricted to the example standing wave engine. With slight modification, more commercially interesting engines like traveling wave thermoacoustic stirling heat engines can be modeled. Under the assumption that beyond the stability limit, the acoustic field does not change except for its magnitude, important properties of the system can readily be obtained, such as the impedance in the engine core, called the stack, the over-all dissipation to production ratio and others. The results are verified with a so-called 1D low reduced frequency model result where numerical integration is applied to find the transfer matrix of the stack.

Session "Transport noise (Poster)"

Wednesday Transport noise (Poster)

Binned fit approach for evaluating noise levels from vehicle traffic

Riccardo Zei and Gaetano Licitra
CNR-IPCF, Pisa

Noise from vehicle traffic is an environmental issue in both metropolitan and rural areas. The Statistical Pass-By (SPB) method (ISO 11819-1) is widely recognized as the preferred method for characterizing the influence of a road pavement on traffic noise since it accounts for engine, exhaust and aerodynamic noise. This method is labor and time intensive since the background noise levels need to be 10 dB(A) less than the measured vehicle noise in order to get a clean data set of measurements. In this paper, a binned fit technique rather than a linear regression is presented and then applied to a typical case, i.e. a data set of nearly one hundred events collected in one-day work: statistical uncertainties evaluation is taken into account with a particular focus when only a small number of events of interest are detected during on observation. A procedure for enlarging the set of analyzed data including the events with a background noise level less than 10 dB(A) is also discussed.

Wednesday Transport noise (Poster)

Field Results on Highway Noise Emission in Italy

Dorina Spoglianti[a], Alessandro Bertetti[b], Marco Falossi[b] and Pasquale Bottalico[b]
[a] *S.I.N.A. S.p.A., Milano;* [b] *Studio Progetto Ambiente, Torino*

Noise emission from roads strongly depends on surface construction process, aging and conservation status. Field measurements in Italy mainly concern mean to low speed roads, whereas nearly no data can be found in literature on highways. The need for systematic noise data along with detailed characteristics on measurements conditions, traffic speed and flow and surface age and variety is remarkable in the predictive stage of the design process. Reliability of noise impact assessment actually depends on common practice values and cannot affordably spend more detailed knowledge on noise emission in the lack of a deep comparison with national roads construction practice. A field campaign has been carried out on four Italian highways. Three measurement sections has been defined for each road. Less than one year and four to six year old porous asphalt is the main objective of measurements. Short Leq spectral data have been recorded along with traffic flow and speed. Field results allowed to build a set of affordable statistics. Spectral data can be compared with the standard reference used in the actual END interim calculation method. Differences can be used to define correction factors for the noise assessments to reach a higher level of detail.

Session "Underwater noise due to construction and operation of offshore structures (Poster)"

Wednesday Offshore structures (Poster)

Dolphin's echolocation clicks variability during target discrimination

Gennadi Zaslavski
RAMOT Tel-Aviv University

The dolphins are believed to make broad changes in the spectral content of the emitted echolocation clicks to adjust their parameters during underwater target discrimination. The echolocation clicks of false killer and Atlantic bottlenose dolphin clicks were classified in several categories based on the center frequency and bandwidth of the recorded clicks. However, numerous experimental studies with dolphins did found so far any connection between the click characteristics and the echolocation task performed by dolphin. One well known origin of the echolocation click variability is the directivity of a dolphin click transmission. Clicks along the acoustic axis of the bottlenose dolphin transmit beam are generally very short and broadband and have one peak frequency. As recording aspect increases away from the beam axis, the click waveform changes significantly, especially along the beam slopes, producing multiple peaks in the click frequency spectrum. In this presentation we argue that the variability of the click spectral content during echolocation may be an indication that target discrimination is based on time domain cue but not on the frequency domain cue. In our experiments dolphins readily discrimination between short noise pulses having random energy spectra based on the pulse duration or interpulse interval discrimination cues.

Paper sessions Thursday 21.03.2013

Session "Applications of psychoacoustics"

Thu 8:40 Kurhaus meeting room 1 Applic. of psychoacoustics

A psychoacoustical evaluation of active and passive methods for noise reduction in automotive engineering

Jesko Verhey[a], Jan Hots[a], Tommy Luft[b], Stefan Ringwelski[c] and Ulrich Gabbert[c]

[a] *Otto von Guericke Univ. Magdeburg, Dep. Experimental Audiology;* [b] *Otto von Guericke Univ. Magdeburg, Inst. of Mobile Systems;* [c] *Otto von Guericke Univ. Magdeburg, Inst. of Mechanics*

In our everyday life we are often surrounded by road traffic noise. One important noise source is the engine, especially in the case of vehicles driven by combustion engines. Automotive engineering provides different, active and passive techniques to reduce this noise. The success of these measures is commonly quantified on the basis of physical measures such as the attenuation of the sound pressure level. However, the results of this approach may not always correlate with perception, e.g., at the same sound pressure level a sound may be less acceptable if it has a higher roughness or it has salient tonal components. Thus, the present study investigates the benefit of the noise reduction perceptually. The experiment uses computational and experimental results of sound pressure levels radiated from a car engine as the stimuli. The engine includes a cylinder block and an oil pan. For an active control of the sound radiation, piezoelectric actuators and sensors are attached on the surface of the oil pan. Additionally, a body-mounted engine encapsulation is used to reduce the sound emission as a passive method. The sounds are evaluated in psychoacoustical experiments and model simulations on the basis of different sensations.

Thu 9:00 Kurhaus meeting room 1 Applic. of psychoacoustics

Dieselness of Car Noises in Different Driving Conditions

Jakob Putner[a], Christoph Alexander Divko[a], Hugo Fastl[a] and Alfred Zeitler[b]

[a] *AG Technische Akustik, MMK, TU München;* [b] *BMW Group*

Due to the rising demand for high-power engines, although strict emission regulations must be fulfilled, the share of diesel-powered cars is steadily increasing. Since the Sound Quality of diesel engines has improved over the years, these entered both executive and luxury car segment, where the expectations of Sound Quality are exceptionally high. The parameters of the Engine Control Unit can significantly influence the engine sound. Doing so, one has to keep in mind that Sound Quality and fuel efficiency are often conflicting objectives.

The typical sound character of diesel engines, the so-called Dieselness, has been studied by the Technical-Acoustics Group at the Technical University of Munich and others. A dependency of the Dieselness on the driving condition of the vehicle is indicated by the results.

In the presented study the Dieselness of a car in different driving conditions and with different parameters of the Engine Control Unit is evaluated in psycho-acoustical experiments. In order to analyze the influence of the driving condition on the perceived Dieselness, sounds recorded at different driving speeds and engine loads were rated. Among the examined sounds, the driving condition with the most typical diesel engine sound can be determined.

Thu 9:20 Kurhaus meeting room 1 Applic. of psychoacoustics

eVADER: A Perceptual Study of Three Sound Features Predicted to Increase the Ability of Pedestrians to Detect and Localize Hybrid and Electric Vehicles (Quiet Cars) While Maintaining Low-Level Sound Emission.

Ryan Robart[a], Etienne Parizet[a], J.-C. Chamard[b], Karl Jannssens[c], Fabio Bianciardi[c], Josef Schlittenlacher[d], Wolfgang Ellermeier[d], Perceval Pondrom[e], James Cockram[f], Paul Speed-Andrews[f] and Gemma Hatton[f]
[a] *Insa, Lyon (F);* [b] *PSA, Paris;* [c] *LMS International, Havenoclue (F);* [d] *TU Darmstadt;* [e] *TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM;* [f] *Nissan, London*

The eVADER project endeavors to enhance the technology of electric-vehicles for the safety of pedestrians, especially the visually-impaired. The research presented here focused on eVADER's goal to isolate features of replacement sounds for electric-vehicles, maximizing pedestrian safety while minimizing noise pollution. It was predicted that 3 sound features (complexity, amplitude-modulation, frequency-modulation) could be the most informative to listeners, allowing for quieter emission. Sounds were synthesized using different combinations of the 3 (features) X 3 (levels). The 9 synthesized sounds were normalized (dBA), Doppler-shifted, and superimposed onto a binaural-recording of a moving electric-vehicle (prototype-sounds). Stimuli were embedded in a noisy background (traffic or traffic + rain), emulating a suburban soundscape. In this simulation, participants were virtual pedestrians, waiting to cross a street, using only sound. In a fractional, repeated measures design, 111 participants (29 visually-impaired) heard 11 stimuli (9-prototype-sounds, 1-electric-vehicle, 1-diesel) over 88 trials. Participants localized approaching cars (perpendicularly). Results indicated that detection of some prototype-sounds was equivalent to that of the diesel car. This was achieved without significantly increasing SPL. Despite normalization, detection varied among prototype-sounds via the 3 (feature) X 3 (level) combinations. This effect was magnified in noisier backgrounds. The practical and theoretical implications will be discussed.

Thu 9:40 Kurhaus meeting room 1 Applic. of psychoacoustics

The Benefit from Interviews in the Frame of Psychoacoustic Evaluations of Aircraft Cabin Noise

Helga Sukowski[a], Stephan Töpken[a] and Reinhard Weber[b]

[a] *University of Oldenburg, AG Akustik;* [b] *University of Oldenburg*

The sound character of the cabin noise in an aircraft strongly contributes to the well-being of passengers. However, even at the same dBA-level cabin noises may differ with respect to their sound characteristics or their perceived loudness. Therefore one typical aim in studies on cabin noise is to explore how people assess the sound in an aircraft cabin. In the framework of a psychoacoustic study on sound preference and loudness 38 participants were additionally questioned several times during the course of the test by means of standardized and guided interviews. The topics have been selected based on previous open interviews in a similar study. Some questions referred directly to the presented sounds. Others referred to general aspects like habituation, effects of sounds on the feeling of safety during a flight or the general attitude towards travelling by air. Here, results concerning the general aspects will be presented together with observed correlations between answers to single questions. For example, the analysis revealed that for most participants sounds during a flight play an important role for their feeling of safety, irrespective of whether air travel is in general connected with largely positive associations or also with negative associations for the individual.

Thu 10:00 Kurhaus meeting room 1 Applic. of psychoacoustics

Criteria for the Determination of the Acoustic Quality of Ships

Robin Seiler[a] and Gerd Holbach[b]

[a] *TU Berlin, Naval Architecture and Ocean Engineering;* [b] *Technische Universität Berlin*

Noise and structural vibrations are known to be a major criterion of passenger and crew comfort on vessels. Concerning airborne sound on board ship description of acoustic quality today is mainly based on a three- or five-stage classification system using critical A-weighted sound pressure levels. Other industrial sectors have stated that nowadays a more sophisticated and detailed evaluation of the entire auditory perception is required. Therefore psychoacoustic or room acoustic models are taken into account. To find better indicators to quantify the acoustic performance on board ship, audio material was acquired, evaluated in a paired-comparison listening tests and analyzed by using the statistic model of the ”Law of Comparative Judgment”. Highly correlated parameters between the available qualitative data and physical, psychoacoustic and room acoustic parameters could be identified. In order to find additional critical values for the most appropriate acoustic indicator, data collected during sea trials of several recently built Mega-Yachts was analyzed. From the results, a weighted rating matrix to describe the quality of Mega-Yachts from an acoustical point of view is derived.

Thu 10:20 Kurhaus meeting room 1 Applic. of psychoacoustics

Towards an European Sound Label for Household Appliances and the Role of Psychoacoustics

Ercan Altinsoy
TU Dresden, Chair of Communication Acoustics

The European Union energy label, which provides information on the energy consumption of household appliances, has proven its reliability for the customers in recent years. However, a label for the product sound perception, which can be very useful for the customers but also manufacturers, is not available up to now. The energy label is required to include the sound power level of the devices. Although the sound power level is an important acoustical parameter, it does not characterize the customers' perception of product sound sufficiently. The psychoacoustical parameters, e.g., loudness, sharpness, tonality, roughness, fluctuation strength, etc., are much more useful for characterization purposes. However, in some cases it is required to adapt these parameters for complex household product sounds and to model their interaction. Another important issue refers to the optimal measurement environment (anechoic chamber vs. real living environment) and the measurement conditions for sound quality testing. The aims of this study are to summarize the results of investigations, which were conducted on three different household appliances (refrigerator, vacuum cleaner, washing machine), and discuss the future milestones on the way to a European sound label.

Thu 10:40 Kurhaus meeting room 1 Applic. of psychoacoustics

Investigations on subconscious perception of product sounds

Sabrina Skoda, Jochen Steffens and Jörg Becker-Schweitzer
University of Applied Sciences Düsseldorf

Popular science dealing with sound design frequently draws on the subconscious effect of sounds. Providing empirical evidence on this is a particular challenge due to the test design. In listening studies on product sound quality the test participants' attention is usually focused on the auditory stimuli being evaluated, due to the experimental task. This significantly affects the evaluation behaviour. However, in everyday life this kind of artificial attention focusing on a product sound doesn't necessarily occur. Humans are exposed to multiple sensory impressions which are consciously and subconsciously perceived and cognitively processed. In terms of ecologically valid assessments the question arises how sound design affects the overall evaluation of a product, if test participants are not explicitly focused on the product sound. This also includes the question which target group is addressed by product sound design. In a laboratory experiment disguised as a product test two participant groups had to evaluate different household appliances. The test participants could freely interact with the devices, which were presented to one group in original condition and to the other group with modified noise behaviour. Subsequently the assessments from both groups were compared. The results from this study will be presented within this contribution.

Thu 11:00 Kurhaus meeting room 1 Applic. of psychoacoustics

Analytical Hearing-adequate Assessment of Disturbed Radio Broadcast

Marc Lepage[a], Udo Müsch[a], Frank Kettler[a], Jan Reimes[a], Jörg Zerlik[b], Frank Homann[b] and Christoph Montag[b]
[a] *HEAD acoustics GmbH;* [b] *Robert Bosch Car Multimedia GmbH*

Radio broadcast signals may be disturbed in various ways as often experienced in driving situations. Audible and disturbing ”pops”, noise bursts, short term mutes, or noticeable stereo/mono switching occurs. Such parameters can be assessed by applying relatively simple level or spectral analyses for the FM receiver output signals. However, it needs to be considered that the perception in a vehicle may differ from these analytic receiver measurements. The transition between mono/stereo playback, its critical timing or the design of ”high cut” filters (cut-off frequency, attenuation) may be perceived differently in the vehicle due to reflections and reverberation. Furthermore the correlation of such analyses to perception by the human hearing requires experts' experience or is even often unknown. This contribution discusses hearing-adequate analyses of receiver signals after HRTF filtering to simulate specific vehicles. A data base of individual ratings for the same samples provides the link to quality perception.

Thu 11:20 Kurhaus meeting room 1 Applic. of psychoacoustics

Test Environment for Realistic Listening Evaluation of Disturbed Radio Broadcast

Udo Müsch[a], Marc Lepage[a], Frank Kettler[a], Jörg Zerlik[b], Frank Homann[b] and Christoph Montag[b]
[a] *HEAD acoustics GmbH;* [b] *Robert Bosch Car Multimedia GmbH*

The quality of in-vehicle radio reception (radio broadcast) depends on various parameters, both, transmission and receiver related, such as the field intensity, propagation characteristics (reflections, interference, multi-path transmission), the antenna design and, last but not least, the implemented signal processing in the FM receivers itself. Depending on the current RF transmission path, well known disturbances like short term ”pops” or noise bursts occur in cars. To optimize the listening quality under disturbed transmission conditions, several techniques are common in FM receivers, such as attenuating high frequencies (”high cut”), switch from stereo to mono playback or temporarily even mute the loudspeaker signal. In order to evaluate these kinds of disturbances by the human hearing, a specific listening test was designed, where test persons assessed a high number of listening examples in a controlled but realistic environment. The use of a driving simulator including visual feedback generated an appropriate cognitive load. 18 test persons judged more than 100 samples (different music styles, speech, diversely disturbed). The more than 2000 ratings provide a data base for the quality assessment of typical disturbances in radio broadcast. The test design and a number of results are discussed.

Thu 11:40 Kurhaus meeting room 1 Applic. of psychoacoustics

Effect of synchronous multi electrode stimulation on rate discrimination in cochlear implant users.

Andreas Bahmer and Uwe Baumann
Audiologische Akustik, HNO, Goethe-Univ. Frankfurt am Main

Most cochlear implants implement stimulation strategies which apply sequential electrical pulses to encode acoustic signals such as speech, noise, and sounds. Parallel stimulation of adjacent electrodes has been employed in recent cochlear implant (CI) systems. We investigated whether parallel stimulation of three adjacent electrodes enhances rate pitch perception compared with single electrode stimulation. Most comfortable loudness (MCLs) levels were assessed in single and multi electrode condition in 12 subjects (15 ears, PULSARci100/SONATAti100 implant, MED-EL). Rate pitch discrimination was determined by means of an adaptive procedure (two-interval two-alternative forced choice, 2I2AFC) at individual MCL in the single- and multi-electrode condition at base frequencies of 100, 200, 283, 400, and 566 pulses per second. To achieve MCL in the multi-electrode condition significantly higher stimulation current compared with single stimulation was required. No significant difference between single- and multi-electrode condition just noticeable differences in rate discrimination (JNDR) group was found. In contrast, a pairwise comparison of individual results in a subgroup recruited out of successfully completed runs at high base rates showed statistically an improved rate discrimination in 17 of 24 runs in the multi-electrode condition. Therefore, a potential effect of parallel stimulation on rate discrimination is conceivable.

Session "Active acoustic systems"

Thu 15:00 Kurhaus meeting room 1 Active acoustic systems

Adaptive Feedback Control for Active Noise Cancellation with In-Ear Headphones

Christoph Bruhnken[a], Sylvia Priese[a], Hatem Foudhaili[b], Jürgen Peissig[b] and Eduard Reithmeier[a]
[a] *Leibniz Univ. Hannover, IMR;* [b] *Sennheiser electronic GmbH & Co. KG*

In active noise control (ANC) headphones, disturbing noise is minimized by an out-of-phase anti-noise. Therefore, the noise is recorded by microphones next to the ear. The signals are filtered to generate the anti-noise. There are two main control strategies depending on the position of the microphones, feedforward (FF) control with an external reference microphone and feedback (FB) control with an error microphone inside the headphones. Most of the available ANC headphones use static strategies, but adaptive algorithms have the great advantage, that they are self-adjusting to the disturbance. Therefore these can achieve a better active attenuation. This presentation will focus on adaptive FB controllers for in-ear headphones. The main problem regarded to in-ear headphones is the inter-subject variability of the secondary path. These interpersonal variances can affect the speed and the stability of the adaptation. Furthermore these can cause an unstable closed loop. Hence an inverse identification of the secondary

path will be shown to speed up the adaptation and guaranty the stability of the closed loop. Thereafter an iterative adaption of the FB controller will be presented. Measurements will confirm this adaptation method.

Thu 15:20 Kurhaus meeting room 1 Active acoustic systems

Psychoacoustical Evaluations of Active Noise Control in Headphones

Maximilian Behn

TU Berlin, Institut für Strömungsmechanik und Techn. Akustik

In our modern world noise constitutes a significant problem as it is considered a thread to health. One possible way of reducing noise impact in various environments is the use of headphones with active-noise-cancellation (ANC). Lately, research on ANC-systems for the use in headphones has shown great advancement and let to launches by an increasing number of players on the market. However, to achieve the greatest possible increase in comfort it is useful to not think of active noise cancellation as a mere problem of control engineering, but to consider aspects of auditive perception for the design of ANC-systems. This was subject to a Bachelor thesis on "Psychoacoustical evaluations of active noise control in headphones". In order to investigate the subjective evaluation of comfort regarding to ANC-headphones, listening tests have been conducted. The design and conduct of these listening tests will be discussed as well as the statistical analysis. Following, a primary component analysis (PCA) has been undertaken on the acquired data resulting in a system of linear independent factors. Finally, these factors have been interpreted with regard to contextual plausibility. The presentation will illustrate the results of this study and give an outlook to possible further investigation.

Thu 15:40 Kurhaus meeting room 1 Active acoustic systems

The Need for Psychoacoustics in Active Noise Cancellation

Sylvia Priese[a], Christoph Bruhnken[a], Daniel Voss[b], Jürgen Peissig[b] and Eduard Reithmeier[a]

[a] *Leibniz Univ. Hannover, IMR;* [b] *Sennheiser electronic GmbH & Co. KG*

Noise cancelling headphones become more and more popular in our traveling society. They reduce unwanted ambient noise to enhance the listening experience or to make especially flights more relaxing. Companies claim noise cancelling effects of around 90% without giving details what this exactly means for the user. To investigate the perceived attenuation psychoacoustics has to be taken into account, because the measured sound pressure level differs from the observed loudness. However, besides some rather obvious approaches, like A-weighting, there is no focus in research on combining psychoacoustics and active noise cancellation. A current study on adaptive noise cancelling algorithms for in-ear headphones shows the deeper need for psychoacoustics. Even though certain filters achieve the best attenuation they were assessed as more unpleasant than others and were not preferred. Based on these results this presentation wants to prompt for research connecting the two fields of expertise to design even better controllers in the future.

Thu 16:00 Kurhaus meeting room 1 Active acoustic systems

Active Noise Cancellation in the Exhaust Gas System of a Ship's Engine

Kai Simanowski[a], Philip Griefnow[a], Norbert Hövelmann[b], Delf Sachau[a]
[a] *Helmut-Schmidt-Univ. Hamburg, Mechatronik;* [b] *ThyssenKrupp Marine Systems AG*

Large motor vessels are normally driven by big combustion engines causing high noise levels. The exhaust gas system of a 2200 kW research marine diesel engine, located at a shipyard hanger, ís equipped with an experimental setup. Here the possibilities of ANC are examined under rough, but realistic conditions, namely high SPL (140 dB), high temperature (450 °C) and high airflow (25 m/s). The commercial off-the-shelf (COTS) loudspeaker is protected against the high temperature. Therefore it is installed at the end of a lateral which is connected at right angles with the main tube and contains devices for cooling it's exterior wall and inside volume. A FxLMS algorithm is used with a speed sensor at the engines drive shaft to obtain a reference signal. The actuator for anti noise is mounted at the end of the lateral and a probe microphone, serving as error sensor, measures the sound directly in the main tube. A COTS amplifier is used, as well as rapid control prototyping components and laboratory measuring equipment.

Thu 16:20 Kurhaus meeting room 1 Active acoustic systems

Position Optimization of Loudspeakers and Microphones of a large Active Noise System

Jan Foht[a], Heiner Mattausch[a] and Delf Sachau[b]
[a] *Helmut-Schmidt-Univ. Hamburg;* [b] *Helmut-Schmidt-Univ. Hamburg, Mechatronik*

Passengers in aircraft cabins are exposed to annoying noise. It can be low frequent with a narrowband almost tonal spectrum. Active noise control (ANC) is a way to reduce this noise. The achievable reduction depends on the placement of actuators and sensors. A nonlinear optimization that selects positions for microphones and loudspeakers from a superset of possible locations is implemented as a genetic algorithm. It is applied to a mock-up with a large number of possible microphone and loudspeaker positions. The optimization is restricted by several conditions like the number of allowed components and the size of a monitoring volume. These conditions are varied and for each variation the positions are optimized. The performance of the optimal active noise system is numerically estimated and validated in a full scale wooden mock-up.

Thu 16:40 Kurhaus meeting room 1 Active acoustic systems

eVADER: Electrical Vehicle Alert for Detection and Emergency Response

Perceval Pondrom[a], Juan J. Garcia-Bonito[b], Joachim Bös[a] and Holger Hanselka[a]

[a] *TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM;* [b] *Applus+ IDIADA, Santa Oliva, Tarragona (E)*

Electric vehicles are considerably quiet. Recent studies suggest that they may constitute an increased safety risk for pedestrians and bicyclists in traffic. The risk that an electric or hybrid vehicle moving slowly or stopping, backing up or leaving a parking place be involved in an accident with a pedestrian or a cyclist was found to be twice as high as for a vehicle with an internal combustion engine. eVADER (Electrical Vehicle Alert for Detection and Emergency Response) is a project part-funded by the European Commission. It aims at defining solutions to warn vulnerable users of a nearby moving electric vehicle while providing means for heightening the awareness of drivers in critical situations, without significantly increasing the overall noise of the vehicle. To achieve this goal the focus is set on the selection of optimal warning signals in terms of detectability to alert pedestrians and other road users of the presence of the electric vehicle, the integration of in-vehicle intelligent systems to detect pedestrians and to generate a warning that will induce an appropriate reaction of the driver to avoid a collision and the design of a steerable sound beam generator to selectively warn pedestrians without increasing the ambient noise.

Thu 17:00 Kurhaus meeting room 1 Active acoustic systems

Active structural acoustic control on a double-layer acoustic panel

Ondrej Jiricek, Vojtech Jandak and Marek Brothanek

CTU in Prague

The paper deals with active structural acoustics control (ASAC) applied to a lightweight structure in order to increase transmission loss at low frequencies. The presented results show efficiency of moment actuators is particularly developed for ASAC mounted on a double-layer acoustic panel consisting of two metal sheets separated by an air gap. The moment actuators were applied to the incident plate and to the radiating plate of the double layer system, optimal actuator positions were selected based on laser scanning measurements of surface vibrations. Experimental results from these two arrangements of active systems were compared. The two-channel Filtered-x LMS algorithm was used in the experimental part of ASAC with promising results in the frequency range from 60 Hz to 200 Hz.

Thu 17:20 Kurhaus meeting room 1 Active acoustic systems

Active Noise Control to reduce Low-Frequency Noise in small and medium-sized Rooms: From Use Case to System Setup

Christian Kleinhenrich[a], Arndt Niepenberg[b] and Detlef Krahé[a]
[a] *Bergische Universität Wuppertal;* [b] *WaveScape Technologies GmbH*

Low-frequency noise can cause severe stress particularly in living- and sleeping rooms but also in offices. Due to increased noise insulation for medium and higher frequencies, low-frequency noise manifests itself since this insulation normally is not very effective for long wavelengths. Active noise control systems are suitable for reducing low-frequency noise. In small and medium-sized rooms local improvements can be achieved for example at the top end of a bed. However, also reduction of low-frequency annoyances for the entire room is possible in some cases, especially when standing waves are present. In general, damping success depends on the particular noise situation and whether the setup of an active noise control system meets the demands. Therefore, this paper evaluates different preconditions of low-frequency noise in small and medium-sized rooms. Relevant conditions are the particular noise situation in a room such as the presence of standing waves and if the aim is to reduce the noise globally or locally. These constraints and demands will lead to different system setups and affect the positioning of sensors and actuators as well as the strategy of a control algorithm.

Session "Sandwich materials"

Thu 8:40 Kurhaus meeting room 2 Sandwich materials

Implementation of a software for the prediction of the sound transmission loss of sandwich structures

Edoardo Alessio Piana[a], Anders Nilsson[b], Anna Marchesini[a] and Paola Milani[a]
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Sandwich and honeycomb materials are increasingly used by the vehicle and building industries. Consequently, the prediction of the acoustic properties and in particular the sound transmission loss of sandwich structures is of major importance. The dynamic and acoustic properties of a composite sandwich beam or plate depend on the geometry of the structure as well as on the material properties of core and laminates. Some of the basic parameters of a sandwich structure can be determined by means of some simple tests on a beam element of the structure. For such kind of test, the beam is suspended by strings to simulate free-free boundary conditions. By exciting the beam by an impedance hammer the first natural frequencies of the beam can be determined. Based on these measurements of natural frequencies and the weight and dimensions of the beam, the static bending stiffness, shear modulus of the core and bending stiffness of the laminates are determined. The procedure can be reversed to determine the theoretical coefficients for the bending stiffness curve, which is then

used to compute the transmission loss of the panel once a few physical and mechanical parameters are known.

Thu 9:00 Kurhaus meeting room 2 Sandwich materials

Determination of the sound transmission loss for sandwich panels by using point mobility measurements

Anna Marchesini, Paola Milani and Edoardo Alessio Piana
Università degli Studi di Brescia

In recent years new techniques for the determination of the transmission loss of sandwich panels have been developed. One of the methods is based on a model which, given an orthotropic sandwich panel, requires physical and mechanical properties of the materials and the natural frequencies of two beams, orthogonal directions, of the plate. Once incorporated in a mathematical model, these simple input data allow the prediction of bending stiffness, coincidence frequency, material losses and sound transmission loss of the panel. Once the material parameters for a sandwich or honeycomb panel are determined through these simple tests, also the point mobility of the corresponding infinite plate can be calculated. In this paper the predicted and measured mobility results for an aluminum honeycomb plate are discussed. Some investigations have been performed in order to compare the bending stiffness computed from measurements on beams to that obtained from measurements of point mobilities of a plate. Finally, the sound transmission loss predicted from measurements on beams and measurements of mobilities are compared to measured sound transmission losses.

Thu 9:20 Kurhaus meeting room 2 Sandwich materials

Weight minimization of vehicle inner floor panels with acoustical, thermal and deflection constraints.

Ulf Orrenius[a], Giorgio Bartolozzi[b] and Eva Lundberg[a]
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Metal sandwich panels with corrugated cores are widely used in the transportation industry, e.g. as elements in train floors and ship-decks. The main driver is weight and competitive solutions are enabled due to high stiffness-to-mass ratio. However, such designs may suffer from poor acoustic transmission properties. Therefore, combined structural-acoustic optimization is attractive. A difficulty is that detailed modelling of the core leads to large numerical models and long solving times, in particular for acoustic transmission predictions. Therefore, reduction of the complex shaped core to an equivalent orthotropic homogenous material is here applied. The parameters derived are shown to match those derived using a detailed FE core representation. The homogeneous core material derived is included in a multilayered FE model to represent a sandwich structure using laminate theory. The model is validated with experimental data with particular focus on the acoustic insulation. Thereafter, a structural optimization process is outlined targeting weight reduction while accounting for static and acoustic loads as well as thermal insulation requirements. The process is applied

to determine optimal design solutions for train inner floor panels using realistic functional design parameters for thermal and acoustic insulation as well as local deflection due to passenger load.

Thu 9:40 Kurhaus meeting room 2 Sandwich materials

Towards the Validation of a Simple Test Procedure to Determine the Sound Transmission Loss of Precast Panels

Paola Milani, Anna Marchesini and Edoardo Alessio Piana
Università degli Studi di Brescia

According to the international standards, the only way to determine the sound transmission loss of building elements in a laboratory, is through tests carried out in sound transmission rooms. Though, some building elements such as precast panels, cannot be easily tested in a transmission room. For such elements a different procedure can be applied in order to determine the sound transmission loss starting from the frequency response function of a test sample. The test sample is suspended by chains in order to simulate free-free boundary conditions, then an accelerometer is placed at one end of the panel, while at the other end the specimen is hit by an impact hammer. The bending stiffness of the panel can be determined extracting the values of the natural frequencies related to the bending modes from the FRF. As a consequence, the coincidence frequency and the sound transmission loss can be easily computed. To validate this procedure, different kinds of precast panels were tested in a sound transmission room and the resulting sound transmission loss were compared to the ones determined by using the impact method. One major outcome was that the internal losses play a significant role in the evaluation of the TL.

Thu 10:00 Kurhaus meeting room 2 Sandwich materials

Acoustic retrofitting of existing floor: dry floating floor treatments

Carola Aratari and Riccardo Gandolfi
Tecnasfalti Isolmant, Carpiano

The level of sound insulation achieved by existing separating floor is influenced by original design, the materials used, the structural junctions with other walls and floors, the quality of workmanship, previous alterations or changes to the building element. In order to ensure better comfort condition, the acoustic retrofitting of existing floor is an increasingly widespread practice in refurbishment intervention. Considering the acoustical behaviour of hollow clay floor, the paper illustrates different floating floor treatments. Low thickness solution that can be dry laid on existing floor can significantly improve impact and airborne sound insulation. In particular, tree intervention typologies for floor acoustic retrofitting were tested: - resilient overlay platform floor systems; - resilient overlay shallow platform floor systems; - composite overlay system. Thought the frequency spectrum, these dry laying platform floor systems are analysed in order to show the relation between design options, material chooses and acoustical performances.

Session "Advances in sound absorbing materials"

Thu 10:40 Kurhaus meeting room 2 Sound absorbing materials

Identifying micro- and macro- characteristic lengths governing sound wave properties in cellular foams

Camille Perrot and Minh Tan Hoang
Université Paris-Est / CNRS

Identifying microscopic geometric properties of and fluid flow through opened-cell and partially closed-cell solid structures is a challenge for material science, in particular for the design of porous media used as sound absorbers in building and transportation industries. Firstly, we revisit recent literature data to identify the local characteristic lengths dominating the transport properties and sound absorbing behavior of real polyurethane foam samples by performing numerical homogenization simulations. To determine the characteristic sizes of the model, we need porosity and permeability measurements in conjunction with ligament lengths estimates from available scanning electron microscope images. We demonstrate that this description of the porous material, consistent with the critical path picture following from the percolation arguments, is widely applicable. This is an important step towards tuning sound proofing properties of complex materials. Secondly, macro-characteristic lengths simulations were performed numerically in opened-cell and partially closed-cell polyurethane foams. Various representations were tried to bridge the micro- and macro- characteristic lengths. A successful one uses the curve of the viscous characteristic length over mean throat size as a function of membranes' closure rate. It was found to be close to one, meaning that the viscous characteristic length is a good indicator of the interconnection sizes

Thu 11:00 Kurhaus meeting room 2 Sound absorbing materials

Dispersion measurement techniques for the characterization of the mechanical properties of poro visco-elastic materials; some preliminary results

N.Bert Roozen[a], Bert Verstraeten[a], Christ Glorieux[b] and Philippe Leclaire[c]
[a] *KU Leuven;* [b] *KU Leuven, Laboratory of Acoustics and Thermal Physics;* [c] *Université de Bourgogne*

Dispersion measurement techniques are commonly used to determine the mechanical properties of poro visco-elastic materials such as the shear modulus. However, the frequency range for which the modes of propagation are measureable is limited to the relatively low frequencies, up to approximately 1500 Hz, depending upon the material under investigation. In this paper, advanced measurement techniques based on the propagation of guided and interface waves are presented which allow the useful frequency range to be extended.

Thu 11:20 Kurhaus meeting room 2 Sound absorbing materials

Sensitivity of Vibroacoustic Response in Multi-Layered Anisotropic Poro-Elastic Panels with Non-Aligned Properties

Peter Göransson[a], Olivier Dazel[b] and Jean-Francois Deü[c]
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The sensitivity in the response due to relative alignment of multiple layers of anisotropic open cell porous materials is investigated for various configurations, including but not limited to e.g. finite sized panels with different edge restraints, etc. The acoustic response is evaluated through numerical experiments, using e.g. Finite Element solutions, Transfer Matrix Method solution, etc. It will be shown that, depending on the degree of anisotropy of the porous material properties, their relative alignment may have a significant influence on the acoustic response. The influence of the boundary conditions between the layers and at interfaces to solid components will be illustrated. It is common knowledge that the different elastic-anelastic, acoustic-viscoacoustic interaction mechanisms governing the behaviour of porous materials, in general exhibit different degrees of anisotropicity depending on the type of material and the inherent micro-structural build. In the discussion the importance of the anisotropies as such, and the alignment, of these mechanisms will be highlighted, contributing to the currently ongoing discussion of further advancing the knowledge of anisotropic behavior.

Thu 11:40 Kurhaus meeting room 2 Sound absorbing materials

Ergun-Wu Equation: A Novel Approach for the Determination of Physical Parameters in Low/Medium Porosity Materials.

Alessandro Schiavi[a] and Louena Shtrepi[b]
[a] *INRIM, Torino;* [b] *Politecnico di Torino - Dipartimento Energia*

The experimental determination of effective porosity and tortuosity in medium/low porosity materials (typically $\leq$0.5) is still a challenge debated in metrology. In this paper is proposed a semi-empirical approach to the problem, based on the implementation of a new resistive model and accurate experimental input data. The empirical model is based on the recent redefinition of Ergun's equation (Wu et al., 2008) and on the geometric model for tortuosity (Yu et al., 2000). On the basis of measured quantities, such as the airflow resistivity and the average pore diameter, it is possible to determine the average effective porosity and the average tortuosity of the material in a defined range with a proper confidence level. In this work is also addressed the problem of a suitable determination of the average pore diameter and a definition of an average equivalent pore diameter in fibrous materials is also proposed.

Thu 15:00 Kurhaus meeting room 2 Sound absorbing materials

Sound Absorbing Material Characterization by the Means of an Unconventional Test Set-Up

Marianna Vivolo, Bert Pluymers, Dirk Vandepitte and Wim Desmet
KU Leuven

Vibro-acoustic characterization of structural and non-structural components has become extremely important in several technology fields. Knowledge of acoustic transmission loss, coupled vibro-acoustic behaviour and sound absorption properties of innovative materials and layouts represents a crucial step in the optimization of product and process design. Amongst others, automotive industries have loudly raised the need for practical and efficient techniques to investigate these properties in their laboratories. Exploiting an innovative test setup, designed and built at KU Leuven, full characterization of the NVH performance of lightweight constructions (as well composites, sandwich panels as trim multi-layered mats) is possible, allowing for the identification of acoustic Insertion Loss, coupled vibro-acoustic behaviour and absorption characteristics. In this work the authors present the corresponding experimental procedures, with dedicated focus on the identification of the sound absorption properties of multilayered trim treatments. The influence of sample dimensions on the use of a small rigid acoustic cavity (with a volume less than 1 m3) for sound absorption identification is studied. Comparison and correlation with standard reverberant room tests are shown. Numerical models (boundary element and wave based models) further illustrate the accuracy and limitations of the proposed experimental evaluation.

Thu 15:20 Kurhaus meeting room 2 Sound absorbing materials

Observations on absorption measurements in impedance tubes

Antje Meister, Joachim Bös and Holger Hanselka
TU Darmstadt, FG Systemzuverlässigkeit und Masch.-akustik SzM

An impedance tube is used for measuring acoustic absorption coefficients of materials. Even though the procedure is standardized, huge differences in measured absorption can be observed. A major effect is due to the way of placing the test sample in the tube. In our case the measurement is based on the 2-microphone method. The tube is designed for measurements of test samples mounted at a certain distance to the tube closure. This can be achieved with a movable stamp - which basically provides two possible ways of mounting. Based on OFAT(one factor at a time) tests it will be shown that the direction, from which the sample is placed into the tube, has a major effect. This is tested on various different samples, and it turns out that polyurethane foams show a stronger effect than melamine resin foams. Furthermore the effect of sample size on absorption is tested. Even though this effect is already very well described in literature it is never looked at from the point of production accuracy. If a test sample is too small for the test tube absorption increases noticeably at high frequencies- and so would give wrong test readings when high production accuracy cannot be provided.

Thu 15:40 Kurhaus meeting room 2 Sound absorbing materials

Experiences on the measurements of open field surface impedance

Raffaele Dragonetti, Rosario Romano and Carmine Ianniello
Univ. of Naples 'Federico II'

The impedance tube is the most classical tool used to measure the surface acoustic impedance of small samples of systems for sound absorption. Since the first implementations of standing-wave tubes in the forties many measurement techniques based on the use of tubes associated with more or less sophisticated theories have been developed. However, there are instances where neither an impedance tube nor a reverberation room can be utilized to obtain useful information: e.g. materials which cannot be removed reliably from their location or other causes. So one must resort to on site or open field measurement techniques. Also in this area various proposals are reported in the literature. Some are based on the use of p-p and p-U probes or other microphone configurations. In this paper the authors report about the problems related to their open-field measurement of the specific acoustic impedance vs. the incidence angle for layers of porous materials laid on a hard floor. One of the aims of the study was the comparison of the angle-weighted average sound absorption coefficient calculated with the formula of Paris and the corresponding values of αSabine obtained with standard measurements in a reverberation room.

Thu 16:00 Kurhaus meeting room 2 Sound absorbing materials

Development of Consolidated Granular Materials as Sound Absorbers: Acoustical and Mechanical Characteristics

Seyed Mohammad Hassan Zolanvari and Christof Karlstetter
Fraunhofer-Institut für Bauphysik, Valley

With the aim of acoustic performance for interior environments new acoustic absorbers were invented in Concrete Technology Group at Fraunhofer IBP. The main profits of the new materials are their efficiency, flexibility, low cost and straightforward production procedure that eliminate costly process of sintering. The aim of this paper is to report and discuss the results of designed experiments. The new acoustic absorbers have a porous granular media. In the set of experiments different grain types and sizes are used. The grains are consolidated by various binder types. Absorption coefficients together with flexural and compressive strengths are measured to display the acoustical and mechanical behaviors of the materials. To have a better interpretation of these behaviors analogy between the grain formations and atomic packing types are considered. Acoustic absorption is studied by changing following parameters: grain size, grain type, different grain size combinations and types of compositions. It is believed that in these cases material characteristics can be controlled. As a final point, a comparison is made with a commercial material. The comparison reveals approximately similar behavior for acoustical properties with significant cost deduction.

Thu 16:20 Kurhaus meeting room 2 Sound absorbing materials

Acoustic absorption by plants

Kirill Horoshenkov and Amir Khan
University of Bradford (UK)

The normal incidence, plane wave acoustic absorption coefficient of twenty five leaving plants is measured using a 100mm impedance tube apparatus and the procedure detailed in the ISO 10534-2 (1998) in the presence and absence of soil. It is shown a 100-150mm high living plant is able to absorb a considerable proportion (up to 60%) of the incident sound energy in the frequency range of 500- 1000 Hz. A three-parameter equivalent fluid model proposed by Miki (Miki, J. Acoust. Soc. Jap. (E) Vol. 11, 25-28 (1990)) is used to explain the observed absorption coefficient spectrum of a plant. It is shown that the plant leaf area per unit volume and dominant angle of leaf orientation are two key morphological characteristics which determine the ability of a plant to absorb sound. These characteristics are related semi-empirically to the effective flow resistivity and tortuosity which can be used in the equivalent fluid model to describe accurately the acoustic characteristics of a plant. It is shown that the same model can be used to predict accurately the acoustic absorption coefficient of a layer of porous soil with and without a plant.

Thu 16:40 Kurhaus meeting room 2 Sound absorbing materials

Acoustical Modeling and Optimisation of Perforated Honeycomb Panels

Francesco Pompoli and Paolo Bonfiglio
MechLav, Tecnopolo dell'Università di Ferrara

Honeycomb panels are widely used in noise and vibration applications mainly because of their high stiffness and damping despite their light weight. In the past a lot of research has been carried out on honeycomb panels in terms of sound transmission loss in different fields (i.e. transportation, buildings, noise barriers, etc...). On the contrary sound absorption of such structures is quite poor since laminates are usually impervious. Perforation of the two skins makes possible to obtain a resonant system which has a sound absorption having two typical frequencies, which can be optimized, for different applications, by varying the geometry of the panel. The acoustic modeling can be implemented using the series impedances method or a FEM approach, while the viscous losses within the holes can be calculated through fluid-dynamic simulations and compared with the formulas from literature for single layer perforate systems. Numerical results are compared with experimental tests in terms of normal incidence sound absorption coefficient.

Thu 17:00 Kurhaus meeting room 2 Sound absorbing materials

On Recommendable Acoustics for Amplified Music and a New ON/OFF Absorption Technology for Multipurpose Halls.

Niels-Werner Adelman-Larsen
Flex Acoustics, Lyngby (DK)

Previous studies have shown that what distinguishes the best from the less well liked halls for pop and rock music is a short reverberation time in the 63, 125 and 250 Hz octave bands. Since a quite long reverberation time in these bands is needed in order to obtain warmth and enough strength at classical music concerts, variable acoustics must address these frequencies in order to obtain desirable acoustics in multipurpose halls. A new, variable broadband absorption product is presented. Absorption coefficients measured are approx. 0.5 in the 63 Hz - 1 kHz bands while decreasing at higher frequencies when in the ON position. In the OFF position the product attains absorption values close to 0.0. Since the product is placed in the entire ceiling area the T30 of a hall can be lowered by almost 50% in the important octave bands of musical instruments. The technology, which is thus the only one to enable for variability at these scientifically proven most important low frequencies, is meant to be used everywhere where both classical as well as amplified music is being played such as in music schools and performing arts centres.

Session ”Tyre/road noise 2”

Thu 8:40 Kurhaus conference room Tyre/road noise 2

Optimization of the tire/road noise for C3 drive axle tires in regional application: status of the project

Lars Schnieders
Continental Reifen Deutschland GmbH

In contrast to passenger cars - where four tires of one type are mounted - tires of heavy commercial vehicles are determined by their position on the vehicle and the service conditions. Especially the drive axle tires in regional service cause a significant higher tire/road noise than trailer tires for example. This is caused by a robust pattern design with many lateral orientated grooves, which cause the whole tire to structural vibrations. The source of these vibrations is mainly the edge of the contact patch. From these areas the vibrations propagate in circumferential direction and are then emitted from the tire surface mainly in the horn areas as airborne noise.

Within the scope of ”Leiser Verkehr 3” it is the task to deepen the understanding of the origin and the spectral composition of rolling noise for drive axle tires. Besides the compliance with the noise regulations the legal and customer requirements in terms of safety and cost effectiveness have to be ensured. The contribution of ”Continental Reifen Deutschland GmbH” to ”Leiser Verkehr 3” and first results are presented.

Thu 9:00 Kurhaus conference room Tyre/road noise 2

Tyre /Road Noise Reduction at Trucks and Vans with LWRT Underbody Panels

Klaus Pfaffelhuber, Frank Uhl and Carsten Riewe
Röchling Automotive AG & Co. KG

Due to the CO2 reduction requirements at cars, vans and trucks, an aerodynamically optimised covering of the area below these vehicles becomes more and more important. Stiff sandwich underbody panels made from glasfibre reinforced thermoplastic layers (LWRT: Low Weight Reinforced Thermoplastics) are meanwhile established in passenger cars. By using porous layers, these LWRT-panels can have additional sound absorptive properties. So aerodynamical and acoustical improvement can be combined.

In near and far field measurements the pass by noise reduction achieved by absorptive LWRT underbody panels was investigated at a small truck and a van. Furthermore the sound reduction potential of these panels was measured by using noise emitting sources near the tires and microphones around the truck.

Theses activities are part of the LeiStra3 (Leiser Straßenverkehr 3) projects funded by the german ministry of economics.

Thu 9:20 Kurhaus conference room Tyre/road noise 2

Experimental and Numerical Analyses of the Rotating Tire Dynamic Behavior

Peter Kindt[a], Cristobal Gonzalez Diaz[a], Stijn Vercammen[a], Christophe Thiry[a], Jason Middelberg[a], Jan Leyssens[a] and Roland Close[b]
[a] *Goodyear Innovation Center, Luxembourg;* [b] *oodyear Innovation Center, Luxembourg*

This paper reports on the work that has been performed in the framework of the European industry-academia project TIRE-DYN, with partners Goodyear, Katholieke Universiteit Leuven and LMS International. The goal of this project is to quantify the effect of rotation on the tire dynamic behavior. Therefore, experimental and numerical analyses have been performed for different operating conditions of the tire with respect to loading and rotation speed. The presented numerical analyses are based on a highly detailed tire model, which includes the vibro-acoustic coupling effects and the viscoelastic material behavior. The experimental analyses are based on acceleration measurements on the inner liner of a tire which is rolling over a cleat. The experimental and numerical results show that a rotating tire is subjected to Coriolis accelerations which make the wave speed of the waves travelling in opposite direction of the tire rotation to diverge from the speed of the waves travelling in the rotation direction. This causes tire resonances with complex or travelling mode shapes.

Thu 9:40 Kurhaus conference room Tyre/road noise 2

Interior Tire-Road Noise - Experimental Component Investigation of the Structural Dynamic Behaviour of the Rim

Eskil Lindberg
KTH Royal Institute of Technology, Stockholm

Low frequency interior tire-road noise may be categorised as a structural-borne noise phenomenon. That is, the force fluctuation in the contact between tyre and road causes vibration that is transferred through the suspension system into the vehicle compartment. The transfer of acoustic energy through all the different components, namely the suspension system, is a complex process, where components of fundamentally different acoustical properties are combined. Furthermore, mode-coupling and non-linear effects of large deformations may complicate the understanding of the process. In this paper one component in this transfer of acoustic energy is investigated: the rim. Traditionally, in the tyre-road noise literature the rim is mostly treated as a rigid component. However, from road measurement of interior noise an up to 5 dB difference in interior sound pressure level is found. This paper is primarily an experimental study where the rim structural dynamics is correlated with measured interior noise levels.

Thu 10:00 Kurhaus conference room Tyre/road noise 2

Joint speed and wheelbase length estimation of two-axle road vehicles through acoustic sensing

Patrick Marmaroli, Xavier Falourd and Hervé Lissek
Swiss Federal Institute of Lausanne

We will discuss about microphone array processing dedicated to road traffic when the array is placed on the roadside. Due to the broadband nature of the noise resulting from the tyre/road interactions, front and rear axles can be discriminated using generalized cross-correlation functions (GCC). Former studies showed that it is possible to jointly estimate speed and wheelbase length of passing-by vehicles by filtering successive GCC in time with a sequential Monte Carlo method (particle filter). In this presentation, different signal processing strategies (array geometries and tracking techniques) are assessed through in-situ measurements.

Session "Transport noise"

Thu 10:20 Kurhaus conference room Transport noise

Quality Traffic Data for a sound Calculation

Thorsten Kathmann[a], Hartmut Ziegler[a] and Martin Pozybill[b]
[a] *DTV-Verkehrsconsult GmbH, Aachen;* [b] *Ministerium für Verkehr und Infrastruktur BW, Stuttgart*

In Germany the Road Traffic Census takes place every five years to supply traffic date for all major roads. In recent road censuses the basis were manual counts, but a change is underway to use automatic classifiers (in Baden-Wuerttemberg alone 450) giving both traffic and speed data for up to 8 vehicle classes. The results of such counts form the basis for road traffic noise calculation. In a manual count the night time values for the average hourly traffic volume, which is a much needed value, are estimated based on the AADT, as no night-time data is available. Using automatic classifiers for the first time night time data was available allowing a comparison of the different methods and derived values. With the new data the road traffic noise calculation is put on a sound basis offering some surprising results. Using the new data it will be possible to calculate the road traffic noise more accurately, perhaps find solutions to improve the German road traffic noise legislations and maybe in future even provide the authorities with measured noise levels, as one of the detectors is equipped with a microphone for vehicle classification!

Thu 10:40 Kurhaus conference room Transport noise

Measurement of Traffic Noise with Guide Posts

Christian Fend[a] and Martin Pozybill[b]
[a] *ACCON GmbH, Augsburg;* [b] *Ministerium für Verkehr und Infrastruktur BW, Stuttgart*

The completely automatic census of street traffic continues its advancement. Step by step this modern technology is replacing manual counting methods nation-wide. Modern systems therefore can be integrated in standard guide posts for installation along roads outside city limits. The vehicle speed as well as the vehicle classification is determined with radar sensors. For achieving even better detection rates modern systems additionally use microphone signals.

It was investigated whether those systems are also applicable for noise measurements. The measurement of traffic noise according to the standard DIN 45642 requires a microphone position at a distance of 7,5 m from the center of the lane and a microphone height of 1,2 m and thus deviates substantially from the position of a guide post microphone.

The noise levels from the guide post and reference microphones are opposed and ways to convert the guide post values to standardized values are presented. Technical capabilities and limits of guide post noise measurements are discussed.

Thu 11:00 Kurhaus conference room Transport noise

On the Linearity of Road Traffic Noise Source

Claudio Guarnaccia and Joseph Quartieri
Università degli studi di Salerno

One of the most important acoustical noise source in urban environments is road vehicular traffic. Car, in fact, is the preferred means of transportation for people in European Union. Human life quality, however, should be considered when dealing with road transportation, since noise can produce several effects on health. In order to properly predict noise from road traffic, a source model must be performed, according to the general and particular parameters of area under investigation. Usually, road traffic is considered as a linear source, without any consideration about the traffic flow or any other parameter. In this paper, the authors define and evaluate a ”degree of linearity” coefficient, related to the power law of the source-receiver distance in the logarithmic propagation formula. In the linear scheme, one expects to find a linear dependence of the intensity from the distance, while, in the point scheme, a square law is considered. Analyzing the two available sets of experimental data, the authors corroborate the linear hypothesis. In addition, considering the dependence of the data from traffic flow, ”degree of linearity” coefficient results are close to the expected value, i.e. 10, especially in the medium range of traffic flow.

Thu 11:20 Kurhaus conference room Transport noise

Application of Neural Networks for Calculation of Intensity of Traffic Noise Sources

Zoran Petrovic, Marina Pljakic and Jelena Tomic
Faculty of Mechanical and Civil Eng Kraljevo (SRB)

Definition of types and noise intensity levels of traffic noise sources is necessary step in noise mapping. The intensities of noise depend on large number of parameters like number and types of vehicles, speed of the vehicles, number of road lanes, quality of road, road inclination, sound absorption and reflection by the surroundings etc. Besides, some of the parameters cannot be easily quantified. The paper presents a procedure for calculation of intensity of sound sources by application of neural networks that learn on examples of measurement data acquired in various traffic and environmental conditions. In the procedure are used both numeric data and fuzzy data, which describe characteristics that cannot be numerically expressed.

Thu 11:40 Kurhaus conference room Transport noise

Noise mapping and Action plan realization within LIFE+ "NADIA" PROJECT.

Francesco Asdrubali, Samuele Schiavoni and Francesco D'Alessandro
CIRIAF- Università di Perugia

The European Directive 2002/49/EU (END) has defined new indicators and instruments to evaluate environmental noise due to transport infrastructures. The Directive introduces the concept of "Strategic noise mapping" as "a map for the global assessment of noise exposure", also defining roads, railways, airports and agglomerations that require to be analyzed trough this instrument. The results of the noise mapping activities should be used to drawn up Action Plans to manage noise issues and effects. The Action Plans should be transmitted to the European Commission no later than 18 July 2013 by the competent authorities in compliance with the requirements of Annex V of the END and ensuring an adequate public participation. The Action 3 and 4 of the EU-funded LIFE+ NADIA project (Noise Abatement Demonstrative and Innovative Actions and information to the public) are focused respectively on the noise mapping activities and the Action Plans for each one of the project partner (Province of Genoa, Province of Savona, Municipality of Prato and Municipality of Vicenza). The aims of the paper is to explain how these activities have been carried out within NADIA and to explain the goals of the project.

Thu 15:00 Kurhaus conference room Transport noise

Tempo 30 wegen Lärmschutz auf Hauptverkehrsstraßen

Ulrich Peschel
Umweltbundesamt, Dessau-Roßlau

Tempo-30-Zonen im Nebenstraßennetz sind inzwischen vielerorts umgesetzt. Sie werden eingeführt, um die Verkehrssicherheit zu erhöhen, den Verkehrslärm zu mindern und die Feinstaubbelastung zu reduzieren. Von Geschwindigkeitsreduzierungen auf stark befahrenen Innerortsstraßen, an denen viele Menschen leben, werden ähnlich positive Effekte erwartet.
In vielen Lärmaktionsplänen wurde Tempo 30 auf Hauptverkehrsstraßen als eine Maßnahme zur Lärmminderung - vor allem zum Schutz der Nachtruhe - vorgeschlagen. Einige Vorschläge wurden bereits umgesetzt. Andere Kommunen beginnen jetzt Versuche mit Tempo 30 auf diesen Straßen.
Können die Erfahrungen im Nebenstraßennetz auf Hauptverkehrsstraßen übertragen werden? Wo liegen die Schwierigkeiten bei der Planung und Einführung? Wie kann die Akzeptanz bei Autofahrern und der Wirtschaft verbessert werden? Was muss getan werden, damit Autofahrer die Geschwindigkeit tatsächlich senken?

Thu 15:20 Kurhaus conference room Transport noise

Mitigation of the Diffraction of Noise Barriers

Michael Chudalla
Federal Highway Research Institute (BASt)

Unfortunately there is no perfect quietness in the shadow zone behind a noise barrier. The value of sound insulation of the elements of a noise barrier in laboratory test is in the range of 20 to 60 dB. But if they leave laboratory and stay in ”real life” situation, the effectiveness of noise barriers is reduced by the diffraction over their top. With increasing traffic, noise barriers along highways are growing higher and higher when there are buildings nearby with need of noise protection. To minimize noise barrier heights, or to increase their effectiveness leaving their height, a mitigation of the diffraction edge would be nice.

Constructions with the aim to reduce diffraction will be presented. These constructions act like prisms in optics. They are effecting the direction of the sound propagation. Results of scaled model measurements will be presented.

Thu 15:40 Kurhaus conference room Transport noise

German Airport Noise Surcharges - Method of Calculation and Effects

Kai Johannsen[a] and Kristin Hübner[b]
[a] *Berlin Brandenburg Airport;* [b] *TU Berlin/WIP*

Over the last decade nearly all major German airports have switched to noise surcharges based on measured sound levels at take-off and landing of aircrafts.

The methods used to calculate and define the surcharges are similar for most German airports, and will be presented for the case of Berlin Airports. The effects of noise surcharges on the deployment of aircraft types, based on an empirical study of air traffic at four German airports over a 10-year period, are also presented here. During this 10-year period the fraction of quiet aircrafts did increase, however, the study could not prove that the noise surcharges were the major reason for this, as there are many other economic influences, e.g. fuel burn, on the decision of which kind aircraft is deployed at certain airports.

Nevertheless, the empirical study does indicate some influence due to the noise surcharges, from which recommendations for an optimization of noise surcharges could be drawn and are presented.

Thu 16:00 Kurhaus conference room Transport noise

Aircraft noise in the changing times

Berthold Vogelsang[a] and Dietrich Kühner[b]

[a] *Niedersächs. Ministerium für Umwelt, Energie Klimaschutz;* [b] *debakom, Odenthal*

Environmental protection evaluates adverse effects of noise exposure, such annoyance or sleep disturbance using specific characteristics such as the commonly used LDEN and LN. The wake-up probability is frequently described using the characteristics LpAS,max or the LAX. The noise effects research establishes the necessary correlation by deriving exposure -response-curves. The characteristics to describe impairment are usually based on the ICBAN scale using parameters such as % HA, %A and %HSD, SD%. In contrast to road and rail noise, new studies for aircraft noise show strong evidence that for identical values of exposure, the value of the impairment characteristics has increased. So far no explanation of this effect could be identified from noise effects research publications. In this paper, other exposure characteristics are introduced, such as percentile levels or equal loudness to interpret simple examples, which may explain the observed increases.

Thu 16:20 Kurhaus conference room Transport noise

How to Use Noise Monitoring Results for Managing Air Transport Noise

Markus Petz[a], Uwe Gösmann[b] and Andrea Cerniglia[a]

[a] *ACCON Italia Srl.;* [b] *Flughafen Stuttgart GmbH*

Most of the international airports and many regional airports in Europe operate a noise monitoring system with multiple monitoring stations and in order to inform the public and other stakeholders publish monthly noise reports. However, the noise monitoring results can also be used for managing air transport noise and noise action planning. The information of the height of each single noise event together with corresponding flight data from the aircraft transponder also allows a detailed cause-analysis relationship to be derived. Various noise impacts by equivalent aircraft types from different airlines show the acoustical effects on airline specific Flight Management Guidelines such as the behavior related factors of the individual pilots. Based on noise monitoring and flight data from Stuttgart Airport and a software tool developed by ACCON for cause-analysis the variation of pass-by noise levels for comparable flight movements induced by various Flight Management Guidelines can be identified. Accordingly, the noise reduction potential by optimized take-off and approach taking into account the local distribution of sensitive areas and population density; can be presented. A demonstration of how to develop a ”best-practice-guide”, which should be published by the airport operator as part of their noise action planning, will be presented.

Thu 16:40 Kurhaus conference room Transport noise

Acoustic Equipment of Stations at Vienna's Underground Railway

Verena Dreitler[a], Günther Achs[a] and Andreas Oberhauser[b]
[a] *FCP Fritsch, Chiari & Partner ZT GmbH;* [b] *Wiener Linien GmbH & Co. KG*

On the basis of an inspection of the acoustic room characters of the Vienna underground stations of 1979, the stations at deep level were equipped with sound absorbers in the ceiling area of the train station and in the track area. In the course of the rail maintenance operations it has been shown, that absorbers near the track are less feasible because of pollution problems. Therefor a detailed survey was carried out specifically in the track area to better understand their effectiveness. To evaluate the effect of absorber panels in the track area of the stations at Vienna's underground railway, measurement based inspections were carried out in a selected station with a closed cross-sectional area. In this process the sound immissions and the reverberation time in the station were determined in 2 cases. In the first case the station was measured with the original absorber equipment according to the design of 1979, in the second case the absorbers in the track area were removed. The results of the realized inspections and their impact on the future acoustic structuring of Vienna's underground railway stations will be explained in the context of this article.

Thu 17:00 Kurhaus conference room Transport noise

Railway noise measurements during a six-day observing period in the German Middle Rhine valley

Arthur Schady
German Aerospace Center (DLR), IPA-DA, Oberpfaffenhofen

Railway noise is a demanding problem in many regions of Europe. Noise mapping is required due to European Directivity. But noise mapping adopts standard calculation method only (e.g. VBUSch), neglecting many features and variability of real surroundings like sound propagation in areas with a structured topography and modified meteorological fields and weather conditions. A misfit between single measurements and the noise mapping not only is based upon singular events, but also on the approximations of the calculation. A further purpose of this measurement was to describe the process chain from emission through transmission to immission. Beside the source also the soundscape as well as the meteorological conditions were recorded. With the measurements it is possible to assess the singular railway noise starting from the source propagating to the receiver near the house facades of residents. Here the results of a 6-day measurement campaign are presented and related to the values of to the railway noise mapping. It is demonstrated how to derive representative data from limited places and time frames. The achieved data serve for better simulation results and a better assessment of large scale railway noise and its specific influence factors.

Session "Soundscaping: Creating and designing"

Thu 8:40 Kurhaus Czerny hall Soundscaping: Creating

Soundscape - the different noise control through the use of resources

Brigitte Schulte-Fortkamp
TU Berlin, Institut für Strömungsmechanik und Techn. Akustik

In contrast to many other environmental problems, noise pollution continues to grow and it is accompanied by an increasing number of complaints from people exposed to the noise. The growth in noise pollution involves direct, as well as cumulative, adverse health effects. It also adversely affects future generations, and has socio-cultural, aesthetic and economic effects. The concept of noise annoyance needed to be broaden to an integrated environmental, psychosocial, and socioeconomic assessment of the community situation to reach a more realistic basis for environmental impact and health risk assessments. Soundscape research represents a timely paradigm shift in that it combines physical, social and psychological approaches and considers environmental sounds as a 'resource' rather than a 'waste' to satisfy human needs and wants. Therefore, balancing between the expertise from people living in respective areas and acoustic measurements, architectural planning will lead to a new understanding of a concept of an environment under "noise control" as soundscape suggests exploring noise in its complexity, its ambivalence and its approach towards sound.

Thu 9:00 Kurhaus Czerny hall Soundscaping: Creating

On the relationships between urban morphology, noise resistance and soundscape

Jian Kang and Yiying Hao
University of Sheffield, School of Architecture (UK)

This paper aims to explore the relationships among urban morphology, noise resistance and soundscape, through case studies in typical low density cities in Europe. Noise mapping techniques are employed and a Matlab program has been developed to calculate spatial statistical sound level matrix. Questions considered include, how to improve low-density residential area's traffic noise resistance through control of urban morphological parameters, and how to enlarge the quietness of traffic noise environment by the use of masking effects such as from water sounds or bird songs. Initial results show that the spatial sound level attenuation indices of Lmax-Lmin, L10-L90, L20-L80, Lavg and L50 can indicate a site's noise resistance at different levels; noise attenuation on façades and in open areas has different characteristics and noise attenuation on façades is influenced by urban morphology more significantly than that in open areas. It seems that a site with a greater spatial sound level attenuation may not necessarily have a larger quiet area. Building coverage and buildings' layout and shape have vital influences on the traffic noise resistance of low-density residential areas. Consequently, a series of regression models have been generated between urban morphological parameters and the spatial sound level attenuation.

Thu 9:20 Kurhaus Czerny hall Soundscaping: Creating

Modeling the Soundscape Quality in Urban Spaces

Giovanni Brambilla[a], Maria Di Gabriele[b], Veronica Gallo[a] and Luigi Maffei[b]
[a] *CNR-IDASC, Roma;* [b] *Second University of Naples - RiAS*

The researches on soundscape have clearly addressed the need to transfer their outcomes into the practice of soundscape design. In this process, the numerical models are useful tools to assist urban planner and designers in estimating the potential users' ratings of a designed soundscape and to tailor it to match the subjective expectation. To develop such models, experimental data on both descriptors of the sonic environment and subjective ratings of the soundscape are necessary, hopefully including data on other factors that may affect the perception of the environment, such us the visual aspect. The experiments carried out by IDASC and RiAS in the framework of the COST Action TD0804 "Soundscape of European Cities and Landscapes" have provided data suitable to develop the above models. In particular, descriptors of the sonic environments binaurally recorded during soundwalks in 8 urban squares (2 in Naples and 6 in Rome, with different use, lay-out and sonic environment) were available, as well as subjective ratings of these recordings played back in laboratory. The paper describes preliminary models obtained from the collected data that may be applied in urban open spaces with similar physical and social environments.

Thu 9:40 Kurhaus Czerny hall Soundscaping: Creating

Sound Design Education in Interaction Design at Zurich University of the Arts: Enabling Sound Thinking for Sound Design

Daniel Hug
Zurich University of the Arts

In Interaction Design at the Zurich University of the Arts, sound is an important element in the curriculum. This is motivated by the advantages of multimodal interfaces, and the fact that many everyday commodities have small or no screens, and even disappear in our environment.

From a pedagogic standpoint, the challenge lies in enabling our students to make informed decisions about when and how to use sound in potential future applications, taking into account that sound is but one of many aspects they need to consider.

Instead of aiming at mastering certain tools and sonic production tasks, we focus on the development of the understanding of sound as material for creative expression in the context of interaction design - sound thinking for sound design. Some core elements are: listening, understanding, sonic conceptualization, sonic exploration in action and prototyping sonic experiences. Building on this, we have devised a series of educational activities, including: analysis and transplantation of sounds and soundscapes, semantic foley, everyday interaction remix, sonic wizard-of-oz mockups, and functional prototypes of sounding artifacts. These elements can be integrated with our general interaction design process.

We will present this approach to sound education and discuss project cases, pointing out relevant insights.

Thu 10:00 Kurhaus Czerny hall Soundscaping: Creating

Soundscape Planning in dense compact cities - the need, constraints and opportunities in Hong Kong

Kin-Che Lam and Lawal Marafa
Chinese University of Hong Kong

As one of the densest cities of the world, it is of paramount importance to manage the acoustic environment. In spite of the strenuous efforts to control road traffic noise, noise levels have not dropped significantly in the past few decades in Hong Kong. There is hence the need to adopt alternative noise management measures such as soundscape planning. This paper reviews findings of soundscape research undertaken in Hong Kong and examines the constraints and opportunities. Previous work has highlighted the health effects of noise exposure and potential benefits of crafting an amicable acoustic environment. The findings also indicate there is much scope to enhance urban livability through soundscape planning by linking the urban with the countryside environment and innovate with various urban design measures in a vertical compact city.

Thu 10:20 Kurhaus Czerny hall Soundscaping: Creating

Objective and subjective assessment of sound environments in urban parks for soundscape design

Hyung Suk Jang, Jooyoung Hong, Inhwan Hwang and Jin Yong Jeon
Hanyang University, Seoul

In the present study, objective and subjective evaluation of acoustic environment in urban parks were conducted by field measurements and soundwalks, respectively. Through field measurements, sound pressure levels, psychoacoustical metrics and room acoustic parameters were calculated to investigate physical characteristics of urban parks. In the soundwalks, subjects assessed both sound and landscape environments in urban parks to explore soundscape perception. From the results, correlation between acoustic parameters and soundscape perception were analyzed. In addition, the indicators characterizing urban park soundscapes were investigated.

Thu 10:40 Kurhaus Czerny hall Soundscaping: Creating

Tuning the historical city of Antwerp, to code and re-code quiet semi-public places.

Maria Leus, Marleen Arckens and Tess de Weerdt
Artesis University College, Antwerpen (B)

Quality planning for revival of urban public spaces is still concentrated on visual aspects of the environment and neglecting human experiences as aural qualities of a place although they are an important aspect of the genius loci. Until now, all attention in research concerning quiet spaces in urban landscape is centered on natural places. However, quiet places in an historic city centre are mainly far less green and often semi-public spaces such as: courtyards, little squares and enclosed gardens. The ëAmplified Silence' research project aims at developing a methodology for semi-public

places in an urban environment by converting sound/silence into a manageable environmental quality. The case data is selected in terms of our research question which argues that sound and silence as intangible aspects of the tangible built urban semi-public space can act as an aural catalyst making these in-between places an important part of everyday urban life. The research resulted in defining acoustic and non-acoustic criteria and the design of a framework consisting of tools and concepts enabling architects, urban planners and heritage managers to preserve and design quiet urban places. These strategic methods that adopt soundscape in the design of public spaces will increase the quality of life.

Thu 11:00 Kurhaus Czerny hall Soundscaping: Creating

Soundscape within the strategy of Bilbao city to improve Quality of Public Spaces

Itziar Aspuru
Fundacion Tecnalia Res. & Innovation, Donostia-San Sebastián (E)

The technological knowledge of Tecnalia, and the will and experience of Bilbao City Council, on citizen participation and renovation of the city, are allied to improve the quality of life at the public spaces of Bilbao. The aim of this alliance is to give practical and positive results for the city. The hypothesis of this strategy is that sound quality in public spaces helps to improve quality of life of citizens. The goal is that all new urban projects in the city that include the development or renewal of squares or parks, incorporate acoustic comfort as one of the conditions for the final design. Tecnalia and Bilbao are laying the groundwork to propose, within the possibilities of action in each place, specific improvements that lead to a sound environment appropriate to the use and the expectations that citizens have of that space. The proposed actions will consider the soundscape approach, since they will deal with sounds that people value as positive and that enhance the enjoyment of the space. This paper explains the strategy defined to obtain practical results from the alliance of Tecnalia and Bilbao city, and presents first results of its implementation, linked to the Life project Quadmap.

Thu 11:20 Kurhaus Czerny hall Soundscaping: Creating

Modelling spatial distribution of wind turbine noise in sub-urban environments

Fei Qu, Jian Kang and Aki Tsuchiya
University of Sheffield, School of Architecture (UK)

Wind turbines are increasingly developed in the global process of producing renewable energy. However, they generate significant noise, especially at low frequencies. This could have an impact on the soundscape and some studies have also suggested that they may cause adverse impact on human health and well-being. This research explores the method of modelling spatial distribution of wind turbine noise, based on the technique of noise mapping. Particular attention is given to sub-urban environments, where various factors are taken into account, including buildings of different size, height, orientations, material, as well as wind direction and background noise. The accuracy of using existing noise-mapping software to

calculate wind turbine noise is examined and improved by comparing with other micro-scale simulation techniques. This study will contribute to further studies linking the parameters of wind turbines with level of exposure relating to health impact and well-being, as well as soundscape assessment in sub-urban areas.

Thu 11:40 Kurhaus Czerny hall Soundscaping: Creating

Factors affecting perception of noise barriers' performance

Jooyoung Hong and Jin Yong Jeon
Hanyang University, Seoul

In the present study, laboratory experiments were conducted to evaluate noise barriers performance according to barrier types. Five types of barriers in terms of materials were selected: timber, metal, concrete, vegetation and glass. The experiments consisted of three parts; 1) audio-only condition, 2) visual-only condition, and 3) audio-visual condition. Aesthetic preference of noise barriers, preconception on noise attenuation by barriers and noise annoyance were evaluated by subjects. As results, insertion loss of noise barrier highly correlated with overall preference of noise barriers. The effect of preconception on noise attenuation was significant whereas visual preference on noise barriers performance was relatively insignificant.

Session "Soundscaping: Outreaching and training"

Thu 15:00 Kurhaus Czerny hall Soundscaping: Outreaching

Soundscape Classification: The Case Studies Of Some European Historical Urban Centers

Veronica Gallo[a] and Maria Di Gabriele[b]
[a] *CNR-IDASC, Roma;* [b] *Second University of Naples - RiAS*

Researches on soundscape have clearly shown the need to take into account the subjective perception of the environment, as it is influenced by psycho-physical factors and therefore, should be evaluated by a multidimensional approach. A previous study was carried out in 20 squares in the historical centre of Rome, aimed to classify the urban spaces through the combination of different environmental parameter influencing the human perception and comfort. Acoustic and psychoacoustic descriptors were measured together with other physical (illuminance) and geometrical (shape) parameters. The above methodology was applied to other urban contexts namely 17 squares of 3 UK cities (Sheffield, Manchester and York). The survey was performed during a stage research, undertaken by the authors at Acoustic Group in Sheffield, and supported by to the COST Action TD0804 "Soundscape of European Cities and Landscapes". The study is aimed to figure out if an a priori classification of both Italian and English squares (based on their geometry and predominant sound sources) would be in agreement with the clustering obtained by statistical analysis, based on physical parameters taken in field.

Thu 15:20 Kurhaus Czerny hall Soundscaping: Outreaching

The Study of Soundscape - COST Training School 2012 on 'Measurement, Analysis and Evaluation of Soundscapes'

Luca Nencini[a], Karlo Filipan[b], Fabio Kaiser[c], Laura Estévez[d], Luca Fredianelli[e], Luca Cassina[f], Dunja Porupski[g], Marco Chetoni[h], André Fiebig[i], Klaus Genuit[i] and Brigitte Schulte-Fortkamp[j]

[a] *Dustlab, nonprofit organization, Pisa;* [b] *University of Zagreb;* [c] *Freelance, Salzburg (A);* [d] *Laboratorio de Acústica Aplicada, Universidad de León (E);* [e] *E. Fermi Physics Department, University of Pisa;* [f] *Department of Earth Sciences, University of Pisa;* [g] *DARH 2 L.l.c., Samobor (HR);* [h] *CNR-IPCF, Pisa;* [i] *HEAD acoustics GmbH;* [j] *TU Berlin, Institut für Strömungsmechanik und Techn. Akustik*

In the context of COST Action TD 0804 in July 2012 a Training School on "Measurement, Analysis and Evaluation of Soundscapes" was carried out in HEAD acoustics GmbH, Herzogenrath, Germany. Seventeen international young researchers learned about and discussed the concept of soundscape, binaural measurements techniques, psychoacoustic parameters analysis and different soundscape evaluation methods. The young researchers had the opportunity to practise what they learned by performing a soundwalk in Aachen urban area. The soundwalk included binaural measurements and filling up semi-structured interview forms. The paper describes the study, the gained experiences and the results of the in-situ ratings compared with additionally performed laboratory listening tests. Finally, the obtained data and results are presented and discussed. Acknowledgements: COST Action TD 0804 on Soundscape of European Cities and Landscapes, HEAD acoustics GmbH, Technical University of Berlin.

Thu 15:40 Kurhaus Czerny hall Soundscaping: Outreaching

Voice of the City - An International Educational Action with Guided Sound Exploration.

Andreas Drechsler[a], Oliver Graber[b], Hans-Peter Meier-Dallach[c] and Marion Hermann-Röttgen[d]

[a] *HFT Stuttgart;* [b] *Universität für Musik und darstellende Kunst Wien;* [c] *cultur prospectiv Zürich;* [d] *IB-Hochschule Berlin/Köln/Stuttgart*

Initialized by the international workgroup HIDS (German shortcut for "Problems with listening in society, city and school") the educational action intends to increase the competence in listening mainly of young people. The essential part is a guided sound exploration that invites the listeners to discover the acoustical characteristics of a city. In different European cities (Vienna, Stuttgart, Zürich, Berlin) soundwalks will be arranged including similar urban spaces in each city like pleasure grounds, public places, railway stations or areas of power and governance. Fields of interest are for example whether the listeners notice the differences of the urban spaces and how they describe these differences. Furthermore whether the soundscapes of these spaces are described in a similar way in all participating cities. The paper will outline the design of the project and discuss the ideas and intentions of this educational action. Also first results from the conducted soundwalks in Vienna will be presented.

Thu 16:00 Kurhaus Czerny hall Soundscaping: Outreaching

Using body language indicators to assess the effects of soundscape quality on anti-social behaviour and noise

Lisa Lavia[a] and Harry Witchel[b]
[a]*Noise Abatement Society, Hove (UK);* [b]*Brighton and Sussex Medical School (UK)*

Building upon "Sounding Brighton", a collaborative project exploring practical approaches towards better soundscapes focusing on soundscape issues related to health, quality of life and restorative functions of the environment, a further stage of the project provides the opportunity to raise awareness and promote communication on soundscapes among the general public, stakeholders and those involved in policy, including encouraging exploration of new ways of listening in local soundscapes, and new ways of tackling noise and improving local soundscape quality.

The project is working to provide opportunities to demonstrate how an applied soundscape approach might contribute to public engagement and enhancing social cohesion in urban spaces.

The paper will report on further work to develop the use of applied soundscape interventions in clubbing districts within English cities designated as police high stress areas due to night noise and anti-social behaviour.

Thu 16:20 Kurhaus Czerny hall Soundscaping: Outreaching

Using body language indicators for assessing the effects of soundscape quality on individuals

Harry Witchel[a] and Lisa Lavia[b]
[a]*Brighton and Sussex Medical School (UK);* [b]*Noise Abatement Society, Hove (UK)*

Building upon "Sounding Brighton", a collaborative project exploring practical approaches towards better soundscapes focusing on soundscape issues related to health, quality of life and restorative functions of the environment, a further stage of the project provides the opportunity to raise awareness and promote communication on soundscapes among the general public, stakeholders and those involved in policy, including encouraging exploration of new ways of listening in local soundscapes, and new ways of tackling noise and improving local soundscape quality.

The project is working to provide opportunities to demonstrate how an applied soundscape approach might, alongside tackling conventional noise problems, contribute to local planning and environmental improvement as part of a citywide engagement process in areas including urban green spaces, the built environment and traffic noise. So far, a soundscape map of the city has been developed; and a public outreach exhibition and conferences have taken place.

The paper will report on further work to develop a better understanding of the effects of soundscapes on community well being, social cohesion and the physical and mental health of individuals through the use of body language indicators.

Thu 16:40 Kurhaus Czerny hall Soundscaping: Outreaching

Developing an acoustic pleasantness rating for household appliances and small machines to improve soundscape quality in the built environment

Gloria Elliott and Lisa Lavia
Noise Abatement Society, Hove (UK)

At present, the only way in which the sounds made by household appliances and small machines (”devices” hereafter) are objectively assessed is through the measurement of sound power (or related parameters). While such measurements (if A-weighted) are useful, they cannot capture the user reaction to the device. Ideally, what a prospective purchaser or user of a device wants to know is not what its sound power is, but how annoying and/or pleasant that device sounds.

There are a number of objective, measurable parameters which have been defined to capture acoustic features of machines which are selected to be well-correlated with certain subjective qualities generally referred to as Sound Qualities.

The paper will explore a robust system of ranking different models from each of a set of devices. The rankings will express the relative ”acoustic pleasantness” of the models to determine which SQPs (extant or new) correlate best with acoustic pleasantness.

Session ”50 years of A-weighting, where from, where to?”

Thu 17:00 Kurhaus Czerny hall 50 years of A-weighting

The History and Future of A-weighting

Beat W. Hohmann
Suva Luzern, Bereich Physik

A-weighting is the standard weighting curve applied to acoustic and audio measurements, designed to reflect the response of the human ear. The concept appeared already in 1936 in an ASA tentative standard. Since the first IEC publication on sound level meters in 1961 it remained unchanged. More than 50 years later it may be time to reassess A-weighting remembering the following facts: Ï A-weighting was a simplification due to technical limitations at the time of introduction; Ï A-weighting was based on equal loudness contours but is used also for assessment of hearing damage risk where a simulation of the transfer function from the sound field to the basilar membrane would be more appropriate; Ï A-weighting may be wrong by about 15 dB at 3 kHz as it neglects the ear canal resonance - but this is exactly the frequency domain where hearing is most sensitive and most vulnerable; Ï A-weighting is often criticized and blamed for bad correlation with effects on hearing (also in many discussions at DAGA conferences), but no alternative solution is given.

This paper will discuss the background, applications, shortcomings and possible improvements of A-weighting. With all the knowledge we have today, how should A-weighting look like?

Thu 17:20 Kurhaus Czerny hall 50 years of A-weighting

Check of addition rules for spectral parts of sound in hearing experiments with common non-e-technic sounds

Reiner Grigo
grigo ingenieure, Pforzheim

The Zwicker-method of loudness scaling is seen as the more precise method compared to A-level-decibels. The Zwicker method adds in a linear way the parts of areas under hearing appropriate weighting curves - instead of adding the energies of spectral parts in a logarithmic procedure as usual. The Zwicker - Method is proved by hearing experiments which show up to fifteen dB growing loudness level when broadering a noise spectrum from small to wide with a constant sound pressure.
The hearing experiments are done with white noise of equal level in each frequency - such noise in nature or technic does never or very seldom occur. Therefor the usefulness of the linear adding ZWICKER method compared to energetic addition shall be checked with real noise spectra in hearing experiments.

Session "Environmental noise: Noise mapping"

Thu 8:40 Kurhaus Lentner hall Environmental noise: Mapping

Strategic Noise Maps for the City of Vienna - Problems and required improvements

Werner Talasch
Österr. Arbeitsring f. Lärmbekämpfung

The Strategic Noise Maps for the Agglomeration Vienna had shown, that there are a number of problems arrising from the Environmental Noise directive of the European Union. The directive requires the Mapping for all roads in an agglomeration. As it is not possible to give exact figures for the traffic flow in small roads, it is only possible to use categorisized figures for the traffic flow an receive so incorrect Noise Maps. Also do we have no information of the traffic speed. A Revision of the environmental noise directive should give advice how this has to be handled.

Thu 9:00 Kurhaus Lentner hall Environmental noise: Mapping

2002/49/EC Railway Noise Maps Update: Approach, Validation, Improvements

Andrea Cerniglia[a], Antonella Volta[b], Morena Giani[b], Paolo Pezzoli[c] and Mariagiovanna Lenti[a]

[a] *ACCON Italia Srl.;* [b] *Ferrovie Nord Milano;* [c] *Indapro, Pedrengo*

Achieving appropriate noise maps is not possible without some preliminary considerations related to the quality of input data: for that reason, prior to entering the data into the model, it is necessary to perform a precise data acquisition and validation (and manipulation) in order to receive correct output information. This paper will describe a new approach in terms of quality improvement by updating the noise maps of an important railway infrastructure. Furthermore, comparative results from noise monitoring along the investigated railways will be discussed with strong focus on validation possibilities and quality assurance of the calculated noise maps. The procedure and the subject matter for participation of the public will be also presented.

Thu 9:20 Kurhaus Lentner hall Environmental noise: Mapping

Methods to identify hotspots

Kerstin Giering

HS Trier, Umwelt-Campus Birkenfeld

Im Rahmen eines für das Umweltbundesamt durchgeführten Forschungsvorhabens wurde ein Vorschlag für ein Verfahren zur Identifizierung von Lärmhotspots im Rahmen der Lärmaktionsplanung entwickelt. Dazu wurde zunächst eine detaillierte Literaturanalyse durchgeführt. Hierbei wurden zum einen die in der 1. Stufe aufgestellten Lärmaktionspläne deutscher Kommunen, insbesondere Ballungsräume, sowie europäische Ballungsräume ausgewertet. Zum anderen wurde die einschlägige nationale und internationale Literatur analysiert. Die in der Literatur gefundenen Methoden werden vorgestellt. Die gefundenen Hotspot-Identifizierungsverfahren wurden für ein Testgebiet rechnerisch umgesetzt und grafisch dargestellt und bewertet. Es zeigte sich, dass die Identifizierung von Hotspots deutlich stärker von grafischen Parametern (bspw. Skalierung) als von der zugrundeliegenden Methode abhängt. Daraus abgeleitet wurde ein Vorschlag für eine zweistufige Herangehensweise bei der Identifizierung von Hotspots entwickelt: 1. Die Berechnung eines Hotspotmaßes auf der Basis der Daten der Lärmkartierung und 2. eine ergänzende qualitative Bewertung der Hotspots mit Hilfe eines Indikatorensystems.

Thu 9:40 Kurhaus Lentner hall Environmental noise: Mapping

Embedded Parks in Quiet Zones

Markus Petz and Agnes Fabian
ACCON Italia Srl.

One of the targets of the just finalized European 7th Framework project "CityHush Acoustically Green Road Vehicles and City Areas" was to support city administrations to eliminate harmful effects of noise exposure and decrease levels of transport noise, especially in urban areas. Step change solutions were proposed to reduce noise in the city environment. The project dealt with developing suitable problem identification and evaluation tools and with designing and developing solutions for hot spots, which show high correlation with annoyance and complaints. A particular attention had been paying to investigate boundary conditions and maximum noise gains for Quiet Zones and especially for Parks Embedded in Quiet Zones where only quiet low emission vehicles are tolerated. Within the CityHush project existing noise levels in different parks of European cities were determined and the influence of local parameters, such as size of a Quiet Zones, was investigated. Moreover a variation of congestion charges and traffic restrictions in dependence of different percentages of low noise vehicle ownerships inside a Q-zone and outside (countrywide) were evaluated on different noise and annoyance criteria. Possibilities, limits and knock-on effects to reduce noise in the city environment will be shown.

Thu 10:00 Kurhaus Lentner hall Environmental noise: Mapping

Combined Network of Biodiversity and Acoustic Value in Greece

Nefta-Eleftheria Votsi[a], Antonios Mazaris[a], Athanasios Kallimanis[b] and John Pantis[a]
[a] *Aristotle University of Thessaloniki;* [b] *University of Ioannina (GR)*

Biodiversity loss imposes the inclusion of ecosystem services in conservation planning to highlight the benefits of sustainable management, augment revenues and emerge the internationality of conservation. Our goal was to present a multi-functioning tool providing an added value, the Quietness, in the ecosystem services supplied by the NATURA 2000 protected areas. We identified Quiet Areas (QAs) that overlay in NATURA 2000 sites. We, then, focused on priority habitat types that are included in QA network to investigate if high biodiversity areas coincide with QAs. We also superimposed an altitudinal map to estimate the contribution of the combined network to ecosystem representation. The last approach entailed the spatial distribution of the combined network. 71.76% of NATURA 2000 network overlaps with QAs. Forest and semi-natural areas prevail in the combined network. 46.20% of the existing priority habitat types form the combined network as well. QA and NATURA 2000 network follow the similar altitudinal pattern. In the combined network, the higher values of clustering are found in high biodiversity areas. The proposed combined network could preserve natural soundscapes and protect people from harmful noise effects, promise added revenues by the means of ecosystem services and fulfill Greece' obligations to the Noise Directive (2002/49/EC).

Thu 10:20 Kurhaus Lentner hall Environmental noise: Mapping

Modeling L_(C-A) Indicator for Noise Quality Evaluation

Elena Ascari[a], Mauro Cerchiai[b] and Gaetano Licitra[c]
[a] *CNR IDASC, Roma;* [b] *ARPAT - Area Vasta Costa - Settore Agenti Fisici;* [c] *CNR-IPCF, Pisa*

Recently, reported annoyance and soundscape approach have grown their importance in noise mitigation planning to suggest solutions for polluted sites. In this context, low frequency noise is known to cause a significant part of complainers due to transportation noise, so it is important to achieve not only energy reduction but also a ”pleasant spectrum” after mitigation. To evaluate influence of low frequencies, many studies suggested to calculate difference between C-weighted and A-weighted levels, henceforth called L_{C-A}, which reflects into an increased perception of A-level. This study intends to verify, using prediction models, values of L_{C-A} in different mitigated scenarios: in a previous study authors have already tested the mitigation site with available models, this paper will point out results produced with NMPB 2008 and NORD 2000, not previously used. Moreover, a large scale simulation of this indicator will be provided and compared with measurements in different urban areas that have been surveyed (G.Licitra et al. ”Tranquillity analysis by soundwalks in Pisa’s green areas”, Acoustics 2012 Hong Kong) to evaluate how low frequency noise influence soundscape rating.

Thu 10:40 Kurhaus Lentner hall Environmental noise: Mapping

Quality-Assured Noise Mapping - Part I: Cartography

Frank Hammelmann[a], Karl-Wilhelm Hirsch[a] and Berthold Vogelsang[b]
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Noise maps are a popular tool to document and present noise loads, noise indices and other information related to the assessment of noise situations. If such data are shown as layers together with geo-referenced topographical layers, all layers (1) need to be referenced to the coordinate system of the resulting map and (2) must have the same resolution. Part I discusses the uncertainties that follow from adapt these different coordinate systems. Algorithms to evaluate noise indices must consider distances and angles between sources, receivers and so forth. They rely on the geometry given in metric, right-angled coordinate-systems. In this ëplan’ of the situation everything geometrical is clear. ëMaps’ are meant to indicate any projection of the earth surface to a plane. In principle, such maps cannot offer the ësimple’ coordinate system of a plan. Map coordinate-systems never are at the same time isometric and isogonic. Nevertheless, the bearing for any point is clear. Bringing together the plan’s and the map’s data in a quality-assured ways to a noise map is a challenge if it comes to compile large-scale and local noise from plans. Part I give guidance on how to come up with quality-assured maps.

Thu 11:00 Kurhaus Lentner hall Environmental noise: Mapping

Improvement of noise analysis by involving a geographic information system

Micha Köpfli
LCC Consulting AG Software Engineering, Zürich

Computing noise exposure and deriving appropriate noise abatement measures is a multistep process.
The effectiveness of a measure typically is rated based on the resulting immissions. However, for a proper assessment detailed information about affected persons and objects should be taken into account.
The linking of the calculated immission data with geocoded information as demographic data or information on land use and/or building permits allows specific statements about health effects or loss in value of real estates.
A geographic information system (GIS) allows to fulfill that crucial requirement - and more. It contains a full set of functionality to prepare, homogenize, validate, visualize and evaluate the necessary data.
By integrating noise calculations in a geographic information system noise analysis is improvement significantly.

Thu 11:20 Kurhaus Lentner hall Environmental noise: Mapping

Feasibility of automatic noise source recognition in collaborative wireless sensor networks

Xavier Valero[a], Luca Nencini[b], Francesc Alías[a] and Bruna Vinci[b]
[a] *La Salle - Universitat Ramon Llull, Barcelona;* [b] *Dustlab, nonprofit organization, Pisa*

Wireless sensor networks are composed of multiple distributed sensors intended to monitor physical parameters as for instance, noise. In this context, SENSEable- Pisa project is a crowdsourcing-based system, which promotes citizens' participation in noise policy as requested in European directive 2002/49/CE. The system uses low cost wireless noise sensors selflessly hosted by Pisa citizens, which may require the installation of a measuring system at their apartment, with the aim of sharing the measured noise values in a virtual community. Up to date, noise sensor networks only collect basic information, which mainly consists of the noise signal levels. As a further step, in this work, we attempt to incorporate new system functionalities to provide additional information about the noise signals. Specifically, we aim at automatically recognising the origin of the recorded noise signal (i.e., road traffic, aircraft, railway noise, etc.) by making use of advanced audio signal processing techniques and artificial intelligence algorithms. Preliminary results employing data collected from several actual nodes of the SENSEable-Pisa sensor network are described. Based on these results, the feasibility of a future real-time application is discussed.

Thu 11:40 Kurhaus Lentner hall Environmental noise: Mapping

Influence of vertical temperature gradients on outdoor sound propagation in a narrow valley

Filippo Berlier, Michel Vuillermoz, Marco Cappio Borlino, Daniele Crea, Christian Tartin and Christian Tibone
ARPA VALLE D'AOSTA

The aim of this work is to understand the correlation between the propagation of environmental noise and vertical temperature gradients. The study is based on empirical data collected in Aosta Valley (IT) between 2006 and 2012. In this area thermal inversion occurs frequently, this phenomenon produces an increase on noise levels due to downward refraction of acoustical waves. First a method to characterize temperature profiles was developed following standard methods and equations. Temperature data have been collected with 10 thermometers on the side of the valley to build 1000 meters profiles. Then noise levels collected in 6 different points were analyzed to understand the correlation with various temperature profiles. An important part of the work was the choice of the different conditions frame (time duration, weather, season...). Analysis show a significant influence of the meteorological conditions on noise levels at different points of observation. This influence is more important at the bottom of the valley and it produces, sometimes, an increase of the noise levels: especially during the night, levels increasing is often perceptible and it produces a growing on disturb on population.

Session "Environmental noise: Action planning"

Thu 15:00 Kurhaus Lentner hall Env. noise: Action planning

Noise action planning in Vienna

Wolfgang Khutter
Wiener Umweltschutzabteilung - MA22

In Austria, the European directive relating to the assessment and management of environmental noise has been incorporated into national legislation ("Umgebungslärmschutzgesetz"). In Vienna the directive has been implemented in the Viennese regional law ("Wiener Umgebungslärmschutzverordung"). Furthermore, public participation and citizen participation relating the drawing up of strategic noise maps in 2012 as well as the development of subsequent action plans have been set within the Government agreement of the two ruling parties in 2010. The Municipal Department 22 - Environmental Department in Vienna is responsible for the implementation of the noise action plan. Together with the noise action planning an online tool for noise information (Lärm Online Informations System - LOIS) will be updated and expanded. In the future proactive information and direct dialogue with the population regarding noise reduction will be strengthened. LOIS will start positive approaches regarding participative noise reduction starting in 2013, both on local hot spots as well as the whole Vienna city

boundaries. As a first step, a dialogue process took place with district administrations and with all relevant specialized municipal departments concerned. Following this, districts will be addressed where planning and implementation of specific activities for short term noise reduction can be realised.

Thu 15:20 Kurhaus Lentner hall Env. noise: Action planning

Implementation of Noise Action Plans in Berlin

Dorothea Salz, Bernd Lehming and Horst Diekmann
Senate Dep. Urban Development and Environment, Berlin

Berlin, like many agglomerations in Europe, suffers from high noise pollution, in particular from road traffic. Moreover, Berlin has a long tram network. In particular during night time a lot of people are affected by rail traffic noise. So, the need for action is huge and likewise the playing field for application of new techniques and approaches.
Berlin declared 70 dB(A) at day and 60 dB(A) at night as the prior target (to avoid health risk) and 65 dB(A) at day and 55 dB(A) at night within health provision as targets in the noise action plan. By setting out a wide spectrum of measures the plan points to many different actions. At the same time noise action planning has sometimes reached it's limits because of it's complexity and of the large number of stakeholders with many conflicting goals and interests. The Noise Action Plan is to be understood as an integral part of many urban plans as land use plans and urban and traffic planning, especially the Municipal Traffic Master Plan.
The current implementation of the noise action plan of 2008, results of the currently conducted public participation and the development of the new noise action plan will be presented.

Thu 15:40 Kurhaus Lentner hall Env. noise: Action planning

Recommendations for drawing up of noise action plans in small and medium sized municipalities

Joachim Richard
Planungsbüro Richter-Richard, Aachen

Recommendations for drawing up noise action plans in small and medium sized municipalities Dipl.-Ing. Jochen Richard, Planungsbuero Richter-Richard, Aachen (D)
In the second phase of the noise abatement planning according to the EU-Environmental Noise Di-rective (2002/49/EC) beyond the agglomerations all major roads with more than three million vehi-cles passages per year and major railroad lines by more than 30,000 train passages per year and great airports with more than 50,000 aircraft movements per year are to be taken into considera-tion. Therefore, with the second phase increases in small and medium sized municipalities the ne-cessity to issue a noise action plan for the first time. The non-agglomerations of the first phase must evaluate and update their measures and has to examine additional roads.
Therefore, in particular for the small and medium sized municipalities recommendations are espe-cially valuable to an effectual procedure, to the

effect of single measures and to effective measure combinations. Subjects would be, for example: Topical experiences with the effect from noise re-duction measures, interplay between road engineering/ road traffic act measures and town plan-ning/ building-related measures and discovery of quiet areas in open country.
Indication: The lecture will be held in German.

Thu 16:00 Kurhaus Lentner hall Env. noise: Action planning

Current implementation and outlook of road traffic noise abatement in Switzerland

Irene Schlachter
Fed. office for the environment, Noise and NIR division, Bern

The aim of the Swiss environmental protection act is to protect people from harmful or disturbing noise. Also it states that early preventive measures must be taken in order to limit effects that could become harmful or a nuisance. The Swiss Federal Council concretized these regulations in 1987 in the Swiss noise abatement ordinance. The strategy of implementation, as well as enforcement will be explained with a short overview of the fundamentals of Swiss road traffic noise abatement. An analysis of the different categories of measures taken so far serves to point out the strengths and the weaknesses of current road traffic noise abatement in Switzerland. It serves as a starting point to implement broader strategies such as the intensified use of potential noise reduction measures directly at the source. Important elements of measures taken by the authority are presented.

Thu 16:20 Kurhaus Lentner hall Env. noise: Action planning

European Database of Noise Reducing Devices

Marco Conter, Martin Czuka, Simon Breuss and Manfred Haider
AIT - Austrian Institute of Technology

The European Noise Reducing Devices market offers many already approved products, while many new ones are appearing. However, even if the European product standard EN 14388 is published since 2005, no comprehensive database of the NRD acoustic performances does exist yet. In the frame of the European project QUIESST (2009- 2012), Work Package 4 deals with the performance evaluation of Noise Reducing Devices investigating the relationship between laboratory and in-situ methods. Having the clear scope to help manufacturers, infrastructure administrations, research centres and engineers to have more detailed information on the correlation between those methods and to win a better overview of the different products present on the market main objective of this work package was the creation of a comprehensive database for the noise barriers present currently in Europe. The Database provides the different stakeholders with data on the acoustic performance of European NRD and with information on the practical use of those data. The paper summarises the main findings of work package 4, describing the use of the database developed within the QUIESST project.

Thu 16:40 Kurhaus Lentner hall Env. noise: Action planning

The Matter of Environmental Noise Management Models

Zanda Krūkle[a] and Rūta Bendere[b]
[a] *University of Latvia, Riga;* [b] *Institute of Physical Energetics, Riga (LV)*

Environmental noise management policies which aim to reduce noise-related health issues have became an important part of current pollution management strategies at different governance levels. Recent environmental noise management development, especially in newly developed countries, stresses the need for research in these areas and ensuring that a proper weight is given to both the practical and theoretical aspects of noise management. One area with insufficient research is the environmental noise models which conceptually describe the noise management system in countries. Therefore this study is devoted to the analysis of the existing theories and environmental management models. The research includes the literature studies and investigations on noise management models applied in Europe. European countries are chosen as the focus of this article due to the common requirements for the agglomerations larger than 100 000 inhabitants and a lack of regulations for noise issues in smaller municipalities. The main outcome of the research is a review of the information regarding to the environmental noise models used in Europe. Key words: Europe, environmental management, models, noise

Thu 17:00 Kurhaus Lentner hall Env. noise: Action planning

Economic Analyses of Noise Abatement Measures

Ronny Klaeboe and Knut Veisten
Institute of Transport Economics, Oslo

Cost-benefit analyses convert different streams of monetary values to a common format. This enables us to compare different noise abatement and soundscape improvement measures according to their associated investments and maintenance costs. These costs are compared against the accumulated benefits derived over time from the measure.

Analyses of ”green” measures undertaken as part of the 7th. Framework programme HOSANNA indicate that non-acoustic benefits can have an important effect on the economic viability of noise abatement measures.

Expanding the scope of analysis to not only consider acoustic benefits, but also take aesthetic and amenity values into account, transforms acoustically motivated measures failing to satisfy conventional criteria for economic viability into measures that not only are cost efficient but robustly so. We also discuss how cost benefit analyses may be used to supplement purely acoustical analyses of different noise abatement configurations/treatments.

Thu 17:20 Kurhaus Lentner hall Env. noise: Action planning

Subjective evaluation and psychoacoustic analysis of the sound quality of low-noise asphalt on motorways in North-Rhine Westphalia

Michaela Kärst, Jochen Steffens and Sabrina Skoda
University of Applied Sciences Düsseldorf

Road traffic noise has become a societal problem in recent years due to a steadily increasing traffic volume. In order to reduce noise emissions, low-noise porous asphalt layers are installed more and more often. This contribution deals with subjective sound quality evaluation of different road surfaces. First immission measurements and dummy head recordings of various asphalt surfaces were performed on selected motorway sections in North-Rhine Westphalia. Subsequently representative noise scenarios from these recordings were assessed by test participants in a listening study under laboratory conditions. The influence of moderator variables, like traffic composition, speed limit and the distance between sound source and listener, on the sound evaluation was investigated as well. In order to obtain ecologically valid results the assessments were also carried out with regard to everyday contexts such as communication and sleep. The results revealed a significant reduction of perceived annoyance concerning the low-noise asphalts on the one hand. On the other hand the influence of the moderator variables could be confirmed. A regression analysis showed that objective measures like the psychoacoustic parameters sharpness and tonality as well as the A-weighted sound pressure level can explain a great amount of variance in the subjective evaluation data.

Session "Building acoustics: General 2"

Thu 8:40 Puccini Theatre Building acoustics: General 2

In the field measurement UNI EN ISO 140 application for large volume open-space rooms

Fabio Angelini[a], Andrea Belingheri[a], Chiara Scrosati[b], Davide Vecchiato[a] and Giovanni Zambon[a]
[a] *Università degli Studi Milano Bicocca;* [b] *Istituto per le Tecnologie della Costruzione, ITC - CNR*

This work has the aim of evaluate the applicability of set of UNI EN ISO 140 standards about in the field measurement methodologies of building acoustic insulation, in case of large volume rooms. The object of the study is a modern conception tertiary sector building (with advanced engineering and architectural solutions), located in the urban area of Milano. During the in the field measurement of passive building acoustic requirements the issue of large open-space measurements came out; this case is not covered explicitly by the UNI EN ISO 140 standards. In this regard, from some hints in the 140-14 standard it was possible to identify, through the analysis of the distribution of sound levels within the open-space, smaller spaces to be used as a minimum unit to survey (said "virtual volumes"). The measures, performed on all seven floors of the building, focused on the airborne insulation between different units and on the impact sound insulation of floors. The collected data, statistically processed, allowed to draw some

considerations concerning the most appropriate operating methodology for performing the measurements on these types of spaces.

Thu 9:00 Puccini Theatre Building acoustics: General 2

Revision of ISO 717: Future Single-Number Quantities for Sound Insulation in Buildings

Werner Scholl[a], Judith Lang[b] and Volker Wittstock[a]
[a] *Physikalisch-Technische Bundesanstalt;* [b] *Technologisches Gewerbemuseum Wien*

The standard ISO 717 is the main link between measured or predicted sound insulation spectra in buildings and legal requirements. It provides the procedures to evaluate representative single-number values from given frequency spectra of sound insulation. At an ISO meeting a few years ago, the wish came up to reduce the large variety of selectable quantities. Thus, a simplified and more straightforward system of single-number quantities was proposed which is now discussed in the corresponding standardisation working group of ISO. The main features of the proposal are the mandatory inclusion of frequencies below 100 Hz, the deletion of the reference-curve shifting system (as used for Rw e.g.), the expression of impact sound insulation in terms of a sound reduction index as well, and a new sound reduction index especially for speech intelligibility. This presentation will report the state of discussion and highlight some aspects like uncertainty of low frequencies, influence of the chosen reference sound source spectra, or how to adjust current sound insulation requirements to the new quantities. The new concept of single-number description will appear as a separate standard ISO 16717 to allow a smooth transition from the existing ISO 717 system to the new one.

Thu 9:20 Puccini Theatre Building acoustics: General 2

Comparison Between Single Number Descriptors of Sound Reduction

Nicola Granzotto and Antonino Di Bella
University of Padova, Department of Industrial Engineering

Single number descriptors of acoustic performances of building elements are very useful both for classify different construction systems and requirements in buildings. On the other hand, rating methods of ISO 717-1 standard have many limitations about frequency range and application by means of spectrum adaptation terms. Currently an new standard (ISO 16717-1) is under development and represents a different approach to the concept of weighted index. In this work the main differences between present and coming standard are pointed out and possible correlations of the indexes to construction typologies were considered, starting from laboratory measured data.

Thu 9:40 Puccini Theatre Building acoustics: General 2

Considerations On Low Frequencies Results Of In Situ Sound Insulation Measurements

Renzo Cremonini and Patrizio Fausti
Università di Ferrara

The aim of this work is to assess the main problems related to field measurements at low frequencies (50 - 80 Hz), currently scheduled in draft standards and proposed by COST Action TU0901. The investigation focuses on the statistical analysis of previous data, relating to field measurements of sound insulation carried out over a ten year period. The data contain results in the extended frequency range 50 - 5000 Hz, but a specific procedure for the measurements at low frequency was not used. The three main parameters (the levels in the source room, the levels in the receiving room and the reverberation times) were studied, in terms of variability at low frequency. The results showed a greater uncertainty for measurement levels in the source and receiving room with respect to measures of reverberation time, at frequencies between 50 and 100 Hz. In addition, the study assesses the effect of loudspeaker power up to 50 Hz, the presence of background noise at low frequencies, the rooms shape and dimensions, the presence of a non-diffuse sound field inside the rooms.

Thu 10:00 Puccini Theatre Building acoustics: General 2

Typical heavyweight walls performance: variability and density function distribution of airborne sound insulation single number quantities.

Carolina Rodrigues A. Monteiro[a], Cristian Mondaca[a], María Machimbarrena[a] and Sean Smith[b]
[a] *Applied Physics Dep., Universidad de Valladolid (E);* [b] *Inst. for Sustainable Construction, Napier University, Edinburgh*

This paper performs an investigative analysis of the acoustic behavior of different heavy walls, based on ”in situ” airborne sound insulation measurements. The objective is to evaluate the performance variability of hundreds of similar solutions. The input data correspond to an extensive database of airborne sound insulation tests, collected over five years, for heavy walls commonly used in the UK. Besides, the density function of different airborne sound insulation descriptors is studied using non parametric methods and it is revealed that slightly non normal distributions are found. This can be relevant when estimating constructions performance and uncertainty by simulation methods.

Thu 10:20 Puccini Theatre Building acoustics: General 2

Subjective Evaluation of Airborne Sound Insulation below 100 Hz

Reinhard Neubauer and Jian Kang
University of Sheffield (UK)

Based on the demand to have a better sound insulation in subjective regards, it is necessary to have an extended frequency range, namely from 50 Hz to 5000 Hz. While the standard procedures to describe sound insulation, such as in ISO 717-1, the weighting curves do not consider frequencies below 100 Hz, in the standard there is a spectral adaptation term which is used to cover the frequency range from 50 Hz up to 5000 Hz, resulting in a combined single value like Rw + C50-5000. In order to show how the airborne sound insulation is affected by the extended frequency range down to 50 Hz, in this study, some results are presented comparing sound insulation with and without the extended frequency range in terms of psychoacoustic values. A number of psychoacoustic descriptors have been used to describe sound events, including Loudness, Sharpness, Roughness and Fluctuation Strength. Various damping curves featuring airborne sound insulation have been examined.

Thu 10:40 Puccini Theatre Building acoustics: General 2

Results of the application in Spain of the questionnaire proposed by "COST Action TU0901/ WG2"

Stefano Pedersoli and María Machimbarrena
Universidad de Valladolid (E)

This paper show the results of the application in Spain of the questionnaire proposed by "COST Action TU0901/ WG2". The purpose was to correlate noise annoyance with expected building performance (estimated) and measured sound insulation data. In order to adapt to the specific survey of the study, some modifications were done to the prototype proposed by the COST. The modifications only adapted the questions to Spanish people and some of them were eliminated because they were not applicable in the study area. In order to study the correlation of sound insulation in buildings with the discomfort perceived by users, the sound insulation was measure in situ (both airborne noise as noise impacts) on adjacent properties. Sound insulation has also been calculated using CTE (technical code) of Ministry of Housing of Spain.

Session "Experience with the ISO 10052"

Thu 11:00 Puccini Theatre ISO 10052

Experiments for Searching the Optimal Positions to Determine Reverberation and Level in Rooms

Henning Alphei and Max Koch
Akustikbüro Göttingen

Es werden Versuche beschrieben, die optimalen Mirkrofonpositionen für die Messung der Nachhallzeiten und der Pegel in typischen Wohnräumen zu finden. Dazu wurden Messungen in einem engen Raster in verschieden großen Räumen vorgenommen. Es wurden Pegel und Nachhallzeit in Terzen bestimmt und die Abweichungen der Messorte untereinander bestimmt. Es wurde versucht, die Orte und die Anzahl der Messpunkte zu ermitteln an denen die Abweichung zum Mittelwert möglichst gering waren. Dazu wurden verschiedene Auswahlkriterien für die räumliche "Abtastung" untersucht und verglichen.
Die Untersuchungsergebnisse werden vorgestellt und die daraus ableitbaren Auswirkungen auf die Wahl diskreter Messorte in Empfangräumen bei der Bestimmung der Pegel und der Nachhallzeitkorrektur diskutiert.

Thu 11:20 Puccini Theatre ISO 10052

Comparison Between Field Measurements Methods of Acoustic Performances of Buildings

Chiara Martina Pontarollo and Antonino Di Bella
University of Padova, Department of Industrial Engineering

The evaluation of acoustic performances of buildings and building elements is very important not only for legal requirements fulfilling, but also for assessment of overall quality or to investigate possible ways of improvement. In this work different experiences of field measurements are showed, with a focus on the comparison between technical method described in ISO 140 standards for field measurements and survey method of ISO 10052, with the aim of evaluate the effectiveness of different methods for the evaluation of airborne sound insulation, impact noise and equipment noise, taking in account several aspects as measurements set-up and repeteability.

Thu 11:40 Puccini Theatre ISO 10052

Interlaboratory Test for Field Evaluation of Noise from Equipment in Residential Buildings

Antonino Di Bella, Chiara Martina Pontarollo, Nicola Granzotto and Francesca Remigi

University of Padova, Department of Industrial Engineering

In this work the results of an interlaboratory test on field measurements of noise induced from equipments are presented. The aim of this test is to compare different measurement methods on the same site and to point out precision values for field measurements carried out by several operators and instrumental chains. Measurements were performed in a multi-storey residential building using the methods described both in ISO 16032 and ISO 10052 standard, including a comparison with the Italian standard UNI 11367 about acoustic classification of residential units. Interlaboratory test involved groups of operators from university institutions, staff of companies operating in the field of building acoustics and consultants.

Session "Noise protection at home"

Thu 15:00 Puccini Theatre Noise protection at home

Noise protection standard at home for timber construction

Roland Kurz

Kurz und Fischer GmbH, Winnenden

Legal disputes over acoustic protection at home have increased significantly in the last few years. In the building practice there is uncertainty about that, because the references to the noise protection at home after DIN 4100 or VDI 4100 are usually not considered during the design and building construction phase. A noise protection standard in timber construction and common constructions were determined for houses and apartments through surveys carried out with manufacturers and firms specialized on timber construction. The results were determined and catalogued in a multi-staged acoustic protection concept with the aim to bring more transparency into the field of noise protection for non-experts.

Thu 15:20 Puccini Theatre Noise protection at home

Typological Analysis and Statistical Evaluation of Laboratory Measurements of Sound Reduction of Building Elements

Cora Pavarin, Nicola Granzotto and Antonino Di Bella
University of Padova, Department of Industrial Engineering

The comparison of noise reduction performance of building elements and systems, determined by laboratory tests, provides useful information for the acoustic designing. In many cases representative values of performances can be find by typological analysis of building element characteristics. In this work a statistical survey based on typological classification was performed and an evaluation of the average performances of building elements is presented. The available data were divided into groups, differentiated by type, components and materials. For each group average, mode and median of single number indexes are presented and the statistical distribution of results is analysed. Acoustical data derive from laboratory measurements performed by the Acoustic Laboratory (LabAcus) of the Department of Industrial Engineering at the University of Padova.

Thu 15:40 Puccini Theatre Noise protection at home

Sound insulation of internal pedestrian doors

Bernd Sass
ift Rosenheim GmbH

Since the implementation oh the german standard DIN 4109:1989 the sound insulation of internal pedestrian doors is relevant for planning of residential and office buildings, hotels and other buildings in Germany. Especially for doors insufficient sound insulation is object of customer complaint in many cases.

As tool for planning of the right requirements in field, a couple of standards for planning and design of internal doors exists. Also the right labelling for CE-marking and verification in field is an important topic for manufacturers. During the last years the standards for sound insulation of internal pedestrian doorsets has changed. Additional to the work on DIN 4109, which is still in process, following standards can be mentioned: VDI 3728, the product standard prEN 14351-2 and the standards for measurement and weighting EN ISO 10140 and EN ISO 717.

Within this article the relevant changes with relevange fort he sound insulation of doors will be presented.

Thu 16:00 Puccini Theatre Noise protection at home

Sound Transmission between Rooms - Effect of Air Inlets and Outlets
Karlheinz Bay and Philip Leistner
Fraunhofer-Institut für Bauphysik, Stuttgart
For the correct determination of sound insulation between rooms all acoustic transfer paths have to be taken into account. Thus, it is also necessary to consider the sound transfer via ventilation and air conditioning systems, since this can substantially reduce the sound reduction effect of the partition wall, for example due to a direct duct connection. This transfer path is discussed by using a computational model and measurements. The modelling of the acoustic behaviour was carried out based on the transfer matrix method for a one dimensional wave guide. Firstly, the air outlet in the receiving room and the transmission from the duct into the room is considered. A general setup of the model is shown and compared to measured data. Secondly, the model is extended by the transfer path of the duct system including the air inlet. For example, the sound insulation between two rooms connected by a pipe with open ends is examined. Apart from this, the transfer path from the room into the duct-system represents a point of particular interest: the transmission of the air inlet. Thirdly, the transmission paths were merged into the total sound transfer to predict the flanking transmission of a complete ventilation system.

Thu 16:20 Puccini Theatre Noise protection at home

Analisi del rumore prodotto dagli scarichi idrici negli edifici di civile abitazione (Analysis of noise by waste water in residential buildings)
Roberto Bianucci[a], Giovanni Bonansegna[b] and Gianpiero Majandi[c]
[a] *Studio Tecnico Bielettro;* [b] *Studio Tecnico Bonansegna, Empoli;* [c] *STUDIO MAJANDI, Bonemerse (CR)*
The noise produced by technological systems must not exceed the limits set by the DPCM 5/12/1997 of the 35 dB (A) LAmax with constant time slow. In the exhaust noises are generated in various points so that you can identify: noise from falling, noise impact, noise runoff. For the reduction of the emission level, we must distinguish between the various types of noise and the way in which these can be conveyed. In particular will be analyzed: - The method of proof of the European standard DIN EN 14366 ”Laboratory measurement of noise emitted by the exhaust system.” - The measured noise level inside the drain pipe. - The turbulence in the first horizontal portion and methods for noise reduction. - Noise in the vertical section. - Noise in the horizontal section.

Thu 16:40 Puccini Theatre Noise protection at home

In situ and laboratory measurement of service equipment decoupling in buildings with Swiss pendulous hammer

Victor Desarnaulds[a], Robert Beffa[b], Delphine Bard[c] and Hervé Lissek[d]
[a] *EcoAcoustique, Lausanne (CH);* [b] *Univ. of Applied Sciences Western Switzerland HES-SO, Geneva;* [c] *Division of Eng. Acoustics, Lund University (S);* [d] *Swiss Federal Institute of Lausanne*

The latest version of the Swiss standard for building acoustics (SIA181) introduced a new measurement method, based on a pendulous hammer for evaluating the decoupling performance of service equipment. This method was developed for assessing noise induced by the manipulation of service equipment in bathrooms and kitchens. In this study, we are investigating the relevance of such method for timber frame building where decoupling performances are particularly important. This study determines the advantages and the limitations of this methodology, which allows identifying the main propagation paths for equipment noise. A series of in-situ measurements has been performed to identify the best building constructions, service equipments configurations but also some workmanship errors. Laboratories investigations have been also conducted to understand and optimize the decoupling of two type service equipments systems.

Thu 17:00 Puccini Theatre Noise protection at home

Installation Walls made of Gypsum Blocks and Plasterboard

Andreas Ruff and Heinz-Martin Fischer
HFT Stuttgart

One of the most annoying noises in buildings is the installation noise caused by the excitation of sanitary equipment. To reduce the transmission of installation noise into adjacent rooms there are requirements in Germany for the construction of installation walls, where sanitary equipment is attached to. Such installation walls should have a sufficient high mass per unit area (m' = 220 kg/m^2). However, in contemporary building constructions lightweight installation walls made of solid gypsum blocks or plasterboard are often used instead of heavyweight walls. On the contrary to the heavyweight walls the lightweight solid gypsum walls are not connected rigidly to the adjacent building elements, they are decoupled by elastic interlayer. Within a research project the sound transmission of such lightweight gypsum walls is investigated for different sanitary equipment. For the analyses the decoupling and hence the reduction of the sound transmission of the solid gypsum walls is in the focus of attention. As a comparison a representative plasterboard installation wall is also investigated. In addition the applicability of the calculation model according the EN 12354-5 should be checked by the investigated transmission situations. The paper gives an overview about the results of the research project.

Thu 17:20 Puccini Theatre Noise protection at home

Integrated Vibro-Acoustical Design Optimization of Multi-storey Buildings

Andreas Rabold[a], Stefan Kollmannsberger[b] and Ernst Rank[b]
[a] *ift Rosenheim GmbH;* [b] *Chair for Computation in Engineering, TU München*

Timber buildings have been pioneering building constructions in terms of energy conservation and resource efficiency. Low-energy-consumption or so called passive-houses built of timber are known to combine an environmentally-friendly construction principle with high expectations on aesthetics and modern architecture. The number of multi-storey residential buildings erected in timber construction has been steadily increasing in the last few years, also in urban areas and centres. Compared to similar construction projects built in concrete the design of a multi-storey building in timber construction is more demanding and challenging to the architect and construction engineer. Reasons for this are tougher requirements on fire safety regulations in these buildings as well as the absence of sufficient realized examples and design tools for the proof of performance of vibration control and sound insulation. In a current project these design tools shall be further developed by using a combination of FEM and SEA for the proof of performance. The contribution presents after an overview of the project the first steps towards the application of the FEM-based computation of airborne and impact sound transmission, including flanking transmission.

Session "Recent advances on sound and vibration active control 2"

Thu 8:40 Hotel Terme room 1 Sound and vibration control 2

Development of Piezoelectric Inertial Actuators for the Reduction of Vibrations in a Car Body

Tobias Röglin, Torsten Bartel, Stefano Breda, Samuel Gaisbauer, Dirk Mayer and Jonathan Millitzer
Fraunhofer Inst. for Struct. Durability and System Reliability LBF

A great deal of vibrations caused by a car engine is transduced into the driver's cabin via the torque arm, which provides a connection between the engine and the car body. The torque arm prevents the rotational movement of the engine caused by the angular acceleration of the crank shaft. In the framework of the European research project Green City Car, inertial actuators based on piezoelectric ceramics are developed, aiming at the reduction of the transmitted vibrations. Thereby several conceptual solutions are evaluated and compared. The most promising designs are chosen, characterized and tested in a test rig. There the original torque arm is placed between a shaker and the car's original subframe, fixed on a span. The shaker simulates a controlled engine run-up. The inertial actuator is attached to the subframe nearby the torque arm. In combination with an adequate control strategy the performance of the inertial actuator in reducing vibrations induced into the car body is investigated. The final aim of this research is the integration of a suitable inertial actuator into a prototype of a next generation city car.

Thu 9:00 Hotel Terme room 1 Sound and vibration control 2

Application of active and semi-passive control strategies at a double glazing window

Oliver Heuss[a], Tim Bastian Klaus[a], Christian Thyes[b] and Jacqueline Rausch[c]

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Windows still are a weak point of facades regarding the acoustic transmission. The desire to further improve the low frequency behavior led to the development of different strategies to actively control the vibrations of windows in the last years. The coupled structural problem of vibrating plates and an isolating air gap in between demands different approaches for control. At the acoustic test-stand for plates and double glazing windows at the LOEWE-Zentrum AdRIA these techniques are being tested in a laboratory environment. By combining active vibration control and semi-passive techniques, together with newly developed sensors and actuators, the interdisciplinary project of different AdRIA partners shows up new concepts as well as picking up established ones, which will be optimized regarding a hybrid application. Printed strain gauges on the window are tested for adequacy in AVC control, passive and semi-passive Helmholtz Resonators influencing the air gap behavior are compared and dielectric elastomer actuators are developed. Furthermore a strategy for controlling sound power rather than sound pressure levels is developed. The recent advances of the project are being presented.

Thu 9:20 Hotel Terme room 1 Sound and vibration control 2

Global Active Control with the Help of local Noise Control Treatments in the Transmission Path - A Comparison

Uli Krause and Delf Sachau

Helmut-Schmidt-Univ. Hamburg, Mechatronik

A suitable positioning of loudspeakers and sensors is needed to achieve a global attenuation of a sound field in an enclosed interior. Is the main transmission path known for the technical scenario the noise can be blocked within that path with the help of a local active noise treatment, which controls the sound radiation and thus directly the noise at the source. This local approach is an efficient alternative to modal control concepts, which are hard to realize at higher frequencies due to the high modal density. A comparison of different local control concepts is done with the help of a numerical model of the sound transmission of propeller noise through the fuselage into a room, modeled as pure Neumann boundary condition. The dimensions of the room are comparable to an aircraft cabin.

Thu 9:40 Hotel Terme room 1 Sound and vibration control 2

Outlet Versus Interior Feed-Forward Active Noise Control for Ventilation Ducts

Jens Rohlfing and Paolo Gardonio
Università degli Studi di Udine

This paper presents theoretical and experimental studies on the microphones-loudspeakers configuration for duct feed-forward active noise control systems. Three configurations are investigated. First, a ëstandard' arrangement, where the reference microphone is placed upstream from the control loudspeakers, close to the primary source, and the error microphone is placed downstream from the control loudspeakers, close to the duct outlet. Second, a ëcompact duct' configuration, where both the reference and error microphones are moved close to the control loudspeakers to form a compact control system. Third, a ëcompact outlet' arrangement where the compact control arrangement is moved to the duct outlet. Problems with the compact configurations may arise from the shortened time advance of the reference signal and acoustic near field effects. The experimental studies are carried out on a laboratory duct setup, with a radial ventilator as primary noise source and four control loudspeakers. The system is driven by an adaptive filtered-x RLMS algorithm, implemented on a DSP board. It is shown that, if a sufficient sampling rate is used, all three control configurations produce considerable reductions in the radiated noise from the duct outlet, with significant advantages for the ëcompact' configurations which offer modular solutions simple to implement in practice.

Thu 10:00 Hotel Terme room 1 Sound and vibration control 2

Active Control of Counter Rotating Open Rotor Interior Noise

Thomas Haase, Malte Misol, Stephan Algermissen and Hans P. Monner
German Aerospace Center (DLR), Braunschweig

Future aircrafts have to meet the restrictive fuel consumption guidelines of the European Committee. Therefore lightweight materials like carbon fibre reinforced plastics (CFRP) and new engine concepts are investigated. Counter Rotating Open Rotors (CROR) are a very promising approach for a more efficient aircraft. But in combination with a CFRP fuselage the interior noise levels will be increased dramatically because of the high pressures on the fuselage and the low transmission loss of CFRP. In this work active concepts as a lightweight compliant solution will experimentally investigated to improve the acoustic comfort of future aircrafts. A typical aircraft sidewall panel is therefore realized in a sound transmission loss facility and will be controlled actively by a feedforward control system. The panel is excited by a typical multi tonal pressure field which is generated by a speaker array. This preliminary study shows that an active structural acoustic control system can effectively improve the acoustic comfort inside the cabin.

Thu 10:20 Hotel Terme room 1 Sound and vibration control 2

Sensitivity-Study of a Noise-Reduction System for Airplanes

Uli Krause, Jonas Hanselka and Delf Sachau
Helmut-Schmidt-Universität Hamburg

Noise in enclosed interiors like an aircraft cabin in the low frequency range can be reduced with the help of active noise treatments. In the real working environment variations of physical quantities appear. This paper investigates the sensitivity of an active noise cancellation system inside an aircraft cabin towards these variations and the resulting disturbances in the secondary path. Therefore the secondary paths are measured for different construction stages and under different environmental conditions inside a mock-up of the airplane. Afterwards the extent of the disturbances is compared for different construction stages and in a following step the impact on the system performance is investigated. Further the impact on the noise reduction using a secondary path model from another cabin construction stage or environmental condition is analyzed. Thereby it is worked out if it is possible to use secondary path models inside an active noise control algorithm from different construction stages without causing a loss in noise reduction. This study shows that changes in the secondary path can result in poor convergence behavior or high control effort. To overcome this deficit a robust control algorithm can be built up with the results of this study.

Session "Thermoacoustics"

Thu 10:40 Hotel Terme room 1 Thermoacoustics

Review of Modern Tools for the analysis of Thermoacoustic Instability in Rijke type Burners

Sathesh Mariappan[a] and R I Sujith[b]
[a] *German Aerospace Center (DLR), Göttingen;* [b] *Indian Institute of Technology, Chennai*

Thermoacoustic instability is a challenging problem in solid and liquid rockets, ramjets, aircraft and industrial gas turbines etc. The paper discusses on some of the recent techniques developed in analyzing thermoacoustic interactions. The paper reviews on two aspects: modeling and stability analysis. The modeling aspect is mainly focused on the asymptotic analysis of the fluid flow equations to eventually obtain the governing equations for a given thermoacoustic system. On the other hand, stability analysis is mainly devoted for the recent tools (such as adjoint optimization) to analyze its non-normal nature. On the other end, techniques like describing function, continuation methods etc. to identify the nonlinear stability boundaries are also discussed. These investigations indicate that thermoacoustic systems exhibit complex dynamical features such as quasi-periodicity, chaotic, even in simple configurations. Their observations and subsequent investigations based on nonlinear time series analysis indicate well defined path from limit cycle to chaotic behavior. Although these investigations are focused on Rijke type burners, the tools are sufficiently general to apply them to

a generic combustor. Towards the end, a discussion on noise induced transition to instability is made, which has more relevance from the practical of view of practical combustors.

Thu 11:00 Hotel Terme room 1 Thermoacoustics

Analytical Modelling of the Dissipation and Dispersion of Entropy Waves in Combustor Thermoacoustics

Aimee Morgans and Chee Su Goh
Dept of Aeronautics, Imperial College London

Lean premixed combustion reduces NOx emissions from gas turbine combustors. However, it also increases susceptibility to damaging thermoacoustic instabilities, caused by a two-way coupling between the flame's unsteady heat release and the acoustic waves within the combustor. To accurately model the acoustic waves generated by unsteady combustion, it is important to account for both the acoustic and entropic disturbances that arise. Entropy waves are silent in a non-accelerating flow, but when they are accelerated, as through the combustor exit, they generate 'indirect' acoustic waves which can propagate back towards the flame. The effect on thermoacoustic instability remains uncertain - combustor models typically either neglect entropy waves completely, or assume they convect unaltered through the combustor. One notable exception is Sattelmayer's work, which models entropy wave dispersion in a non-uniform mean flow using a time-delay spread. In this work, we numerically investigate the dissipation of entropy waves, and revisit their dispersion. Our analysis suggests that dissipation can be neglected, and that the impulse response of entropy disturbances convecting with a non-uniform velocity differs significantly from previously published work. We suggest a modified dispersion model, which indicates that entropy waves remain sufficiently "undispersed" to affect thermoacoustic stability.

Thu 11:20 Hotel Terme room 1 Thermoacoustics

Influence of Vortical Disturbances on Flame-Acoustics Interactions

Raphael Assier and Xuesong Wu
Imperial College London

The problem of premixed combustion in a duct is investigated using an asymptotic formulation, which is derived from first principles and based on low Mach number and high activation energy assumptions (Wu et al. JFM 2003 vol. 497). Contrary to other flame models, such as the Michelson-Sivashinsky equation or the G-equation, the present approach is complete in the sense that it takes into account the interactions between the flame and the spontaneous acoustic field, as well as the interactions between the hydrodynamic field and the flame. The focus is on the fundamental mechanisms of combustion instability. To this end, a linear stability analysis of some steady curved flames is carried out. These steady flames were known to be stable when the spontaneous acoustic perturbations are ignored, but we shown that they are actually unstable when the latter effect is included. In order to corroborate this result, a coupled weakly non-linear

numerical simulation was implemented. The linear instability result is confirmed by the numerical study. In the present work, we also study the effect of vortical disturbances in the oncoming fresh mixture. These vortical disturbances cause wrinkling of the flame, and resonance between flame oscillations and acoustic fluctuations.

Thu 11:40 Hotel Terme room 1 Thermoacoustics

The forced and self-excited heat release response of turbulent stratified flames to acoustic velocity fluctuations

Zhiyi Han
University of Cambridge, Department of Engineering

The forced and self-excited heat release responses of stratified lean-premixed flames to acoustic velocity fluctuations are investigated. A laboratory-scale burner and its boundary conditions were designed to generate high-amplitude acoustic velocity fluctuations in a flame subject to well-defined radial equivalence ratio gradients via an annular fuel delivery system. Simultaneous measurements of inlet velocity and heat release rate were carried out. A high speed ICCD camera was used to capture the chemiluminescence images.

The measurements show that the flame responses vary significantly depending on equivalence ratio split and velocity. The modification of the flame structure by the stratification changes the nonlinear response of flames to both low and high-amplitude acoustic forcing. The non-linearity behavior happens at lower intensities for the enrichment of the inner stream flame than for the premixed and outer stream. The gain of the flame transfer function is lower for the cases of outer flow enrichment. The results confirm previous findings that increasing stratification towards the inner zone increases the gain and susceptibility to instabilities. However, the role of equivalence ratio is less pronounced at higher velocities, so that similar results of flame structures and response behaviors were found under high velocity profiles for all flames.

Thu 15:00 Hotel Terme room 1 Thermoacoustics

Acoustic Transfer Function of Unsteady Impinging Flames

Edgar Fernandes and Janaína Merícia
Instituto Superior Tecnico, Lisbon

Flame jet impingement is widely used in many industrial processes for heat transfer treatment. Due to the increasing emphasis on environmental protection, one of the strategies used is to operate under lean conditions, for low pollutant emissions. However, combustion instabilities can become self-excited. One way of improving stability is to modify the balance between the acoustic gain processes and the losses, reducing the efficiency of the driving processes or by augmenting damping effects.

In this context, this paper addresses the study of an impinging propane-air flame based on an experimental work using Laser Doppler Technique; high speed Cinematography and photomultiplier to quantify the flame sensitivity to upcoming flow and explore the acoustic flame transfer functions

of an impinging flame. The aim is to compare the transfer functions obtained using: a) the relative flame surface area fluctuations (comparable to G-equation solution) obtained directly from the CCD images, applying a tomographic image reconstruction; b) the light emission fluctuations (total light from CCD image v.s. monochromatic emissions acquired using interference filters and a photomultiplier). The analysis should emphasize the influence of stretch/compression effect for linear regime of flame response.

Thu 15:20 Hotel Terme room 1 Thermoacoustics

Investigation of the causes of limit cycle saturation using a G-Equation model in the case of a laminar anchored flame in a simple combustor

Charles Luzzato and Aimee Morgans
Dept of Aeronautics, Imperial College London

Combustion instabilities are self-sustained large amplitude pressure oscillations, due to a coupling between the combustor acoustics and the unsteady heat release at the flame. The flame releases heat, thus generating pressure waves which propagate throughout the tube. These later return to the flame and cause it to release more heat. In an unstable configuration, this leads to linear growth of the acoustic pressure, followed by a limit cycle where the peak amplitude of the acoustic pressure is saturated. This saturation can be caused by two things:

– The flame area cannot increase further, and the unsteady heat release is saturated
– The phase of the source term in the Rayleigh criterion, involving both the unsteady heat release and acoustic pressure at the flame, is modified by the instability.

We shall be using G-Equation flame modelling, coupled with linear plane wave acoustics. The flame discontinuity, and therefore the location of the acoustic emissions, will change with time to coincide with the mean axial position of the flame. This is an important change from other G-Equation models, where the location of acoustic emissions is invariant. With this new model, we shall investigate both mechanisms which cause limit cycle.

Thu 15:40 Hotel Terme room 1 Thermoacoustics

A limit cycle for pressure oscillations in a premix burner

Andrea Di Vita
Ansaldo Energia, Genova

Spontaneous onset of pressure oscillations in a burner for lean, subsonic, premix combustion is related to a feedback between perturbations of heat release at the flame and of stoichiometry at the inlet of the air-fuel mixture. Markstein's kinematic equation describes flame motion; at the inlet, the fuel partial pressure p(fuel-inlet) is constant. Any perturbation in the amount of heat exchanged between the flame and the fluid induces an acoustic oscillation which propagates up to the inlet. Since p(fuel-inlet) is constant, the acoustic perturbation at the inlet perturbs air pressure, hence stoichiometry. This perturbation of stoichiometry is carried by the fluid towards the flame, and perturbs the flame velocity there; the perturbation of

flame velocity affects the heat exchanged between the flame and the fluid, and a feedback mechanism is established. Onset corresponds to overreacting feedback. Near onset, a limit cycle describes oscillations. Investigation of the return map shows that onset occurs as the Mach number exceeds a threshold. The leaner the combustion, the larger the rated heat release, and the lower the working pressure the more likely the onset. Analytical formulae for both amplitude and frequency are provided, together with information about hysteresis.

Thu 16:00 Hotel Terme room 1 Thermoacoustics

Analytical model of nonlinear thermo-acoustic effects in a matrix burner

Maria Heckl
Keele University, Department of Mathematics (UK)

This paper considers a fundamental thermo-acoustic test rig developed by Noiray ("Linear and nonlinear analysis of combustion instabilities, application to multipoint injection systems and control strategies", PhD thesis, École Centrale Paris, 2007). The main components of this test rig are a resonant duct of variable length, terminated by a moveable piston at the upstream end and a perforated plate at the downstream end; a two-dimensional array of small premixed flames is anchored just outside the duct by the perforated plate. We model this with an entirely analytical approach. The flame describing function measured by Noiray is represented by a surprisingly simple time-lag law, which is then used to derive the governing equation for a single acoustic mode in the test rig. This equation turns out to be that of a harmonic oscillator with a damping/amplification coefficient that depends on the velocity amplitude. On this basis we find analytically the pattern of the oscillation regimes in parameter space, in particular the frequency and amplitude of limit cycles at various tube lengths. There is good qualitative agreement with Noiray's observations.

Thu 16:20 Hotel Terme room 1 Thermoacoustics

Preventing thermo-acoustic instabilities by breaking the feedback loop.

Maarten Hoeijmakers, Ines Lopez Arteaga, Viktor Kornilov, Henk Nijmeijer and Philip de Goey
Eindhoven University of Technology

Many combustion devices are highly susceptible to thermoacoustic instabilities. These instabilities are caused by a feedback loop between the heat release and the acoustic reflections in the device. Thus, one possible method to prevent thermoacoustic instabilities is to break the feedback loop by reducing the reflections up and downstream of the flame. In this work, the effectiveness of this approach is investigated. It is shown that (i) reducing the up- and downstream reflection coefficients is only effective for specific conditions on the flame transfer function, and (ii) the flame itself can be an intrinsically unstable element.

Thu 16:40 Hotel Terme room 1 Thermoacoustics

Validation of CFD Simulation of a Thermoacoustic Device

Mohamed Zouhir Dar Ramdane, Tobias Holzinger and Wolfgang Polifke
Chair of Thermodynamics, TU München

The thermoacoustic effect concerns conversion of energy between a gas and a solid medium in the presence of acoustic waves. Although the working principle is well understood, the optimal design of thermoacoustic engines remains a challenge. The present work aims to develop a CFD-based numerical model that can be used as a prediction tool to improve the performance of thermoacoustic systems. Validation of numerical simulation of a simple standing-wave thermoacoustic device - a porous ”stack” placed between heat exchangers in a straight duct - is presented. The analysis of the laminar flow and the prediction of the heat transfer are performed by solving the nonlinear unsteady Navier-Stokes equations including heat transfer using the finite volume method implemented in ANSYS-CFX CFD code. This model is validated against experimental results. For this purpose, the harmonic mode shapes are investigated for various operating frequencies. The impact of damping on limit cycle amplitudes is explored.

Thu 17:00 Hotel Terme room 1 Thermoacoustics

Marginal condition for the onset of thermoacoustic piezo system oscillations with variable piezo impedance and subject to variable temperature gradient

Roberto Baccoli[a], Paolo Giuseppe Mura[a], Roberto Innamorati[a] and Amr Baz[b]
[a] *Università degli studi di Cagliari;* [b] *University of Maryland (USA)*

This paper deal with the problem to derive a marginal condition for the onset of spontaneous thermoacoustic oscillations of a gas in a circular tube, subject to variable shape temperature gradient along the side wall, with one end open and the other closed by a piezo electric element. In this study the acoustic impedance of the piezo element is arbitrary in order to achieve marginal conditions between those exhibited with rigidly close end and those with end opened onto free atmosphere. Moreover marginal condition is outlined having a variable shape of the temperature gradient respect to the position of the stack along the tube. The marginal condition is provided at the same time respect to variable piezo impedance and variable position of the acoustic driver. The solution includes all dissipative effects related to the compressive and shear viscosity and the heat transmission in the boundary layer at the side and end wall. The formulation is given in the framework of the linear theory and the first order theory in the ratio of a boundary layer thickness to the tube radius

Session "Acoustic measurements and instrumentation 2"

Thu 8:40 Hotel Terme room 2 Acoustic measurements 2

Study on the use of plane wave tube as a base for a non destructive control instrument for frescoes damage assessment.

Paolo Tarizzo[a], Claudio Guglielmone[a], Alessandro Schiavi[a], Michele Cerruti But[b] and Luca Zaretti[b]

[a] *INRIM, Torino;* [b] *Politecnico di Torino*

Is it possible to use an impedance device based on a plane wave tube as a low cost and easy to use device for the evaluation of the condition of frescoes? The Non Destructive Techniques status of the art for wall paintings diagnostic techniques offers many solutions that too often require expensive and/or impractical instrumentation, and this contrasts with the needs of cultural heritage curators. The technique presented in this paper is based on the measurement of wall impedances, by means of a specially adapted standing wave tube. The measurement edge contacts the wall painting with a particular soft material that minimizes the damage possibility. The device and technique has been validated in laboratory conditions, on wall samples that simulate the detachment of portion of fresco painting pellicle from the supporting plaster. On the same samples, other laser vibrometer based diagnostic techniques have been tested and compared with the standing wave tube one. Laboratory and in situ measurement results are shown and analyzed.

Thu 9:00 Hotel Terme room 2 Acoustic measurements 2

Transfer function estimation with fluctuating noise

Aulis Telle

HEAD acoustics GmbH

When a transfer function has to be estimated in an acoustically adverse environment, a typical measure against the impact of uncorrelated noise is to average multiple measure-ments coherently. If the measured system response is disturbed by noise with time-varying power, the normal coherent averaging is suboptimal. In this contribution, the method of weighted averaging previously published by the author is used for estimating the transfer function. As shown in previous publications, the optimal weights are directly related to the signal-to-noise ratio in the system response. For optimal averaging results, accurate noise power estimates are needed for every measurement. For the noise power estimation a new method is proposed delivering more robust results than the so-called SWiC method (sliding window correlation) previously used. Furthermore, the averaging method is extended to the signal power varying from measurement to measurement. The original application of this method is the acoustic function testing of the Eustachian tube, where strong transient disturbing sounds and time-varying noise are present. However, the concept is general so it is applicable to any system identification task.

Thu 9:20 Hotel Terme room 2 Acoustic measurements 2

Characterization of Quasi-Stationary Plane Wave fields with Sound Intensity Microprobes

Giorgio Sacchi[a], Martina Buiat[b] and Domenico Stanzial[a]

[a] *CNR-IDASC, sezione di ricerca di Ferrara;* [b] *Università di Ferrara*

In a recent published work [J. Acoust. Soc. Am., 129 (6), June 2011, pp. 3745-3755], two of the authors described the full bandwidth calibration of a p-v probe using a progressive plane wave field as a reference. The experimental realization of such field was obtained in a 84 m long wave guide installed in the LARIX laboratory of Ferrara University, and the calibration was performed at 6.5 m far from the source. To check how good the acoustical field matched the theoretical conditions, measures at two different points were compared, showing an excellent agreement with expected results. Recently, the guide was shortened to 48 m, the calibration point was moved to 12.5 m and a fraction of 5 m was modified so that measurements every 0.2 m could be performed. Toghether with a more accurate characterization of the calibration field, these modifications allowed the study of the behavior of sound energy and its related parameters also for quasi-stationary wave fields, obtained simply disconnecting the guide right after the fraction. Some of the obtained results for both cases are here presented and discussed.

Thu 9:40 Hotel Terme room 2 Acoustic measurements 2

Estimating (electro-)acoustic model parameters using Differential Evolution (DE) optimisation algorithms

Christian Budde

Hannover

In computer science, Differential Evolution (DE) is a method that optimises a problem by iteratively trying to improve a candidate solution with regard to a given measure of quality. While this method can be applied to any optimisation problem in general, it can also be very useful in acoustics to fit the parameters of an (electro-)acoustic model to measurement results. In combination with the chosen model it can then be used to estimate higher level parameters. Based on some examples from different acoustic disciplines, the possibilities, advantages and disadvantages compared to other methods will be presented.

Thu 10:00 Hotel Terme room 2 Acoustic measurements 2

Airborne and structure borne noise separation on a loudspeaker

Daniel Fernandez Comesaña and Andrea Grosso
Microflown Technologies

Performance optimization of the loudspeakers cabinet often involves the minimization of the cabinet acoustic radiation for high fidelity reproduction in the mid-high frequency range. In this paper a new scanning technique is used for separating the airborne sound, coming from the loudspeaker membrane, from the structure sound generated by the cabinet. Pressure and particle velocity are measured under normal operational condition (music), closed to the surfaces with a P-U probe. At the same time the transfer functions between the P-U probe and reference position close to the membrane are evaluated as well. For complete characterization of a non - stationary sound field so called position discrimination algorithm is used.

Thu 10:20 Hotel Terme room 2 Acoustic measurements 2

Akustische Untersuchungen bei der ultraschnellen Mikrobearbeitung mittels Hochleistungslaser

Jutta Lindemann
Hochschule Mittweida

Using laser treatment processes, it is possible to achieve a very high precision and therefore, miniature components can be produced. But to save time, money and especially material, an online process monitoring for fault detection is useful. For laser welding and cutting, the usage of optical measurement methods has already been established. They are based, for example, on the detection of the process-dependent plasma. The reliability and validity of the error detection during the process can be increased by using a combination of different sensors. Therefore, both optical and acoustic sensors, such as microphones and accelerometers, were used in the presented studies.

Thu 10:40 Hotel Terme room 2 Acoustic measurements 2

Laser Optical Measurements of Acoustic Particle Velocity in a Duct Flow for Liner Investigations

Anita Schulz[a], Daniel Haufe[b], Andreas Fischer[b], Jürgen Czarske[b], Friedrich Bake[c] and Lars Enghardt[c]
[a] *TU Berlin;* [b] *TU Dresden;* [c] *German Aerospace Center (DLR), Berlin*

In order to reduce aircraft noise, passive acoustically damping devices like liners are applied in aircraft engines. To increase their efficiency a better understanding of the damping physics is required. Therefore, an investigation of the interaction between sound and flow field in the vicinity of the liner surface with non-intrusive laser-optical measurement techniques is beneficial. Hereby, the high dynamic range needed to resolve and separate both the acoustic particle velocity as well as the flow fluctuations is a major challenge. Within this work the validation of two laser-based techniques, the Doppler Global Velocimetry with Frequency Modulation (FM-DGV) and

the Acoustic Particle Image Velocimetry (A-PIV), for the acquisition of the acoustic particle velocity in mean flow conditions is presented. Therefore, a reference hard-walled flow test rig with optical access and a proven microphone-based acoustic duct analysis technique were used. As a further step acoustic particle velocity measurements were conducted at a bias flow liner. In order to study the relation between the acoustic damping characteristics of the liner and the flow field properties, spectral turbulence results are considered. A special focus is put on the evaluation of the energy transfer from the acoustic waves to the turbulent flow fluctuations.

Thu 11:00 Hotel Terme room 2 Acoustic measurements 2

Microphone-Array Measurements of High-Speed Train Noise

Anders Nordborg[a] and Hyo-In Koh[b]

[a] *Sound View Instruments, Borrby (S);* [b] *Korea Railroad Research Institute*

High-speed trains generate both low-frequency aero-acoustic noise as well as high-frequency rolling noise, both of which may be of equal importance. To localise and quantify (sound power determine) all noise sources a microphone-array with 144 microphones and a diameter of 6 m were developed. The microphones were positioned on six spiral arms, with positions generated by the equation for Fermat's spiral. A particular algorithm for sound power determination was developed and compared to loudspeaker measurements in an anechoic chamber as well as on the track, were the subsequent high-speed train noise measurements were carried out. The agreement was very satisfying. Array properties are demonstrated with numerical simulations and measurement results from a Korean high-speed train.

Thu 11:20 Hotel Terme room 2 Acoustic measurements 2

Approaches for a comprehensive determination and assessment of infrasound effects in Germany

Fabian Ebner, Christian Eulitz and Ulrich Möhler

Möhler + Partner Ingenieure AG

The need for a holistic identification and evaluation of infrasound is becoming increasingly important for modern noise protection.

The fact that air pressure fluctuation in the infrasonic range is also produced by slamming of a door shows that infrasound with sound pressure levels below the perceptual threshold exists almost anywhere in our environment.

In the context of a research study, potential sources of infrasound have been identified and the state of knowledge of potential health risks of infrasound has been analyzed. Numerous publications show that infrasonic influence disturbs sleep and recovery, and that it can be associated with a wide range of diseases.

Taking all this into consideration the question arises as to what extent existing rules that specify the requirements for measuring noise immission do justice to the specifics of infrasound. The existing standards are currently limited to measurement techniques that have been used for years. However, they are not specified further with regard to the measurement of infrasound

levels. Therefore, these current standards show a considerable level of uncertainty.
With the help of a simple experimental setup it was possible to identify difficulties with the metrological detection of infrasound and to deduce potential requirements for future infrasound measurements.

Thu 11:40 Hotel Terme room 2 Acoustic measurements 2

Measurement techniques and assessment methods for airborne ultrasound

Christoph Kling and Christian Koch
Physikalisch-Technische Bundesanstalt

Concerns exist that non-audible sound outside of the hearing range presents a hazard to hearing or creates annoyance. A joint research project which is funded by the European Metrology Research Programme (EMRP) started in May 2012 to establish new understanding of human perception of non-audible sound as well as the metrology infrastructure necessary to put in place effective safety criteria based on establishing perception thresholds. One of the main issues is the development and standardisation of new measurement methods and calibration techniques for airborne ultrasound to provide traceability for noise measurement in the high-frequency range.
The talk will present a first preliminary set-up to determine emission of typical air-borne ultrasound sources. The sound pressure is measured using a quarter-inch microphone with a wide-band acoustic analyzer and the dependence of the results on spatial sound field distribution is analyzed. First proposals of data analysis for an assessment of air-borne ultrasound will be presented. Moreover, the metrological basis will be delivered for a proper traceability of microphones in the ultrasound frequency range.

Thu 15:00 Hotel Terme room 2 Acoustic measurements 2

Realisation of the unit watt in airborne sound

Volker Wittstock
Physikalisch-Technische Bundesanstalt

The sound power is a major quantity in applied acoustics. It is the basic descriptor for the sound emission of sound sources and furthermore the base for all quantities in building acoustics. The sound insulation is a sound power ratio, and the impact noise level is a sound power level with a special reference value. In spite of this importance, the metrological infrastructure for the quantity sound power is not well developed. Whereas in other areas, like e.g. ultrasound, there are standard devices for the realisation of power, such a device is not available in airborne sound. It is now intended to implement a primary realisation of the unit watt in airborne sound at PTB. This realisation will be based on an embedded oscillating solid body. The sound power emitted by this device can be calculated by Rayleigh's integral from the distribution of the vibration velocity at the surface of the radiator. The velocity will be measured by a laser scanning vibrometer. The concept will be introduced and advantages with respect to the current situation discussed.

Thu 15:20 Hotel Terme room 2 Acoustic measurements 2

Condition monitoring of capsules packaging using p-v microprobes

Giorgio Sacchi[a], Martina Buiat[b], Fosca Fimiani[c] and Domenico Stanzial[a]

[a] *CNR-IDASC, sezione di ricerca di Ferrara;* [b] *Università di Ferrara;* [c] *University of Bologna*

Among the possible applications of pressure-velocity acoustic probes, a promising field is the condition monitoring. This aspect of the production processes is particularly important in pharmaceutical industry, where toxic or dangerous substances have to be handled. This memory focuses on the packaging of hard gelatine capsules, where it is crucial to quickly and accurately check the filling process in order to avoid errors in the drugs dosing. An acoustic approach was tried by measuring acoustic energetic quantities for 15 different test objects, varying both in quantity and aggregates of the contained drug (powder, pellets, microtablets): first results are here presented and discussed.

Thu 15:40 Hotel Terme room 2 Acoustic measurements 2

A Multi-function measurement system based on a dedicated portable computer and a multichannel sensor system

Michael Sieland and Geerten Verbeekmos

Ziegler-Instruments GmbH

From the point of view of multi-point noise measurements such as in environmental issues, architectural acoustics or noise and vibration assessments in the industrial sector, it takes a lot of time and effort to set up cables between microphones, sensors and measuring instruments. We have developed an easy-to-use wireless measurement system which includes wireless microphones, multi-channel wireless sensor amplifiers and a dedicated portable measuring computer with intuitive touch panel operation. The wireless system can make it easier to set up and expand measuring activities in situations such as environmental measurements across a road or railway, architectural measurements between completely enclosed rooms, measurements between the inside and outside of driving vehicles and mesh-allocated noise monitoring. Measurement functionality of the system can be diversified by the development of software applications, depending on measurement requirements. The potential of the system was investigated through experiments, and by presenting a case study, we show the details of the system, advantages and aspects to be taken into account.

Thu 16:00 Hotel Terme room 2 Acoustic measurements 2

Measurements properly wired

Bernhard Virnich
Müller-BBM VibroAkustik Systeme

In the field of dynamic measurements for noise and vibrations a wire connects the sensor signal to the conditioning system or to the measuring front end. The cable bridges the distance between the signal source and measurement system. This paper is dedicated to the connection cable, which often constitutes the weakest point in the measurement situation. The suggestion to held this speech was born at the workshop of the Fachausschuss Fahrzeugakustik at Ingolstadt in September 2012. A signal captured by the sensor is exposed possible errors on his way to the front end. That could be electrical or electromagnetic effects, emitted by the dynamometer or electric engines or created from mechanical vibration. The longer a cable is, the greater the requirements are to have no signal attenuation or distortions. The speech explains possible problems. It shows differences between cable types and different wire installations and gives support, what users should keep in mind.

Thu 16:20 Hotel Terme room 2 Acoustic measurements 2

Evaluation of Smartphone-Based Audio Applications

Jonas Fischer[a], Thomas Mayer[a] and Norbert Geng[b]
[a] *Müller-BBM GmbH;* [b] *Hochschule München*

Smartphones feature high processing speeds, a distinct mobility, many sensors and elaborate displaying possibilities in small enclosures. Under ideal conditions it is furthermore possible to keep them up to date via the Internet. All these preconditions may enable the use of mobile phones as integrated measurement systems that can be carried along easily. This investigation examines several smartphones and apps for different operating systems. The respective impact of the smartphone hardware, the software and different external auxiliary devices is evaluated. All device under test investigations, as well as analyser and generator functions are verified via professional calibrated measurement systems. Thus it is possible to state in which cases and under which conditions it is possible to use these app-based telephones for audio applications.

Session "Room acoustics 2"

Thu 8:40 Hotel Terme room 3 Room acoustics 2

Measurement Uncertainties of Reverberation Time caused by Noise

Martin Guski and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

The reverberation time is one of the most important room acoustic parameters and also a needed quantity for other measuring techniques, such as determination of absorption, scattering or sound insulation. The common way to calculate the reverberation time is to measure the impulse response and perform a backwards integration. Noise that occurs in every measurement is one of the greatest influences on the uncertainty of reverberation time. ISO 3382 allows different possibilities on how to compensate these noise effects. In this study the performance of five different noise compensation methods are evaluated. Three of the five methods are according to ISO 3382. As a first step a parametric model impulse response is used to investigate the behavior of the different noise compensation methods. Long-term measurements in an auditorium have been conducted to analyze the performance of the different techniques under realistic conditions. Model and measurement show similar results and demonstrate advantages and limitations of the investigated noise compensation techniques. Furthermore, systematic errors dependent on the peak-signal to noise ratio can be observed for the different methods.

Thu 9:00 Hotel Terme room 3 Room acoustics 2

Can we use the standard deviation of the reverberation time to describe diffusion in a reverberation chamber?

Martijn Vercammen and Margriet Lautenbach
Peutz bv, Mook (NL)

It is generally assumed that the limited diffusion proporties of reverberation rooms, especially with an stongly sound absorbing sample, is the main reason for the bad reporducibility values for the sound absorption between laboratories. Reverberation rooms should be made much more diffuse to reduce the inter laboratory differences. Allthough there are practical ways to achieve this, it is most important that there will be a requirement in the ISO 354 standard on the diffusing quality of the sound field. One possibility is to use the standard deviation of the reverberation time for different source-microphone combinations in the reverberation room. Measurements are performed, to investigate the influence of different settings of a reverberation room on the standard deviation of the reverberation time, compared to the theoretical standard deviation. This is done with the interrupted impulse method and the integrated impulse method. The results will be shown in the preseented. The usefullness of this qualification method for the ISO standard will be discussed.

Thu 9:20 Hotel Terme room 3 Room acoustics 2

Simulation-based Validation of Joyce Reverberation Time Equation for Different Room Shapes

Davide Bonsi
Fondazione Scuola di San Giorgio, Venezia

From 1975 to 1980 William B. Joyce of Bell Laboratories published a sequence of papers which culminated with the discovery of an exact equation for the decay constant of sound in a room. The obtained result showed on a geometrical acoustics basis how reverberation process is a function of both surface absorptivity and scattering coefficient, and provided a framework for interpreting traditional formulas like those of Sabine and Norris-Eyring as special cases of a more general theory. The purpose of the present research is that checking the validity of such an approach for a wide class of room shapes, starting with the spherical geometry, for which the Joyce equation is solvable exactly, and including increasingly more complex ones and similar to real cases of practical interest (shoebox, fan-shaped, etc.). The decay curve for each enclosure category will be simulated with the help of a ray tracing software by progressively varying absorption and scattering coefficient; the corresponding decay rates will be compared with the values predicted by traditional reverberation time formulas and some empirical functions, determined by data interpolation, will be proposed.

Thu 9:40 Hotel Terme room 3 Room acoustics 2

Room Impulse Response Measurements in 10 Churches of Rome: Hörsamkeit, Intelligibility and Suitable Positions for Performances of Church Music

Klaus-Hendrik Lorenz-Kierakiewitz[a] and Jobst P. Fricke[b]
[a] *Peutz Consult GmbH;* [b] *Universität zu Köln, Abt. Systematische Musikwissenschaft*

In September 1976 one of the authors the rare occasion was given by invitation of the German Historical Institute in Rome to record room impulse responses together with the Tonmeister Dr. Wolfgang Voigt at several positions in ten (unseated) churches of Rome, among Lateran Church, St. Peter's and Sistine Chapel. At that time still recorded on analogue tape, after first evaluations in 1995 now a careful new digitalization of the measurements was performed in order to extract the room acoustical parameter values of Hörsamkeit and intelligibility (reverberation time, EDT, clarity, reflexion structure, echo-degree, indicators of speech intelligibility) using a state-of-the-art evaluation program. In the detailed examination it was looked into the question, how far the room acoustical properties enable an adequate Hörsamkeit and appropriateness for performances of church music. The examined locations, applied procedures, performance, evaluation and results of the measurements are documented here. As result, Hörsamkeit and intelligibility of the measured churches are evaluated and the question discussed, at which positions a positioning of the musicians would be in nowadays terms disadvantageous especially for polyphonic musical structures, and which one advantageous - albeit in historical practice in

case of doubt music was made, where liturgy and ceremonial dictated the positions.

Thu 10:00 Hotel Terme room 3 Room acoustics 2

Sound Field in Shoebox-shaped Sports Halls with Non-uniformly Distributed Sound Absorption: a Case Study

Constant Hak[a], Nicole Van Hout[b], Remy Wenmaekers[b] and Maarten Hornikx[a]

[a] *Building Physics and Services, Eindhoven Uni. of Technology;* [b] *Level Acoustics, Eindhoven (NL)*

In order to achieve a preferable sound field in traditional shoebox-shaped sports halls, for practical reasons the sound absorbing material is often applied in the upper part of the hall, above the playing area. Due of this inhomogeneously distributed sound absorption, the sound absorbing material properties and the typical shoebox shape of the hall, predictions based on commonly used engineering methods often do not lead to the actual reverberation time and sound level distribution. Underestimations of more than 50% are not exceptional. Three methods to calculate the reverberation time and sound level distribution are therefore compared. The first two are the engineering methods: one based on the diffuse field assumption and the other on a ray acoustic approach. The third method is a full wave model. For an existing sports hall the spatial and frequency dependent reverberation time and sound level in the playing area have been calculated according to the mentioned methods. The results are compared with measured values. Also, a comparison has been made between results from the calculation methods in case the same amount of absorption material would have been distributed evenly over all walls and the ceiling of the sports hall.

Thu 10:20 Hotel Terme room 3 Room acoustics 2

Listening Impression and Room Acoustic Parameters in Concert Halls

Winfried Lachenmayr[a], Gunter Engel[b] and Karlheinz Müller[b]

[a] *MDW Wien;* [b] *Müller-BBM GmbH*

Room acoustic parameters describe a listener's impression in a concert hall. Existing parameters are also used for planning and judging halls but might not cover the whole sonic experience. The same orchestra was accompanied to four major concert halls, measurements and recordings were taken at seven seats thus enabling a direct comparison of halls and seats. A listening test was conducted to examine the room acoustic parameters. Listening samples will be played to demonstrate new findings.

Thu 10:40 Hotel Terme room 3 Room acoustics 2

NURBS and Mesh geometry in Room Acoustic Raytracing Simulation

Tomás Méndez Echenagucia[a], Arianna Astolfi[b], Mario Sassone[a], Louena Shtrepi[b] and Arthur van der Harten[c]

[a] *Politecnico di Torino - Dipartimento di Architettura e Design;* [b] *Politecnico di Torino - Dipartimento Energia;* [c] *Forster and Partners, London*

Room Acoustic Simulation models have been in use for some time now, they are capable of simulating the impulse response of a room, as well as estimate Objective Parameters. Various Benchmarks have been done to evaluate their accuracy in reproducing the impulse response of existing musical spaces (Vorlander).

When it comes to simulating sound reflection of curved surfaces, most simulation models depend on the discretization of these surfaces into smaller planar segments. This simplification can be particularly problematic when it comes to the complex curved forms that are now being used in a wide range of acoustic environments, especially in concert and opera halls.

The advent of advanced computational geometry, in particular the use of Non-Uniform Rational Basis Splines or NURBS, give us the possibility to better represent ”free-form” complex and curved geometry. This presents the opportunity to significantly improve raytracing simulation models. This paper conducts a comparison of simulations done with and without the use of NURBS for concert halls with curved reflective ceilings. Various ceiling configurations and simulation parameters are compared in order to understand the potential of this new possibility.

Thu 11:00 Hotel Terme room 3 Room acoustics 2

Comparison of different modelling strategies to predict the spatial fluctuation of room acoustic single number quantities

Ingo Witew, Pascal Dietrich, Sönke Pelzer and Michael Vorländer

Inst. of Technical Acoustics, RWTH Aachen University

In many empiric investigations it has been shown, that small changes in the source and microphone position yield a measurable difference in the room acoustic single number parameter. So far little experience exists whether these spatial fluctuations of parameters can be modelled using simulated impulse responses. Successful modelling, however, would be beneficial for understanding the origins of the parameters variance over space and would provide the grounds to advance measurement strategies to get more reliable results of the acoustic conditions in auditoria. In this contribution the results of wave based as well as ray tracing simulations are compared to measurement series conducted in a number of different auditoria.

Thu 11:20 Hotel Terme room 3 Room acoustics 2

Computer Simulation Of The Acoustics Of The Ear Of Dionysius (Syracuse-Italy) In Order To Evaluate Objective Descriptors Of Speech Intelligibility

Gino Iannace[a], Elvira Ianniello[b] and Amelia Trematerra[a]
[a] *Second University of Naples, Dep. of Architecture;* [b] *PhD, Pagani*

It is a long lasting myth that the tyrant of Syracuse Dionysius I (the Elder, ca. 432-367 BC) could understand the speech of war prisoners through an aperture in the upper part of the innermost wall of the grotto named Ear of Dionysius. Few years ago the authors carried out a set of acoustic measurements to characterize the acoustics of this site known worldwide for its peculiar reverberation. Unfortunately, they could not perform measurements of the sound transmission from the floor level to the listening spot of the tyrant in the aim to ascertain the degree of truth of the myth. This paper reports a preliminary study about current room-acoustics parameters related to speech intelligibility which were calculated with the aid of a specialized software (Odeon.11). The calibration of the geometrical/acoustic model was performed on the basis of measured values of T30. The results of the simulation suggest serious doubts about the possibility that the tyrant could understand the speech of prisoners

Thu 11:40 Hotel Terme room 3 Room acoustics 2

The adaptation of a recording studio for a performance room, using multiple position room response equalization

Adrian Calin Farcas and Marina Topa
Technical University from Cluj-Napoca (RO)

The temporary change of a recording studio's destination into a location dedicated to live performances is a real challenge in the field of the acoustical research. The modeling of the acoustical parameters along with assuring a quality audition by a uniform distribution of the sound energy which covers the entire surface of the auditorium represents the theoretical and practical subject of this paper. The theoretical part of the paper, describes a model of sound equalization in multiple listening positions. From the practical point of view, it had been proceeded to obtaining an impulse response (IR), demonstrating the efficiency of the noise interruption method versus the direct method of using an impulse signal source for small and medium rooms. Also, it had been developed the prototype for the adaptive filter of equalization in 20 measuring positions in the auditorium surface, using the sound source in two positions where usually the speakers are placed.

Thu 15:00 Hotel Terme room 3 Room acoustics 2

Functional soundscape, outdoors and indoors

Evert de Ruiter
Peutz bv, Zoetermeer (NL)

Soundscape has many definitions, too many. Regarded as a tool to design measures for the improvement of environments for people, it can be an important addition to ëoldfashioned noise control'. Until now the main focus of research has been on outdoor spaces, and the physical -and psychoacoustical- properties of the composition of audible sounds as such: spectrum, levels, but also roughness, sharpness, etc. It is proposed to take the information content of the individual sound sources into consideration, and in particular their meaning to people, and their impact on them. This approach seems even more appropriate for indoor use, because it combines the properties of the building -sound reduction, sound absorption, sound production- and the specific sound sources of the users. Many items of the total ëchoir' of sound sources can be manipulated to some extent, thus enabling designers to enhance positive impacts and to reduce unwanted sounds. This will be illustrated for hotel rooms and hospital rooms.

Thu 15:20 Hotel Terme room 3 Room acoustics 2

Evaluation of acoustics comfort in classrooms

Antonio Iannotti, Fabio Serpilli, Gianni Cesini and Valter Lori
Università Politecnica delle Marche, DIISM, Ancona

The work shows the first results of a study carried out to evaluate the environmental comfort in some classrooms of "Università Politecnica delle Marche", with particular attention to the acoustic comfort. A lot of researches showed that acoustic comfort in schools is very important because noise in combination with thermal and visual comfort, causes annoyance and could impairs communication, learning and concentration. The acoustic comfort of classrooms under test has been evaluated both through questionnaires with students, in order to analyse the subjective rating of acoustic comfort, as well as through acoustic measurements in order to investigate the objective acoustic quality of the classrooms. The acoustic measurements have regarded noise indexes, room acoustic parameters and intelligibility indexes.

Thu 15:40 Hotel Terme room 3 Room acoustics 2

Room Acoustic Design for a 'Plus Energy' Primary School

Detlef Hennings
freelance scientist, Köln

The new built primary school at Hohen Neuendorf near Berlin is designed to comply with a 'plus energy standard' (i.e. negative total CO2 emissions for building operation). This concept includes using the building's massive concrete ceilings as thermal storage for passive cooling. A conflict with room acoustic quality arises, as almost all effective sound absorbers need to cover surfaces whereas thermal storage requires uncovered surfaces for thermal conductivity.

In a ëpuristic' solution surfaces are separated into two fractions: Uncovered ceilings used as thermal storage and walls covered by sound absorbers. As available wall area is rare, highly efficient broadband absorbers ($\alpha >$ 0.9 above 200 Hz) are used. Thus a room acoustic quality corresponding to DIN 18041 recommendations is achieved without affecting the thermal storage properties of the ceilings. Additionally the sound reflecting ceilings and sound absorbing walls result in about best possible conditions for communication across the room, a level decrease of only 3dB per distance doubling and high speech clarity combined.

Binaural measurements modelling typical classroom situations including a full class occupation were performed for quality monitoring. Measured room impulse responses were also used to generate auralized speech samples for documentation and for aural comparisons to other rooms.

Thu 16:00 Hotel Terme room 3 Room acoustics 2

The Acoustic Design of the Gustav-Mahler-Hall at the Grand Hotel Toblach (1999)

Dorothea Baumann
University of Zurich

Expectations were high and opinions split whether the relatively small new hall of the Kulturzentrum Grand Hotel Toblach (32x16x10m, 350 seats) would allow an adequate performance of Gustav Mahlerës First Symphony. Not only the reactions of the first night in July 1999 but immediate popularity and high esteem confirmed success of a hall regularly used for chamber music up to large orchestras (Gustav Mahler Festival, Mahler Chamber Orchestra, Kronos Quartett, orchestra of the WDR, Solisti Veneti with Uto Ughi) and sound recordings (such as the Giardino Armonico by the Deutsche Grammophon). Based on the hotel's style and developed from models of famous concert halls of the nineteenth century the hall maintains the traditional shoe box shape with wooden paneling and coffered ceiling. Hidden absorbing resonators provide a well linearized reverberation time. Thanks to the excellent collaboration with the architects Wachter and partner from Bolzano a hall with a warm atmosphere and transparent acoustics could be designed. Acoustic consultants: PD Dr. Dorothea Baumann, Ing. Maurice Lanfranchi, Arch. Christina Niederstätter (Zürich, Assens, Ritten).

Thu 16:20 Hotel Terme room 3 Room acoustics 2

Sound Radiation from Stage in Theatres of Cesenatico and Longiano

Federica Morandi, Dario D'Orazio, Simona De Cesaris, Luca Barbaresi and Massimo Garai

University of Bologna, Dep. of Industrial Engineering - DIN

If professional musicians have no doubts on the fundamental role that it plays the sound radiation from stage , a quantification of the contribution of the stage has not been made yet. This work is a comparative analysis on the Town Theatre of Cesenatico and the Petrella Theatre of Longiano. The two theatres share the same geographical and historical context and the same type of construction, but while the restoration works in the theatre of Cesenatico led to the creation of a new stage in reinforced concrete, in the theatre of Longiano the intervention consisted of a substantial restoration of the existing wooden structure. In both theatres, experimental measurements were conducted in order to characterize the acoustics of the halls and to study the vibro-mechanical behaviour of the stage. In particular, it was attempted to identify the main mechanisms of radiation of the stage and to quantify the phenomenon. The results show that the re-radiation due to the airborne excitation of the structure does not give significant contributions to the sound field for any of the two theatres. The phenomenon that remains to be investigated is the radiation produced by the mechanical coupling between the stage and the musical instruments.

Thu 16:40 Hotel Terme room 3 Room acoustics 2

Concept for graduation of office rooms in draft VDI 2569

Elmar Schröder

Müller-BBM GmbH

In 2012 the new part 3 of the ISO 3382 standard was published. This standard introduces measures to qualify the room acoustic conditions in open plan offices. Unfortunately, it does not include requirements. In 2011 the German standard committee restarted to revise the German standard VDI 2569. This committee intends to introduce a rating model with three classes A, B and C to assess office rooms on the basis of measures according to the series of standards ISO 3382. Supplementary rules for the choice of the measurement paths in open plan offices are presented. The graduation of the three classes is based on collected data of measurements in many open plan offices according to the method described in ISO 3382-3. The author presents the concept and the intentions of the room acoustic part of the draft VDI 2569. Furthermore some technical aspects like the influence of source and receiver directivity on the measurement results and comparisons of calculated and measured situations will be discussed.

Thu 17:00 Hotel Terme room 3 Room acoustics 2

Effective Course Design in Practical Room Acoustics for Students of Musicology: Conception, Didactics, Procedure

Klaus-Hendrik Lorenz-Kierakiewitz[a], Christoph Reuter[b], Olivia Vrabl[b] and Jörg Mühlhans[b]

[a] *Peutz Consult GmbH;* [b] *University of Vienna, Department of Musicology*

In this contribution the lecturer and students present the design and procedure of the course "Practical Introduction to Room Acoustical Measuring Techniques and Analysis" held at the University of Vienna. Aim of this course was to introduce students of musicology into practical methods of measurement and analysis of room acoustical data. The chosen format, a practical course, allowing the students to immerse themselves in the subject and learning by doing and by experience. After a theoretical introduction into basic principles of room acoustics, measuring and analysis techniques, small groups of students carried out measurements in team-work in different room-types in Vienna (auditorium of Department of Musicology, Karlskirche, Konzerthaus, Musikverein). The self-evaluated measurement results revealed characteristic parameter values for every room, the students designed individual research questions and drew conclusions on their own, which may lead to improvements of the rooms investigated. All contributions are collected in a documentation. Aura- and visualizations of collected data were made available for presentation and teaching purposes. On a meta-level this course offered comprehensive learning experiences as a result of active and experiential learning, constructed knowledge in interaction and allowed in-depth reflective dialogues, paramount learning needs which classical teaching methods often fail to meet.

Thu 17:20 Hotel Terme room 3 Room acoustics 2

Lothar Cremer in Spain: his influence on the Architect García de Paredes

Gonzalo Vallejo - Ortega[a] and José Ignacio Sánchez-Rivera[b]

[a] *E.T.S Arquitectura U. V. A, Palencia (E);* [b] *E.T.S Arquitectura, Universidad de Valladolid (E)*

This paper presents the most relevant conclusions about the influence of the German consultant Lothar Cremer on the Spanish Architect José María García de Paredes. Within the production of Garcia de Paredes, auditoriums constitute a proper board of singular importance as he has designed and built more than a dozen of large auditoriums, highlighting Auditorio Nacional de Musica (Madrid, 1988). García de Paredes was in touch with Lothar Cremer, who collaborated as an Acoustical Consultant in Auditorio Manuel de Falla (Granada, 1978) and Auditorio Nacional de Música, but his influence extends to other halls such as Sala Juan de Villanueva (Madrid, 1983) and Palau de la Música (Valencia, 1987). Cremer's advice is expressed in the treatment of geometrical acoustics (study of reflections from ceilings, walls and balustrades of balconies to determine their own orientation), distribution of public, slope of the stands and choice of materials. The Architect's contact with the Acoustic Consultant is essential to understand

the final outcome of these works, which will be demonstrated by analyzing the project evolution until the final construction of the auditoriums. Cremer's advice and some images of the optical models are unpublished material.

Session "Virtual acoustics 3"

Thu 8:40 Civic room Virtual acoustics 3

Modal Sound Field Decomposition Applicable for a Limited Range of Directions

Hannes Pomberger and Franz Zotter
IEM, KU Graz

The decomposition of spatial sound scenes using spherical microphone arrays is usually based on spherical harmonics. These are the angular eigenfunctions of the Helmholtz equation in spherical coordinates. However, the decomposition in spherical harmonics requires a uniform distribution of microphones over all directions, even if the sound sources of interest are located within a restricted range of directions. For a restricted range of directions the spherical Slepian functions are defined as orthogonalized recombinations of the spherical harmonics that can be reduced without loss of accuracy. Therefore they are suitable for spherical data interpolation on a restricted range of directions, but the reducibility does not hold for radial near to far field extrapolation. A different set of orthogonal functions is achieved by solving the Helmholtz equation with an angular boundary condition. The resulting angular eigenfunctions form an orthogonal basis for a range of directions restricted by the boundary, e.g. a spherical cap delimited by an infinite cone. These spherical cap harmonics allow for radial near to far field extrapolation. Hence they are applicable for modal sound field decomposition based on near field measurenents. This article discusses the characteristics of the spherical cap harmonics compared to the spherical harmonics and Slepian functions.

Thu 9:00 Civic room Virtual acoustics 3

A Virtual Endfire Loudspeaker Array for the Generation of Sound Beams

Sascha Spors[a] and Hagen Wierstorf[b]
[a] *Institute of Communications Engineering, Universität Rostock;* [b] *Assessment of IP-based Applications, TU Berlin*

Endfire loudspeaker arrays together with appropriate beamforming techniques allow synthesizing sound fields which are confined to a narrow beam in direction of the array. The practical performance of endfire beamforming techniques is limited by the differences between the individual loudspeakers. Furthermore, the direction of the sound beam can be steered only to a very limited extend. Sound Field Synthesis techniques, like Wave Field Synthesis or the Spectral Division Method, allow synthesizing focused sources in front of broadside loudspeaker arrays. This contribution investigates the usage of focused sources as virtual loudspeakers in endfire configuration. The basic properties of focused sources are reviewed and assessed. Endfire beamforming techniques are employed in order to

optimize the directivity characteristics of the virtual array. The overall performance of the approach is investigated in various aspects.

Thu 9:20 Civic room Virtual acoustics 3

Modal Aliasing in Wave Field Synthesis of Directional Sound Sources

Christoph Sladeczek, Albert Zhykhar and Andreas Franck
Fraunhofer Inst. for Digital Media Technology IDMT, Ilmenau

Wave Field Synthesis (WFS) is a spatial sound reproduction technique for the physical creation of virtual source sound fields using arrays of loudspeakers. While early WFS approaches only considered the synthesis of basic virtual source types like omnidirectional point sources, the synthesis of directional sources remains an active area of research today. The directivity of a source can be mathematically described by a linear combination of modal basis functions, such as circular or spherical harmonics. Because practical WFS reproduction systems consist of discrete loudspeaker distributions, the correct spatial representation of virtual sources is restricted by spatial sampling. In this work, we investigate limitations in the synthesis of directional sound sources. To this end, we analyze the effect of spatial sampling on the modal basis functions, which is referred to as modal aliasing. This study makes use of a WFS driving function for linear loudspeaker distributions. Based on this driving function, we propose a criterion to estimate the severity of modal aliasing which can be used to determine the maximum order of modal basis functions for a given loudspeaker distribution. In this way, it can be assessed whether a given directivity pattern can be reproduced correctly by this setup.

Thu 9:40 Civic room Virtual acoustics 3

Simplified Wave Field Synthesis implementation of sound sources with directional radiation pattern

Filippo Fazi[a], Markus Noisternig[b], Ferdinando Olivieri[a] and Thibaut Carpentier[b]
[a] *University of Southampton, ISVR (UK);* [b] *Acoustic & Cogn. Spaces Res. Group, UMR STMS IRCAM-CNRS-UPMC, Paris*

The loudspeaker driving functions for the synthesis of a wave field due to a virtual point source with complex radiation pattern have been proposed by several authors. Their DSP implementation involves a high number of real-time operations that may lead to heavy computational load. In a variety of practical cases, however, the calculation of the driving functions can be simplified by exploiting some properties of the target sound field such as the symmetry of the radiation pattern of the virtual source or the far field approximation of the target field. Some of these simplified formulations are derived in this paper and an outline of their DSP implementation is presented.

Thu 10:00 Civic room Virtual acoustics 3

Construction of an Auralization Laboratory Based on Multichannel Loudspeaker System

Marko Horvat, Kristian Jambrošić and Hrvoje Domitrović
University of Zagreb

As a contribution to addressing the current issues that have been brought up recently in the field of acoustic research related to auralization of sound in both indoor and outdoor spaces, an auralization laboratory based on multichannel loudspeaker reproduction techniques such as Vector-Based Amplitude Panning, multichannel surround or Ambisonics has been constructed at the University of Zagreb, being the first laboratory of this kind in Croatia. The paper presents construction details and the overall progress up to date, as well as desired vs. achieved conditions in the laboratory, regarding the acoustical properties of the room such as the reverberation time, the existence of room modes, the background noise level in the laboratory, etc. Problems and difficulties encountered during construction are described as well, taking into account the position of the given space within the building and the surrounding outdoor environment, the function of the surrounding spaces in the building and the manner in which the building itself was constructed. Suitability of the laboratory for different applications is discussed in light of current demands related to the ongoing research.

Thu 10:20 Civic room Virtual acoustics 3

On the Influence of Loudspeaker and Microphone Array Geometries on the Achievable Listening Room Equalization in a Spatial Continuum

Martin Schneider and Walter Kellermann
Chair of Multimedia Comm. and Signal Proc., FAU Erlangen-Nürnb.

For listening room equalization (LRE) a reproduced sound field is measured by microphones to determine pre-equalizing filters for the loudspeaker signals such that the linear distortion caused by the listening environment is removed at the listeners position. Since the microphones can typically not be placed at the listener's ears, the LRE should be optimized considering a spatial continuum, rather than the individual microphone positions. A relation of the microphone and loudspeaker positions and the equalization apart from the microphone positions was already mentioned in early publications on LRE. Recent hardware allows for the use of a large number of transducers, providing many degrees of freedom for the array setup by the choice of the transducer positions. This gives rise to the question how the transducer array geometries can be optimized not only for reproduction, but also for an effective LRE of the reproduced scene. In this work, we consider LRE filters, obtained by least squares optimization for the microphone positions. The LRE apart from the microphone positions is evaluated for different transducer array geometries. The results show a considerable optimization potential, even when only a moderate alteration of the transducer array geometries is possible.

Thu 10:40 Civic room Virtual acoustics 3

Sound Field Reproduction Applying Stochastic Secondary Sources
Gergely Firtha and Peter Fiala
Budapest University of Technology
Wave field synthesis and spectral division method are two well-known sound field reproduction techniques. Their aim is to reproduce an arbitrary sound field in an extended listening area by driving a secondary source distribution with a driving function derived either in the spatial or in the spectral domain.
The source distribution is realized by densely spaced loudspeakers, that exhibit stochastic properties. In this article the effects of stochastic variation of secondary sources is examined. In previous studies it was revealed that the linear filtering of the driving functions can be interpreted as modifying the spatial and spectral properties of the secondary source elements. Utilizing the theory it is investigated, how the spatial variation of source directivity function and source sensitivity affects the reproduced sound field. Besides analytical examination the results of Monte Carlo simulations are presented - carried out both in time domain and steady state - to visualize the investigated effects, and to compare them with the effects of spatial sampling and secondary source truncation.

Thu 11:00 Civic room Virtual acoustics 3

Comparison of energy-preserving and all-round Ambisonic decoders
Franz Zotter, Matthias Frank and Hannes Pomberger
IEM, KU Graz
Ambisonics is driven by the idea that its underlying multichannel audio representation works nicely on any loudspeaker arrangement, if only it is decoded suitably. Only a little of this promise became true in the past as decoding was an absolutely non-trivial thing for any general, irregular loudspeaker arrangement that spans a three dimensional surface. In fact, known decoding approaches were only well-behaved on special, regular arrangements. The authors recently presented two decoding methods that should cope with loudspeaker arrangements of any kind: energy-preserving and all-round Ambisonic decoding. Which of them is better, and how good are they compared with the classical sampling and mode-matching decoders? This contribution sketches their particularities and shows an examplary comparison using various estimators visualizing the smoothness of the phantom source in terms of loudness and width.

Thu 11:20 Civic room Virtual acoustics 3

Derivation of IIR-pre-filters for soundfield synthesis using linear secondary source distributions

Frank Schultz[a], Vera Erbes[b], Sascha Spors[a] and Stefan Weinzierl[b]
[a] *Institute of Communications Engineering, Universität Rostock;* [b] *Audio Communication Group, TU Berlin*

For planar and linear arrays the driving functions of the individual loudspeakers (secondary sources) can be derived explicitly in the wave number domain by a mode matching approach (known as Spectral Division Method, SDM) or implicitly via the directional derivative of the pressure field on the secondary source distribution's boundary (known as Wave Field Synthesis, WFS). The mismatch of employing secondary sources with 3D monopole characteristics on a linear array for synthesis in a plane requires a frequency, source and receiver position dependent pre-filter. This approach is known as 2.5D-synthesis. It is common practice to realize the pre-filter as FIR-filters. Most implementations ignore the original phase of this pre-filter and realize a linear phase behavior. We compare the application of the pre-filter's original phase and minimum resp. linear phase versions by listening tests. For reduced computational effort in the signal processing chain we furthermore present possible IIR-pre-filter realizations for plane and spherical waves considering the explicit (SDM) and implicit solution (WFS) of the single layer potential. The pre-filter can be parameterized such that a compensation of the frequency response is not applied above the spatial aliasing frequency and below the desired bass cut frequency.

Thu 11:40 Civic room Virtual acoustics 3

Localization in Wave Field Synthesis and Higher Order Ambisonics at different positions within the listening area

Hagen Wierstorf[a], Alexander Raake[a] and Sascha Spors[b]
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Sound field synthesis techniques like Wave Field Synthesis and Higher Order Ambisonics have the advantage of providing correct localization within an extended area in comparison to the sweet-spot phenomenon in stereophony. In practice the localization could be disturbed by errors in the synthesized sound field due to the obliged usage of non-continuous loudspeaker arrays. This study investigates for different types of virtual sources (point sources, plane waves, focused sources) the influence of the applied loudspeaker spacing on the localization. Therefore subjects were placed at many different positions within the listening area for Wave Field Synthesis and Higher Order Ambisonics. The investigation of different positions and loudspeaker arrays was achieved by applying dynamic binaural synthesis to simulate the corresponding ear signals for the different conditions. The participants listened to the conditions via headphones and indicated the perceived direction by pointing with a head mounted laser pointer towards this direction.

Thu 15:00 Civic room Virtual acoustics 3

The Ventriloquism Effect in Wave Field Synthesis: Aspects of Direction and Distance

Florian Völk, Ulrich Mühlbauer and Hugo Fastl
AG Technische Akustik, MMK, TU München

The psychophysical phenomenon usually referred to as ventriloquism effect describes a visually induced shift of hearing sensation positions. In this contribution, the stability of the hearing sensation positions corresponding to virtual sources generated by wave field synthesis with additional visual stimulation is addressed. Discussed are visually induced direction and distance shifts. It is shown that visual stimuli can influence the direction and distance of hearing sensations at which differences occur between individuals and for varying visual stimuli.

Thu 15:20 Civic room Virtual acoustics 3

"The Sound of My Town": an acoustical tour of Parma

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The project "The Sound Of My Town", born from a cooperation of the Industrial Engineering Department - University of Parma with the municipal institution La Casa della Musica, aims to record characteristic soundscapes of the city of Parma with a dual purpose: delivering to posterity an archive of recorded sound fields to document Parma in 2012 with advanced 3D surround recording techniques and creation of a "musical" Ambisonics composition for leading the audience through a virtual tour of the town. The archive includes recordings of various sound fields such as streets, squares, schools, churches, meeting places, public parks, train station, airport and everything is proper of the town. All the recordings are made employing an high quality 32 capsules spherical microphone array (Eigenmike®) and processed by means of a matrix of digital FIR filters for achieving a 3rd order Ambisonics format (16 channels, 3D). The virtual tour will be available inside the museum "Casa del Suono", either in a room equipped with a massive 189- channels Wave Field Synthesis system, designed for group listening, and in a more traditional, single-seat Ambisonics 3D room equipped with 16 loudspeakers.

Thu 15:40 Civic room Virtual acoustics 3

Validation of a Virtual Sound Environment System for Hearing Aid Testing

Jens Cubick[a], Sylvain Favrot[b], Pauli Minnaar[c] and Torsten Dau[d]
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Hearing aid users often have difficulties following a conversation in challenging listening situations, e.g. involving reverberation, background noise and multiple talkers. Loudspeaker-based sound field reproduction techniques like higher order Ambisonics allow for the simulation of such complex sound environments and can be used for realistic listening experiments with hearing aids. However, to successfully employ such systems in hearing aid development, it is necessary to know how experimental results from a virtual environment correlate with those from the corresponding real environment.

In this study, speech intelligibility experiments were conducted with normal-hearing test subjects wearing hearing aids, both in a real room and a simulation of that room auralised via a spherical array of 29 loudspeakers, using either Ambisonics or a nearest loudspeaker method. The benefit with respect to speech intelligibility from a static beamforming algorithm compared to a hearing aid setting with omnidirectional microphones was tested. While the speech reception thresholds were similar in both environments, the benefit from the beamformer setting was smaller in the virtual room. Measured directivity patterns for the hearing aids and interaural cross-correlation coefficients indicated that this was due to a more diffuse sound field in the virtual room.

Thu 16:00 Civic room Virtual acoustics 3

Auralization for office acoustic planning

Sebastian Goossens[a], Roman Stumpner[a], Michael Weitnauer[a] and Georg Brockt[b]
[a] *Institut für Rundfunktechnik, München;* [b] *Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA)*

A multi-media interactive DVD presentation concerning office acoustics was developed in cooperation with the ”Bundesanstalt für Arbeitsschutz und Arbeitsmedizin” (BAuA). The presentation can be utilized with the help of any standard web browser. With audio-visually prepared examples, the acoustic qualities of different office styling variants are made audible by using headphone playback (binaural).The acoustic impression is such that a listener would have the same auditive perception than in the respective room. By this means architects, civil engineers, project planners, clients as well as operators of office rooms and workplaces shall be sensitized to the necessity of acoustic design and departmental planning of the workplace surroundings. This audience can use the artificially created acoustic scenes for comparing the different measures of acoustic design with each other. The scenes are including the one persons office, the three person

office and the open-plan office with 30 workplaces. The presentation enables the user to switch between the different acoustic variants, in order to compare the hearing impression, while playing the respective scene. The additionally presented visual information, such as floor plans or perspective views of the room, are following up the acoustic changes. The Auralization was produced with IRTs software tool ”AUVIS”.

Thu 16:20 Civic room Virtual acoustics 3

Audio System using Binaural Synthesis for Multimodal Telepresence Applications

Esben Madsen, Miloš Marković, Søren Krarup Olesen, Pablo F. Hoffmann and Dorte Hammershøi
Aalborg University, DK

An audio system was developed as part of a multimodal system aiming to go beyond current state of the art in telepresence. This paper provides an overview of how the audio was implemented and documents measurements that were performed on the audio system. The measurements include equalization of microphones, headphones and loudspeakers as well as measurements of network latency and bandwidth requirements of the system. Furthermore, measurements were made to determine whether the level of echo and cross talk cause any issues. The overall system employs multiple modalities to virtually transport a person (the visitor) to a different physical location (the destination). The goal is that both the visitor and the people physically at the destination (the locals) should be provided with a sensation that the visitor is really there. Both the general multimodal system and the auditory part are implemented in a distributed manner. Body-tracking of all participants is provided through the system for the purpose of using binaural synthesis for directional sound. Head-worn microphones are used to capture sound, and the visitor is provided with directional sound through headphones. The visitor is represented to the locals through a physical representation (eg. a robot) with a loudspeaker.

Thu 16:40 Civic room Virtual acoustics 3

Latency evaluation of face-tracking systems

Wolfgang Hess
Fraunhofer IIS, Erlangen

Auditory virtual scene’s synthesis benefits from continuous adaptation to listener’s orientation and position. Using headphones, a head-tracking device can be assembled to the headband. If the virtual sound field is presented through loudspeakers, passive systems like camera-based face-tracking systems have to be used. Localization- and time-accurate, continuous robust capturing of the orientation and the position of the listener’s face is necessary to estimate the position of the listener’s outer ears in the sound field. Current software-based face-tracking technologies allow to use off-the-shelf webcams connected to a computer, hardware/software systems like the MS Kinect provide gaming consoles and computer applications. Low latencies are necessary to avoid smearing effects and inaccurate sound field adaptation. In this work, latencies of face-tracking systems

were evaluated optically by high speed camera capturing and by acoustical measurements.

Session "Signal processing"

Thu 8:40 Civic exhibition room Signal processing

Application of Scattering Nearfield Holography to In-Situ Measurements of Sound Absorption

Markus Müller-Trapet, Martin Pollow and Michael Vorländer
Inst. of Technical Acoustics, RWTH Aachen University

One of the major concerns of in-situ measurements and the deduction of acoustical parameters from these measurements is the determination of a reference signal of the sound source. While the concept of a calibrated sound source seems the most flexible, the position and orientation of the source in the actual measurement is very critical, especially for higher frequencies. Most in-situ measurement methods try to obtain the reference signal by time-windowing, effectively reducing the resolution in low to medium frequencies, depending on the setup.

This paper will examine the applicability of a spatial filtering technique called Scattering Nearfield Holography to the described problem. In this concept, incoming and outgoing waves are separated in the Spherical Harmonics domain by using measurements taken on two concentric spherical shells at two different radii. The theoretical and practical limitations will be discussed and first BEM simulation results will be evaluated. The results will be compared to classical spatial filtering techniques such as Spherical Beamforming and Plane Wave Decomposition.

Thu 9:00 Civic exhibition room Signal processing

Auto Adaptive Periodic Noise Cancelling

Martin Walzer
Rheinmetall Defence Electronics, Bremen

A multi-channel signal consisting of transient and periodic signals is received by a microphone array. This paper introduces an adaptive noise cancellation scheme for the elimination of multi-frequency, time variant, periodic noise while preserving transient parts of the received signal, which have their maximum spectral energy in the same frequency range. Therefore the periodic contents are estimated using modern spectral estimation techniques and are then cancelled in a way that distortions of transients are avoided. The proposed technique is compared to conventional approaches such as adaptive filters and adaptive comb filters. As no noise reference sensor is needed, the scheme is considered advantageous compared to conventional adaptive filtering approaches and as the transient parts of the received signal are only minimally affected by the algorithm, adaptive comb filters are outperformed. The performance is evaluated both synthetic and real data.

Thu 9:20 Civic exhibition room Signal processing

Improving speech intelligibility in background noise by SII-dependent amplification and compression

Henning Schepker[a], Jan Rennies[b] and Simon Doclo[a]

[a] *University of Oldenburg, Signal Processing Group;* [b] *Fraunhofer IDMT - HSA, Oldenburg*

In many speech communication applications (e.g. public address systems in train stations, mobile phones) it is of great interest to maintain a high speech intelligibility even in situations where speech is disturbed by additive noise and/or reverberation. One simple approach is to amplify the speech signal prior to presentation in order to achieve a good signal-to-noise ratio (SNR). However, often this is not possible due to technical limitations of the amplification system or unpleasantly high sound levels. Therefore, algorithms that improve the speech intelligibility while maintaining equal output power are desirable. In this contribution, we propose an algorithm that is capable of increasing the speech intelligibility in scenarios with additive noise. The algorithm combines time-and-frequency-dependent gain and compression characteristics that are computed based on the estimated SII. The performance of the proposed algorithm is compared to a state-of-art algorithm that uses only a time-and-frequency-dependent gain characteristic and to the unprocessed reference signal, both using objective speech intelligibility measures as well as subjective listening tests. Listening tests were conducted with eight normal-hearing subjects with two different noise types and at three different SNRs. Results indicate that the proposed algorithm outperforms the state-of-the-art algorithm in both noise scenarios at equal speech levels.

Thu 9:40 Civic exhibition room Signal processing

Real-time steerable directional sound sources

Arthur Berkhoff and Raymond van der Rots

TNO Technical Sciences, Acoustics and Sonar, The Hague (NL)

Within the eVader project, sound sources in cars are developed that have the objective to warn vulnerable road users while minimizing noise pollution. Nowadays, several sensor systems exist which are able to reveal the position of the vulnerable road users, which information can be used by the warning signal generator. Based on this information, the signal generator is designed to generate the specified warning signal at the location of the vulnerable road user while the acoustic response at other locations is minimized. The directional sound beam was realized with an array of controlled acoustic sources. Changes of the relative positions of the vehicle and the vulnerable road user require continuous adjustments of the sound beam. Different methods to generate the sound beam are described and experimental results are shown. Rapid real-time adjustment of the beaming direction is demonstrated.

Thu 10:00 Civic exhibition room Signal processing

Sound Field Classification in Small Microphone Arrays

Roman Scharrer and Janina Fels
Inst. of Technical Acoustics, RWTH Aachen University

A method for a fuzzy sound field classification is proposed. The method is designed for small microphone arrays like sound field microphones. The spatial coherences between the input signals are utilized as indicators for the classification. The classification is not influenced by the source signal. It is based only on spatial properties that are derived from the input signals. The target classes for the classification are the basic sound fields *free*, *diffuse*, *reactive* and *noise*. The method is able to estimate the energy distribution between the four target classes. The classification performance is verified with theoretic predictions from room acoustic theory as well as measured data.

Session "Otoacoustic emissions and cochlear modeling"

Thu 10:20 Civic exhibition room Otoacoustic emissions

Reconsidering Cochlear Travelling Waves, Implications for Otoacoustic Emissions

Hendrikus Duifhuis
University of Groningen

Let us go back to 1954 when Wever and Lawrence worked out the following agreement with von Békésy regarding the interpretation of his data:
- can be referred to as ... a travelling wave ... provided that nothing is implied about the underlying causes (i.e. how any given segment of the BM gets the energy that makes it vibrate) [PNAS 40:508-512].
The basic point is that the power transmission which allows a traveling wave like response is not forwarded through the cochlear partition, but through the cochlear fluid.
In a healthy cochlea, partition elements have nonlinear properties. This implies that (spectral) components are generated that were not in the stimulus. The generation is distributed over the entire range where the nonlinearity is operative. From these sites the distortion products (DPs) transmit "at high speed" through the cochlear fluid, interacting everywhere possible. The overall behaviour is readily analysed in a time domain approach of the nonlinear cochlea, whereas a frequency domain approach appears to lead to several misconceptions. Nonlinear behaviour in the distributed cochlear damping term is sufficient to account for many of the evoked otoacoustic emissions. Spontaneous emissions require an additional assumption about a number of low level power sources.

Thu 10:40 Civic exhibition room Otoacoustic emissions

Wave Decomposition of a Finite Element Model of the Cochlea

Steve Elliott and Guangjian Ni
University of Southampton, ISVR (UK)

The cochlea is a complicated structure, but its basic function can be understood using a simple model that describes the propagation of a single type of ”slow” wave. It is not clear how a number of geometric and physiological features of the cochlea complicate this simple picture, however, particularly in the generation of otoacoustic emissions. In this paper, a method will be described of decomposing the result of a finite element model of the cochlea, which can include a number of complexities, into wave components. Initial results are presented for a simple box model of the cochlea, which shows that for normal excitation at the stapes, the results of the full finite element model are very well approximated using only the component due to the forward travelling slow wave. The main exception is at positions just beyond the point of maximum response, where an evanescent, higher order, acoustic mode is also excited, although this does not appear to play a significant role in normal hearing function. Extensions to this model will also be discussed, in which the parameters of the cochlea model are not smoothly varying, which can give rise to the negative going waves that generate acoustic emissions.

Thu 11:00 Civic exhibition room Otoacoustic emissions

Assessment of the human ear’s non-linear amplification process by means of distortion product oto-acoustic emissions

Thomas Janssen
Hals-Nasen-Ohren Klinik, TU München

Cochlear outer hair cells (OHCs) are non-linear mechanical amplifiers which extent the dynamic range of hearing considerably. Distortion product oto-acoustic emissions (DPOAEs) which arise directly from the frequency-selective compressive nonlinearity of OHCs provide quantitative measures for assessing sensitivity, compression, and tuning characteristics of the cochlear amplifier (CA). DPOAE level I/O-functions mirror the CA’s compressive nonlinearity when elicited by a special setting of the two primary tones. Slope of DPOAE level I/O-functions was found to increase with increasing hearing loss and thus can serve for assessing loss of CA compression. Extrapolated DPOAE pressure I/O-functions allow for estimating cochlear hearing thresholds. DPOAE iso-suppression tuning curves mirror CA frequency selectivity at selected places in the cochlea exhibiting the V-shape of neural tuning curves. In a cochlear hearing loss the tip of the tuning curves disappears, revealing loss of both CA sensitivity and CA frequency selectivity. DPOAEs can assess characteristics of normal and impaired cochlear function and thus can provide parameters for cochlear modeling. They may have the potential for providing objective hearing-aid fitting parameters, especially in infants in which subjective audiometric tests fail to quantitatively determine cochlear dysfunction.

Thu 11:20 Civic exhibition room Otoacoustic emissions

Probing the nonlinear cochlear amplifier with Otoacoustic Emissions

Renata Sisto[a], Arturo Moleti[b] and Teresa Botti[c]
[a] *INAIL Research, Monte Porzio Catone;* [b] *Università di Roma Tor Vergata, Dipartimento di Fisica;* [c] *Università di Roma Tor Vergata, Dipartimento di Matematica*

Otoacoustic emissions (OAE) may provide a non-invasive way to probe the nonlinear basilar membrane (BM) response to external acoustic stimuli. At first approximation, each frequency component of the OAE response comes mainly from the resonant region, which is the reason for considering OAEs as a potentially powerful audiological diagnostic technique. Unfortunately, the relation between the BM response, which, for each frequency, is a tonotopic function of the cochlear position x, and the OAE response is quite complex, because OAEs are generated by different mechanisms localized at different cochlear places, each characterized by a peculiar dependence of amplitude and phase of the response on the stimulus level (or complex I/O function). Time-frequency filtering allows one to disentangle the different components of the response, and cochlear models provide the mathematical integral relation between the BM displacement function and the resulting OAE generation, for each generation mechanism. Therefore, in a rather indirect and model-dependent way, one is able to study the nonlinear properties of the BM response by analyzing the I/O curves of different types of otoacoustic emissions.

Thu 11:40 Civic exhibition room Otoacoustic emissions

Hearing threshold estimation using pulsed DPOAE

Ernst Dalhoff and Anthony Gummer
HNO-Klinik Tübingen

Hearing threshold estimation based on extrapolation of DPOAE I/O functions typically shows a standard deviation of the estimation error in the order of 10 dB. It has been debated whether estimation accuracy can be improved significantly if interference effects due to there being two sources for DPOAE generation are removed. Recently, we investigated a pulsed-f2 measurement technique for DPOAE in the frequency range 1.5 kHz $<$ f2 $<$ 2.5 kHz at stimulus levels of 25 dB SPL $<$ L2 $<$ 65 dB SPL, and showed that by sampling the DPOAE time signal at 8 ms post-onset, the contribution of the second source can be effectively reduced. Here, we use pulsed-f2 DPOAE growth functions (n=255) from 12 normal-hearing subjects to estimate audiometric thresholds and find a standard deviation of the prediction error of 4.1 dB, whereas in the same subjects the conventional continous-tone paradigm yields a standard deviation of 12.0 dB. Analysis of error sources contributing to the prediction error of the audiometric threshold leads to an estimated standard deviation of the prediction error of the threshold of the auditory periphery of 3.0 dB. We conclude that efficient removal of second-source interference effects can improve the diagnostic value of DPOAE considerably.

Thu 15:00 Civic exhibition room Otoacoustic emissions

Optimal Primary-Level and Primary-Frequency Ratios for the Measurement of Distortion Component Otoacoustic Emissions

Manfred Mauermann
University of Oldenburg, Medical Physics

Several authors suggested ”optimal” primary level differences (L_1- L_2) for distortion product otoacoustic emissions (DPOAE) in humans, some even in combination with a frequency specific variation of the frequency ratio f_2/f_1. The choice of a specific level and frequency- ratio paradigm clearly influences the outcome of DPOAE Input-Output functions. These are often used to estimate the status of cochlear compression, an objective hearing threshold or even loudness functions. Furthermore, all these estimates from classical DPOAE are disturbed by the effects of DPOAE fine structure, which is caused by the interference of mainly two cochlear DPOAE components, the distortion component (DCOAE) and the reflection component. The usage of the DP- Sweep method provides a fast alternative to measure DPOAE with the opportunity of a direct extraction of the DCOAE alone [J.Acoust.Soc.Am.(2008),124(3),1613- 1626]. This avoids the drawbacks of classical DPOAE measurements. However, a good DPOAE paradigm does not necessarily have to be a good DCOAE paradigm, e.g., since the two interfering DPOAE components are saturating at different levels. Therefore, the influence of different primary-level and primary-frequency ratio combinations on the DCOAE level was investigated in 10 young normal hearing subjects at 1.5,3 and 6 kHz for two different types of OAE-system calibration.

Thu 15:20 Civic exhibition room Otoacoustic emissions

Eardrum-based calibration of ear canal probes for improving hearing threshold estimation by means of extrapolated DPOAE I/O-functions

Thomas Fedtke[a], Thomas Janssen[b], Johannes Hensel[a], Volker Schirkonyer[b] and Makram Zebian[a]
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Distortion product otoacoustic emissions (DPOAE) reflect the non-linear amplification process of the cochlea when a special parameter setting that accounts for the non-linear motion of the basilar membrane is applied. Their detection in the ear canal can therefore be used for testing peripheral hearing function. Particularly, extrapolated DPOAE pressure I/O-functions allow the estimation of hearing thresholds.
The widely used in-the-ear calibration of the stimuli provides a way to adjust the stimulus levels properly. However, at frequencies above 3 kHz, the eardrum levels of the stimuli differ considerably from the levels measured by the probe microphone. By transforming these levels to the eardrum position, a sufficiently accurate prediction of the eardrum levels can be achieved up to 8 kHz.

The quality of DPOAE threshold estimation strongly depends on the stimulus paradigm used. One can assume that a more accurate stimulus calibration yields better threshold estimation. The results of a clinical study that compares estimated thresholds with subjective pure-tone thresholds indicate the advantage of the new calibration method.

Thu 15:40 Civic exhibition room Otoacoustic emissions

Vibration DPOAEs used to estimate Middle-ear Transduction for Differential Diagnosis of Hearing Loss

Anthony Gummer and Ernst Dalhoff
HNO-Klinik Tübingen

Distortion product otoacoustic emissions (DPOAE) are by-products of the active cochlear amplifier. Usually, they are measured as sound pressure in the ear canal (p-DPOAE), but can also be measured laserinterferometrically as vibration of the umbo (v-DPOAE). The combination of both, the p-DPOAE and the v-DPOAE, can be used to compute a partial middle-ear reverse transfer function which, when fed into a middle-ear model, allows robust estimation of model parameters. We show in data from guinea pig with normal and pathologic middle-ear function that the automatic fitting routine can detect individual middle-ear transfer properties, and that these middle-ear properties influence the DPOAE amplitudes significantly. Correlation between the slope of semi-logarithmically plotted DPOAE I/O functions predicted from the individual middle-ear parameters and the measured slope of DPOAE I/O functions yields a standard deviation of the threshold estimate of < 4 dB. Thus, middle-ear parameters estimated in this way can be used to improve the differential diagnosis of conductive and sensorineural hearing losses.

Thu 16:00 Civic exhibition room Otoacoustic emissions

Cochlear psychoacoustics - a modeling approach

Bastian Epp
Centre for Applied Hearing Research, DTU (DK)

Even modern hearing-aid algorithms are far from being able to fully compensate for deficits resulting from cochlear damage deficits. In order to develop new compensation strategies, detailed knowledge about how complex sounds are being processed by the cochlea is required.
Otoacoustic emissions provide a non-invasive technique to assess cochlear function, the direct link to perception is however unclear. On the other hand, psychoacoustical measures of cochlear function base on the assumption that cochlear processing can selectively be probed with psychoacoustical paradigms
To shed some light on cochlear processing of complex sounds, a nonlinear and active transmissionline-model of the cochlea was developed, accounting for a variety of data with a fixed parameter set. The model accounts for data on various types of otoacoustic emissions and shows plausible compression and suppression. It was successfully applied to simulate fine-structure effects in audiograms of normal-hearing listeners and to account for differences in modulation-detection near threshold finestructure. Also

key aspects of temporal integration near threshold are correctly reproduced by the model. The success of this model in this broad variety of experimental paradigms suggests that this model approach is a useful tool to bridge the gap between psychoacoustics and non-invasive physical measures of cochlear processing.

Thu 16:20 Civic exhibition room Otoacoustic emissions

The Bounce Phenomenon in Humans

Markus Drexl[a], Margarete Überfuhr[b], Lutz Wiegrebe[b], Robert Gürkov[a] and Eike Krause[a]

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Loud, non-traumatic low-frequency sounds can induce temporary changes in cochlear sensitivity coined the Bounce Phenomenon (BP). These changes are considered to originate from temporary alterations of cochlear homeostasis. Interestingly, the BP is often associated with a tinnitus-like sensation. Four non-invasive measures of the BP were studied in normal-hearing human subjects: DPOAEs, SOAEs, the absolute perceptual threshold, and the tinnitus percept were followed over time after low-frequency stimulation (30 Hz, 120 dB SPL, 90 s). The majority of the subjects showed significant, biphasic level- and phase changes of the quadratic, but not cubic DPOAEs and significant alterations of absolute thresholds. In addition, the level of SOAEs temporarily increased after cessation of low-frequency stimulation. All subjects reported a quite unusual, noise-like tinnitus sensation. These effects persisted for 60-90 s after the stimulation. These findings are discussed with respect to their foundations in cochlear homeostasis: We argue that strong, low-frequency stimulation temporarily induces changes in cochlear physiology as they may underlie inner pathologies like Menière's disease.

Thu 16:40 Civic exhibition room Otoacoustic emissions

The Bispectral Approach for the Analysis of Non-linear Contributions in Cochlear Active Mechanisms

Gabriella Tognola

CNR Inst. of Biomedical Engineering, Milano

This paper presents a new approach to study non-linearity in cochlear active mechanisms. Transient-evoked otoacoustic emissions (TEOAEs) were analyzed with the bispectrum to find out quadratic frequency couplings (QFCs) that occur when a frequency is not only generated by an independent cochlear generator, but it is linked to other cochlear generators. Detection of QFCs was done by using the third-order scaled polyperiodogram. The method was validated with simulated TEOAEs and was applied to TEOAEs of normal hearing adults and full-term neonates. Results revealed the presence of QFCs both in adult and in neonatal TEOAEs. Peculiar patterns and significantly different frequency content were found in the two groups of subjects: adults had QFCs mainly around 2 kHz and neonates had QFCs mainly in the range 3.5-4 kHz.

Thu 17:00 Civic exhibition room Otoacoustic emissions

Numerical simulations of the Transient-evoked Otoacoustic response

Arturo Moleti[a], Daniele Bertaccini[b], Teresa Botti[c] and Renata Sisto[d]
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Recent transient-evoked otoacoustic emission experiments (Goodman et al, 2011; Moleti et al., 2012) have reveled a complex time-frequency structure suggesting the superposition of TEOAE components of different latency and growth-rate. In particular, a short-latency component with close to linear growth has been observed, which could be attributed either to nonlinear distortion or to reflection from cochlear places localized more basally than the resonant place. Time-frequency analysis of the TEOAE response may effectively disentangle these components, but their generation mechanisms must be investigated by performing also numerical simulations using a suitable nonlinear cochlear model. The impulsive strongly nonlinear TEOAE response needs a solution in the time domain of the cochlear differential equations. In this study we discuss the results of TEOAE numerical simulations obtained with a nonlinear nonlocal cochlear model, discretized in the "monolithic" state space formalism scheme. Comparison of the simulation results with experimental TEOAE data suggests that reflection from basal cochlear regions may contribute significantly, at moderate to high stimulus levels, to the experimental TEOAE response. The diagnostic implications of these findings are also discussed.

Thu 17:20 Civic exhibition room Otoacoustic emissions

A Comparison of Spectro-temporal Representations of Audio Signals

Peter van Hengel
INCAS 3, Assen (NL)

Several methods exist to convert an audio signal into a represenation of energy over frequency and time. The use of particular methods seems to be domain specific and few comparisons have been made. For application in the study of real life sounds and the simulation of psychophysical and otoacoustic emission data we use a transmission line cochlea model. This model was compared to a wide variety of other methods on noise susceptibility and spectro-temporal detail. The model has already shown to provide a good match with both otoacoustic emission and psychophysical data and allows a detailed study of OAE generation.

Session "Robust speech recognition"

Thu 9:00 Cult. centre movie theatre Robust speech recognition

Detection of voiced segments in noisy speech as step towards a new robust recognition scheme

Andreas Kitzig, Frank Kremer and Hans-Günter Hirsch
Niederrhein University of Applied Sciences, Krefeld

Humans often understand the contents of speech in noisy environments by recognizing only certain fragments of the speech and extending this fragmental knowledge for the understanding of the whole utterance. These fragments are characterized by a high signal-to-noise ratio as measure for a high speech level in relation to the level of the background noise. We are working on the concept for a new robust recognition approach that is based on this human characteristic. As a first step we detect speech segments with a high speech level. The short-term energy can be taken as a first parameter for the detection. Usually, the segments with high speech level contain voiced speech. Thus, we use a measure of the voicing as a second parameter. The third parameter is a probability measure that the segment contains the spectral parameters of voiced phonemes. We present details of estimating and combining the three mentioned parameters as well as first detection results.

Thu 9:20 Cult. centre movie theatre Robust speech recognition

Binaural Scene Analysis and Automatic Speech Recognition

Constantin Spille, Mathias Dietz, Volker Hohmann and Bernd Meyer
University of Oldenburg, Medical Physics

The segregation of concurring speakers and other sound sources is an important aspect in automatic speech recognition (ASR) in difficult acoustic conditions. Computational Auditory Scene Analysis (CASA) techniques simulate aspects of processing properties of the human perceptual system using statistical signal-processing techniques to improve inference about the causes of audio input received by the system. This study uses a system containing a binaural model, a particle filter and a beamformer to improve ASR performance in multi-speaker conditions with spatially separated moving speakers in anechoic situations and situations with additional modulated diffuse noise at different signal to noise ratios. Compared to the unprocessed (mixed) data in an anechoic two-speaker condition, the word recognition rate obtained with the enhanced signals based on binaural information was increased from 30.8% to 88.4%, demonstrating the potential of the proposed CASA-based approach. In presence of a diffuse noise a significant increase in word recognition rates can also be observed. In addition to these results, the benefits of combining this system with state of the art ASR features and more high level CASA cues like the signal to noise ratio and reverberation time for complex ASR tasks are also shown.

Thu 9:40 Cult. centre movie theatre Robust speech recognition

SVM-Based Preprocessing for Automatic Speech Recognition

Hendrik Meutzner, Sarmad Malik and Dorothea Kolossa
Ruhr-Universität Bochum

In this contribution, we investigate the application of support vector machine (SVM)-based classification as a preprocessor for automatic speech recognition (ASR). The SVM is employed to estimate binary time-frequency (TF) masks for the suppression of additive noise of different types at varying signal-to-noise ratios. The efficacy of different feature sets is analyzed with respect to classification performance for unmatched conditions. The features are generally aimed at capturing amplitude modulation, estimated pitch, and structure in the cepstral domain for each TF unit. The binary masks generated using the optimal feature set are further processed by means of two outlier-removal mechanisms, i.e., cepstro-temporal smoothing and median filtering, which are then used to synthesize the denoised speech signal. Finally, the enhanced speech is used for the purpose of ASR via the hidden Markov model toolkit (HTK). We assess the utility of SVM-based preprocessing in terms of the ASR performance.

Thu 10:00 Cult. centre movie theatre Robust speech recognition

A German distant speech recognizer based on 3D beamforming and harmonic missing data mask

Juan Andres Morales Cordovilla, Hannes Pessentheiner, Pejman Mowlaee, Martin Hagmüller, Franz Pernkopf and Gernot Kubin
TU Graz

This paper addresses the problem of distant speech recognition in reverberant noise conditions incorporating microphone array and missing data techniques. The performance of the system is evaluated over a German database, which has been contaminated with noise of an apartment of the DIRHA (Distant Speech Interaction for Robust Home Applications) project. The proposed system is composed of three blocks. First, the beamforming block yields an enhanced temporal signal by applying a 3D convex-optimization given the target speaker direction as a prior knowledge. Second, the beamformer output is exploited to extract pitch and estimate the stationary part of the background noise. Third, the system produces a final noise estimation, by combining both the stationary noise part as well as the harmonic noise estimate obtained from the pitch. Finally, the filter-bank representation of the enhanced signal and its corresponding missing data mask obtained from this final noise estimate are sent to the speech recognition back-end. The purpose of this paper is to analyze, the impact of employing a beamforming stage followed by a missing data technique.

Thu 10:20 Cult. centre movie theatre Robust speech recognition

Model Based Distribution Equalization Applied on Spectro-Temporal Speech Features

Samuel K. Ngouoko Mboungueng[a], Martin Heckmann[b] and Britta Wrede[a]
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Previously, we applied a distribution equalization on our Hierarchical Spectro-Temporal (HIST) features using empirical distributions estimated from one or several utterances. Although a performance increase could be observed in both cases, we noticed low performance improvement by estimating the distribution using only one utterance. The aim here is to determine a parametric distribution from few data samples whose parameter estimates give the highest probability of producing the observed data. Afterwards, we perform a distribution equalization based on the estimated model after each feature extraction step of our HIST feature extraction framework. We use the TIDigits database and four noise situations for investigating such a model-based distribution equalization in our framework. Additionally, we compare the performance of the HIST features with those of conventional features (MFCC, RASTA-PLP), when a correspondingly distribution equalization has been carried out.

Thu 10:40 Cult. centre movie theatre Robust speech recognition

Stepwise Integration of Auditory Principles in Robust Automatic Speech Recognition Systems

Marc René Schädler and Birger Kollmeier
University of Oldenburg, Medical Physics

In the past, differently motivated approaches were found to improve the robustness of automatic speech recognition (ASR) systems in noisy environments. In a physiologically motivated approach, recognition performance was improved by integration of spectro-temporal processing. One set of features that encode spectro-temporal envelope modulations and respect the technical requirements of state-of-the-art back-ends are Gabor filter bank (GBFB) features. Then, in a rather technically motivated approach, recognition performance was improved further by combining GBFB features with mean and variance normalization (MVN) or histogram equalization (HEQ), especially when training on noisy data [Schädler and Kollmeier, DAGA2012].

In this study we take the next step in combining physiological and technical approaches in order to further improve robustness of ASR systems towards human-like performance. The traditionally employed logarithmically compressed Mel-spectrogram is replaced with physiologically inspired spectro-temporal representations that use compressions other than the logarithm. Additionally, multi-layer perceptrons (MLPs) are employed to further reduce the variability of features caused by additive noise or changed channel characterstics. Different combinations of spectro-temporal representation, spectro-temporal feature extraction, and normalization/variability

reduction are evaluated and compared in up to mid-size vocabulary, noisy ASR tasks.

Thu 11:00 Cult. centre movie theatre Robust speech recognition

New Results on Automatic Speech Recognition in Extremely Reverberant Environments

Christian Hofmann[a], Armin Sehr[b], Soyuj Sahoo[a], Roland Maas[a] and Walter Kellermann[a]

[a] *Chair of Multimedia Comm. and Signal Proc., FAU Erlangen-Nürnb.;* [b] *Beuth Hochschule für Technik Berlin, FB VII*

This paper analyzes the feasibility of automatic speech recognition (ASR) in an extremely reverberant foyer room with a full-band reverberation time of 4.0 seconds. The significant performance degradation in highly reverberant environments with reverberation times of up to 1.0 seconds might suggest that reliable ASR is not possible in such an extremely reverberant room. However, the experimental results presented in this paper show that a word accuracy of more than 80% can be achieved if the acoustic models are carefully adjusted to the reverberation conditions. These promising recognition rates can be explained by three main reasons:

1) Since the sound absorption strongly increases with increasing frequency in the analyzed room, the reverberation concentrates on the lower frequencies.

2) The long room impulse response leads to a significant smoothing of the speech signal so that the late reverberation component in the investigated room is more stationary than in less reverberant rooms.

3) A sophisticated training algorithm is used for adjusting the acoustic model to the room conditions.

Thu 11:20 Cult. centre movie theatre Robust speech recognition

Voice interaction in the Home environment: the DIRHA project

Maurizio Omologo, Alessio Brutti, Luca Cristoforetti, Marco Matassoni, Francesco Nesta and Piergiorgio Svaizer

Fondazione Bruno Kessler, Trento

Voice-enabled interaction with appliances available in a house is gaining major interest. The challenging aspect of the DIRHA project is the development of a distant speech interaction system, robust to speaker position, even in a noisy and reverberant environment and eventually in a multi-speaker and multi-room context. The vision is to allow the interaction at four-five meters from microphones in presence of multiple people, with music playing, and other possible active sound sources. The most advanced technologies resulting from the project will be integrated in real-time prototypes installed in automated homes, and daily used by the end-users for evaluation purposes. The main research fields are multichannel acoustic processing, distant speech recognition and understanding, speaker identification, and spoken dialogue management. The robustness of the speech recognizer is a strong requirement, in particular providing an effective enhancement of the desired speech and a rapid adaptation to the variable

acoustic conditions expected in the different rooms of the home; moreover, the ”always listening” mode implies that acoustic events and speech activities concurring in the given environment are correctly detected and classified. Another important goal regards the portability of the foreseen solutions: the resulting technologies could eventually be applied to several application contexts.

Thu 11:40 Cult. centre movie theatre Robust speech recognition

The EML Transcription Platform - a flexible transcription environment for robust speech recognition

Volker Fischer and Siegfried Kunzmann
European Media Laboratory GmbH, Heidelberg

In the past, research in robust automatic speech recognition has mainly focused on challenges like the presence of different kind of environmental noise or the limitation of the acoustic model size imposed by small devices such as mobile phones or onboard units in cars. Most applications in these areas have been focusing on the recognition of small to medium sized vocabularies employing grammars to improve recognition accuracy. Today, ubiquitous access to the Internet allows speech recognition applications to rely on the computational power of server machines and make use of previously prohibitively expensive decoding strategies and language models. At the same time, the scope of applications has broadened, ranging from real time personal information management applications to less time critical applications such as report dictation over the phone, voicemail-to-sms, or media and contact center analytics. In this paper we introduce the EML Transcription Platform, a speech recognition environment that can flexibly serve applications with contrasting demands. We investigate on the effects of audio streaming and real-time requirements, several strategies for online adaptation, and the usefulness of multi-pass decoding techniques in a robust speech recognition scenario.

Session ”Speech processing”

Thu 15:00 Cult. centre movie theatre Speech processing

Influence of top-down linguistic semantic processing abilities on temporal and spatial processing of a single speech reflection

Anna Warzybok[a], Jan Rennies[b], Thomas Brand[a] and Birger Kollmeier[a]
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Spatial processing of sounds is inevitably linked to binaural hearing. The present study addresses the mechanisms underlying the spatial and temporal processing of a single speech reflection by examining the contribution of low-level and higher-level processing. The relative importance of bottom-up processing versus cognitive, top-down processing is assessed by the comparison of speech intelligibility thresholds across natives and non-natives. A series of binaural speech intelligibility measurements was performed to investigate temporal and spatial integration of a single speech reflection in different noise conditions. The direction (0° to 315° in steps of

45°) and delay (0 to 200 ms) of the reflection as well as the spatial characteristic of the interfering noise (diotic, diffuse, or lateral) were varied. Generally, the trends observed for non-natives match those observed for natives. The estimated length of a temporal integration window, the binaural gain in the presence of non-frontal interferers, and the binaural suppression of a late, detrimental reflection did not differ between non-natives and natives. These findings indicate that temporal and spatial processing of speech reflections as well as binaural unmasking primarily reflect low-level bottom-up processing and are not affected by alterations in high-level top-down processing during the speech recognition process in human listeners.

Thu 15:20 Cult. centre movie theatre Speech processing

The Comparison of Vowel Space in Infant-Directed Speech and Read Speech

Jayanthiny Kangatharan, Maria Uther and Fernand Gobet
Brunel University (UK)

Speech aimed at infants and foreigners has been reported to include the physical exaggeration of vowels, that is vowel hyperarticulation. Although infant-directed speech contains hyperarticulated vowels sounds, it is unclear whether those acoustical qualities differ from other kinds of clear speech. The present study focused on the collection of speech samples produced by eleven mothers interacting with their infants and in another condition where they were asked to read sentences aloud in a clear voice. The phonetic measure of vowel space was compared across conditions. Results showed that mothers' articulatory vowel space in speech to infants was significantly more expanded than their vowel space expressed when reading sentences. This implies the use of increased vowel space as a didactic strategy in dialogue with infants to possibly aid infants' speech perception.

Thu 15:40 Cult. centre movie theatre Speech processing

Vocal tract estimation of nasals using smoothness priors

Christian H. Kasess and Wolfgang Kreuzer
Austrian Academy of Sciences, Acoustics Research Institute

Nasal stops and nasalized vowels are more adequately described using pole-zero models than all-pole models. Related to pole-zero models are branched-tube models where the zeros are generated by the side branches. Typically, the estimation of such branched-tube area functions applies a two-stage procedure, starting with a pole-zero model estimate acting as the basis for the area function estimation. However, the pole-zero description is more general and thus the branched-tube model is in general only an approximation to the unrestricted pole-zero model. Here, we demonstrate the usefulness of smoothness priors for a direct estimation of a branched-tube model for nasal stops in a single step utilizing the log-envelope spectrum. The estimation is based on a variational Bayesian scheme under Gaussian assumptions. Probabilistic priors are used on the reflection coefficients to regularize the solution enabling the inclusion of a-priori knowledge and assumptions. Here, the priors enforce smoothness of the tubes. Regularizing the solution too strongly leads to an increase in the

modeling error. For mild smoothness assumptions, the effect on the estimation error compared to a less or even unregularized estimation is small, however, there is a marked decrease of the intra-subject variability.

Thu 16:00 Cult. centre movie theatre Speech processing

The Influence of high-frequency Envelope Cues on Vowel Identification in low-pass filtered Speech

Wiebke Schubotz, Thomas Brand, Birger Kollmeier and Stephan D. Ewert
University of Oldenburg, Medical Physics

From a spectral point of view, speech signals are highly redundant, since similar information is present in different frequency regions. In the current study, vowel discrimination in consonant-vowel-consonant (CVC) logatomes [OLLO corpus; Wesker et al., Interspeech, 1273 (2005)] was assessed to examine the interplay of fundamental frequency (F0) information in different frequency regions. In the low-frequency region, F0 information is available in the temporal fine structure (TFS), while the auditory system has only access to temporal envelope information in the high-frequency region where F0 can be extracted from the periodicity of the temporal envelope. The CVC speech tokens used were either natural speech or generated by LPC-vocoding (both low-pass filtered at 2.5 kHz) and were masked using a 3 kHz low-pass filtered noise. An additional high-frequency stimulus (4-8 kHz) was presented simultaneously providing variable amount of speech features, ranging from F0 information transposed from the low-frequency region only, zero-crossings of the high-frequency speech part to bandlimited intact speech. Results showed a benefit for low-pass CVC discrimination only in conditions when either the zero-crossings of the original high-frequency speech stimulus were provided in the 4-8 kHz band or when the bandlimited speech itself was provided in that frequency region.

Thu 16:20 Cult. centre movie theatre Speech processing

Voice control for measurement devices

Constanze Tschöpe[a], Dieter Joneit[a], Frank Duckhorn[b], Guntram Strecha[b], Rüdiger Hoffmann[b] and Matthias Wolff[c]
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In many cases of executing measurements the testing engineer has no possibility to control the measurement device, for instance when he lays under a construction element or he has dirty hands because of the coupling fluid. Therefore we had the idea to use speech recognition. We developed a compact system which can be connected via USB port to the measurement device. All parameters which can be set via a graphical user interface the tester can adjust by speech us-ing a headset. We talked to producers of measurement devices and designed together with them a vocabulary including all necessary commands. Speech synthesis is used to repeat important parts of these commands. In this way the tester gets a feedback on the input. Of course the vocabulary can adapt corresponding customer wishes. Therefore the application of the system is not restricted

to measurement devices. We want to present the system and the results in detail and with many examples.

Thu 16:40 Cult. centre movie theatre Speech processing

Speech Enhancement Based on Formants Estimation

Ingo Schalk-Schupp[a], Mohamed Krini[a], Markus Buck[a] and Andreas Wendemuth[b]

[a] *Nuance Communications Deutschland GmbH;* [b] *Otto von Guericke Univ. Magdeburg*

In this contribution, a computationally efficient method for enhancing speech quality and intelligibility by identifying and accentuating formants in speech signals is presented. The proposed method first identifies frequency regions containing speech formants and then accentuates those regions using an adaptive gain factor. The detection of formants can be performed using e.g. LPC techniques for estimating the vocal tract information of a speech sound and then searching for the LPC filter's spectral peaks. A more efficient method is based on IIR smoothing of an amplitude spectrum along frequency using different smoothing constants. This method exploits the difference of a slowly varying and a fast varying spectral envelope for estimating the formants' respective widths and positions. Once the formants are identified, different weighting rules can be utilized to boost the speech signal. A promising rule is the use of shaped windows concentrated on the central frequencies of formants and stretched to their respective width. The gain values around the center of the shaped windows are dynamically adjusted depending on the presumed reliability of the formant estimation and combined afterwards with a regular noise suppression filter. Subjective evaluations indicated that the overall output quality can be enhanced - especially in high noise conditions.

Thu 17:00 Cult. centre movie theatre Speech processing

The influence of dynamic binaural cues on speech intelligibility

Jan Heeren, Giso Grimm and Volker Hohmann

University of Oldenburg, Medical Physics

Binaural cues help locating and segregating sound sources and can have a significant influence on speech intelligibility in complex acoustic conditions. Spatial separation of speech and noise maskers improves the speech reception thresholds (SRT). In binaurally ambiguous static listening conditions, however, the binaural intelligibility level difference (BILD) might become very small. Dynamic binaural cues, e.g., caused by minimal movements of sources or the listeners head, may resolve the ambiguity and thus may increase speech intelligibility. This study investigated the effect of dynamic binaural cues by measuring SRTs in dynamic conditions for four different combinations of presentation angles (S0N0, S0N180, S45N45, S45N135). For each combination, the target and noise signals were oscillating around their nominal position either synchronously, asynchronously, or were not moving. SRTs in all conditions were measured with Oldenburg Sentence Test (OLSA) with 10 normal hearing listeners. For the presentation of the acoustic sources a horizontal 3rd-order ambisonics system was

used. Movements were implemented as small modulations of the presentation angles. The results confirm the hypothesis that dynamic binaural cues may contribute to increased speech intelligibility. However, the data is statistically not significant. The data is presented and further improvements to the measurement conditions are discussed.

Session "Microphone arrays for aeroacoustics"

Thu 8:40 Cult. centre music room Arrays for aeroacoustics

Microphone Array Technology for Enhanced Sound Source Localisation in Cabins

Judith Kokavecz and Carsten Spehr
German Aerospace Center (DLR), Göttingen

Cabin noise generation is an important issue to accompany the weight saving strategies for pollutant emission reduction. The turbulent boundary layer generates vibrations on the fuselage which are transmitted and radiated into the cabin by the lining, the floor and the windows. In addition, the engine and system noise like the hydraulic system and the air conditioning unit contribute to the cabin sound field. To improve the noise-depending comfort in cabins the contribution of each the sound radiating lining and/or the air conditioning have to be seperated. The sound intensity measurement technique can be applied in this difficult environment (reverberant sound field) to measure the energy contribution of the lining. Nevertheless, this method is very time-consuming. Therefore, the department of Experimental Methods at the German Aerospace Center (DLR) Göttingen developed a new microphone array for inflight applications. With this array the sound source localization in reverberant environments like cabins is possible with average beamforming as shown at the inter.noise 2012. In this article a second method will be shown and compared to conventional and average beamforming method. The experiments were conducted in the DLR cabin test facility Do728 as a proof of concept and will be used for inflight measurements.

Thu 9:00 Cult. centre music room Arrays for aeroacoustics

The Current Understanding of the Spectral Broadening Effect by Turbulent Shear Layers

Stefan Kröber, Marius Hellmold and Lars Koop
German Aerospace Center (DLR), Göttingen

In aeroacoustic open jet wind tunnel testing the sound propagation through the turbulent wind tunnel shear layers is accompanied by several effects which may distort the original signal. One of these effects is the so-called "spectral broadening". This phenomenon results in a reallocation of acoustic energy of the sound wave into other frequencies. In case of a tonal sound source this effect leads to difficulties in the interpretation of aeroacoustic measurement results and can also lead to uncertainties by the

determination of absolute levels. In the context of aeroacoustic measurements of counter rotating open rotors and propellers these issues become more and more important. Though numerous experimental, numerical and theoretical studies have been performed, the physical mechanisms behind the spectral broadening phenomenon are not yet completely understood. The present work outlines the current understanding of the spectral broadening phenomenon. On the one hand a brief literature review of elementary work concerning this topic will be provided. On the other hand a comprehensive experimental investigation of the phenomenon of spectral broadening of monochromatic sound waves by wind tunnel shear layers is presented and evaluated in detail.

Thu 9:20 Cult. centre music room Arrays for aeroacoustics

Microphone-Array Measurements in Cryogenic/Pressurized Wind Tunnels

Thomas Ahlefeldt[a], Carsten Spehr[a], Stefan Kröber[a] and Jürgen Quest[b]
[a] *German Aerospace Center (DLR), Göttingen;* [b] *European Transonic Windtunnel GmbH, Köln*

In the development process of aircraft and rail vehicles, measurement techniques based on microphone-arrays are well-known and common practice on small-scaled models in wind tunnels with closed test section. Since conventional wind tunnels cannot generally achieve full-scale Reynolds numbers, measurements are often performed in cryogenic and/or pressurized wind tunnels which are capable of 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. For the application in cryogenic wind tunnels a microphone array was designed and constructed. Measurements have been conducted in the cryogenic wind tunnel DNW-KKK. An overview of the results is given using a single-rod confguration and an airplane half model as aeroacoustic noise sources. The results show a significant Reynolds number dependency of the measured sound power. On the basis of the knowledge gained from the DNW-KKK measurements the microphone array measurement technique has been further developed for use in cryogenic and pressurized wind tunnels. First measurements were performed on a single rod in the Pilot European Transonic Wind Tunnel (P-ETW), followed by tests on a scaled half-model in the ETW itself. Preliminary results are presented.

Thu 9:40 Cult. centre music room Arrays for aeroacoustics

Covariance Matrix Fitting for Aeroacoustic Application

Gert Herold, Ennes Sarradj and Thomas Geyer
BTU Cottbus, Chair of Technical Acoustics

Microphone arrays have become a useful and common tool for acoustic source localisation. In addition to the classical delay-and-sum (DAS) beamforming technique more sophisticated deconvolution algorithms like DAMAS or CLEAN-SC are widely used. These algorithms try to reconstruct a detailed source distribution map based on the rather blurred result obtained by the DAS algorithm.

The recent covariance matrix fitting (CMF) method pursues a different approach. It solves a convex optimisation problem in order to fit the unknown source powers to the measured cross spectral matrix through the sound propagation model.
In this contribution, the CMF method is applied to measurement data obtained for different setups in an aeroacoustic wind tunnel. The results are then compared with those acquired using beamforming and deconvolution algorithms. The accuracy of the method is discussed and some remarks on the computational cost are made.

Thu 10:00 Cult. centre music room Arrays for aeroacoustics

In-Flight determination of acoustic and hydrodynamic pressure fluctuations

Stefan Haxter and Carsten Spehr
German Aerospace Center (DLR), Göttingen

Pressure fluctuations underneath a turbulent boundary layer are responsible for the in-flight excitation of aircraft panels. Therefore, the characterization of these fluctuations is one important step towards modeling cabin noise generation. For this, in-flight and wind tunnel measurements of pressure fluctuations underneath a turbulent boundary layer were conducted. A transient pressure transducer array was used in a flight test in order to obtain properties of the boundary layer concerning the turbulent excitation of aircraft hull at full scale. The array was designed to distinguish between acoustical and convective waves in the wavenumber domain. Another feature of the array was the ability to extract the direction of flow directly out of the transducer phase data. The consideration of flow direction is important when investigating the convective transport of coherent structures in the turbulent boundary layer. Using the present array, the alignment of transducers with the flow is not necessary. A similar array was used in wind tunnel tests at equal conditions. Comparing the wind tunnel and in-flight data yields the possibility to examine the influence of scaling on the excitation characteristic. In the present work, an estimation of the magnitude of both acoustic and hydrodynamic fluctuation is compared for both measurements.

Session "Advanced measurement techniques: Operational TPA, force identification"

Thu 10:20 Cult. centre music room Advanced meas. techniques

Robust Force Identification for Complex Technical Structures with Single Degree of Freedom Excitation using an Adaptive Algorithm in Time Domain

Michael Sturm[a], Andy Moorhouse[b], Wolfgang Kropp[c] and Thomas Alber[d]
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Identification of dynamic forces acting on technical structures is a critical aspect of structure-borne sound and vibration problems. Many situations

require indirect methods since either the excitation location is not accessible for direct force measurements or the interfacial conditions, on which the actual forces depend, may change due to instrumentation. In this paper the problem is addressed where the location of the applied forces is fixed and assumed known. To solve this inverse problem, an indirect time domain identification technique based on an adaptive algorithm is presented. Given the structure's impulse response function and the operational response time history the method allows for recursively reconstructing the time signature of the applied dynamic force. The method is demonstrated for a sophisticated technical structure with single degree of freedom excitation. Numerical and experimental examples are used to investigate the robustness and accuracy of the time domain solution for cases in which the available data is assumed to comprise considerable noise and measurement errors.

Thu 10:40 Cult. centre music room Advanced meas. techniques

Structure-borne Sound Source Characterization using the Example of a Roof Air Conditioning Unit from a Railway Vehicle

Björn Knöfel, Welf-Guntram Drossel, Holger Kunze and Jan Troge
Fraunhofer IWU, Chemnitz

The vibrational behavior of structure-borne sound sources can be examined in many different ways. Within a research project at the Fraunhofer Institute for Machine Tools and Forming Technology IWU, vibration description methods are applied using the example of an air conditioning unit from a railway vehicle. The AC unit consists of several components, where usually the compressors and fans contribute most to the radiated sound power resp. to the transmitted structure-borne sound into the carriage. In a first step, forces and accelerations under steady-state conditions were measured on each of the 6 contact points of the air conditioning unit. Afterwards, all of the dominant vibration sources of the unit were individually investigated concerning its contribution relating to the overall level at the contact points. Finally, knowing the impedances of the contact points between sources and unit enables detailed analysis of the system itself. Moreover, it also indicates "weak points" which have to be avoided according to an improved vibrational behavior of the complete air conditioning unit.

Thu 11:00 Cult. centre music room Advanced meas. techniques

Numerical research on eigenfrequency shift and the change of mode shapes due to a crack in a beam model.

Martin Stache, Steffen Marburg and Marcus Guettler
Universität der Bundeswehr München

Modal properties of mechanical systems are affected by the change of the associated model parameters like mass, damping and stiffness. In this paper the authors investigate the change of eigenfrequencies and mode shapes due to a crack in a beam model and the sensitivity depending on the cracks' location along the medial axis. For this research the commercial finite element code ABAQUS was used. A frequency range up to 40 kHz is considered while only bending like mode shapes are taken into account.

Experimental results proof the validity of the numerical model. The results show a frequency range for different beam geometries in which the structural integrity can be checked by monitoring the change of modal properties.

Thu 11:20 Cult. centre music room Advanced meas. techniques

Scattering of transfer functions in TPA

Timo Lohmann
Bertrandt Ingenieurbüro GmbH

Transfer Path Analysis (TPA) is an easy and therefore widely used approach to calculate and auralize structure-borne sound contributions from a source to a receiver location. However, in many applications the transmitting structures are complex regarding physical properties, boundary conditions and environmental variables for example. On the other hand small variations within the structure can lead to large perturbations of natural frequencies and therefore significant variance in transfer functions especially with higher frequencies. For auralization purpose, it has been shown, that the number of filter modes must not necessarily be equal to the number of physical modes. Now the statistical properties for frequency response functions are determined in a simple case study and the effect on the calculated sound pressure output is investigated.

Thu 11:40 Cult. centre music room Advanced meas. techniques

Comparison of directly and indirectly measured forces for tire-road noise analysis

Bernd Philippen[a], Roland Sottek[a] and Payam Jahangir[b]
[a] *HEAD acoustics GmbH;* [b] *Fachhochschule Köln*

An important task of Transfer Path Analysis is estimating the forces induced by a source into a structure. In practice, it is usually very elaborate or sometimes even impossible to measure these forces directly. Hence, a commonly used approach is an indirect force determination based on operational accelerations and inverted inertance matrices gained from measurements with an impact hammer. A challenge of indirect force determination is considering a strong coupling of structure and source in an appropriate way to distinguish between different connection points. The suspension system of a car is such a strongly coupled system. A transverse control arm, which is a major transfer element of tire-road noise, is applied on a test rig for a detailed analysis. On one side the control arm with triangular shape can be excited by a shaker and on the other side it is connected via its two elastomeric bushings to the test rig. At each bushing a force sensor is placed to allow a direct measurement of induced forces in three dimensions. They are compared with indirectly-determined forces under manageable conditions. Conclusions will be drawn for the case when the transverse control arm is installed in the car.

Session "Flow acoustics"

Thu 15:00 Cult. centre music room Flow acoustics

Analysis of Flow-Induced Noise at a Simplified Car Model Depending on Various Setup Parameters

Stefan Müller[a], Stefan Becker[a], Christoph Gabriel[b], Reinhard Lerch[b] and Frank Ullrich[c]

[a] *Inst. für Prozessmaschinen und Anl.-technik, FAU Erlangen-Nürnb.;* [b] *Chair of Sensor Technology, FAU Erlangen-Nürnb.;* [c] *BMW AG*

Experimental investigations of the flow-induced noise and the resulting interior acoustics are presented. The turbulent flow field results in sound sources which transmit noise to the passenger cabin and in addition to that, the flow field excites vibrations of plane components resulting in the radiation of structure-borne noise. The overflown outer geometry of the simplified car model is identical to the SAE-body. The whole model is insulated acoustically in such a way that noise radiation to the interior is limited to the driver's door. The measurements were performed in an acoustic wind tunnel. In order to quantify the application of energy to different side windows, laser-scanning vibrometer measurements were performed. To modify the flow around the model, obstacles at the a-pillar and various side mirrors were mounted. Furthermore, unsteady pressure measurements were carried out at the window surface using 40 pressure transducers. Microphone measurements were conducted to generate a basis of comparison. The analysis of the coherence between different physical quantities allows for the identification of contributions to the interior acoustics. In addition, the comparison of spectra corresponding to different measuring positions, setup parameters and free-stream velocities enables the characterisation of flow-induced sound and transmission of sound to the interior.

Thu 15:20 Cult. centre music room Flow acoustics

Design and implementation of an aeroacoustic model-scale propeller test stand

Thomas Geyer and Ennes Sarradj

BTU Cottbus, Chair of Technical Acoustics

Using open rotors or propellers is a highly efficient concept for the propulsion of flight vehicles. However, they often have an increased noise generation that contrasts the advantage in efficiency and limits their use. For this reason there is considerable interest in understanding and predicting the noise generation of propellers and the development of potential noise reduction techniques. In this process, experimental tests are very important. While such tests with large propellers require a very high effort, they may alternatively be carried out on a model scale. Such aerodynamic and aeroacoustic tests require a wind tunnel capable of producing the relevant Mach numbers in a quiet flow.

In the presentation, the process of designing and constructing a test stand for acoustic and aerodynamic measurements on model propellers in the

small aeroacoustic wind tunnel at BTU Cottbus will be shown. Special attention is paid to the definition of crucial aerodynamic parameters that allow for the transfer of the model-scale results to existing propellers. For the purpose of illustration, aerodynamic and acoustic results from example measurements on a model propeller will be presented and discussed.

Thu 15:40 Cult. centre music room Flow acoustics

Zonal LES for axial fan broadband noise prediction: Part 1 - Experimental Study

Alessandro Zanon[a], Michele De Gennaro[a], Helmut Kuehnelt[a] and Domenico Caridi[b]
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Broadband noise prediction is a major challenge in computational aeroacoustics for many industrial applications. The objective of this paper is to provide to the scientific community a reference test- case for turbomachinery noise, assessing the potentialities of a novel breakthrough approach for CFD: the zonal LES. The test-case chosen is a 5-bladed axial fan in free field conditions with an outer diameter of 350 mm and an operating point at 1400 rpm whose aerodynamic and aeroacoustic performance have been investigated both from the experimental side (Part 1) as well as from the computational side (Part 2).
In the experimental part of the study the aerodynamics has been investigated by using the planar Particle Image Velocimetry technique (2D-PIV). The aeroacoustic measurements were performed in a fully anechoic chamber with multiple measurement high-sensitivity microphones placed around the fan. The measurements acquired have been successfully compared with CFD zonal LES simulations and constitute a complete and reliable experimental test- case to perform further studies and investigations.

Thu 16:00 Cult. centre music room Flow acoustics

Implementation of ISO 10302-1 to Investigate Noise and Performance of Refrigerator Fans: Practical Challenges and Experimentation

Ryan McKinlay
University of Canterbury

An investigation of noise generation and performance of small axial flow fans was carried out following ISO 10302-1. The subject of this investigation was a low tip speed pressed aluminium axial flow fan, as is used in small commercial refrigeration units. The fan was 200mm in diameter with five equally spaced blades. A plenum chamber test facility was constructed following ISO 10302-1. Sound power level measurements were made using a 10 microphone hemisphere array as described in ISO 3744. This paper discusses the practical challenges of effective implementation of ISO 10302-1 and presents experimental findings. The design process and design considerations are discussed, highlighting solutions for achieving acoustic transparency requirements of the plenum chamber. Details regarding practicality of construction and ease of experimentation are also

explored. Experimental data is presented, focussing on fan characterisation, effect of flow intake obstructions and repeatability of the measurement process.

Thu 16:20 Cult. centre music room Flow acoustics

Aeroacoustical Investigations of Skewed Axial Fans for Automotive Cooling Systems

Mohamed Zayani, Saban Caglar and Martin Gabi
Karlsruhe Inst. of Technology, FG Strömungsmaschinen (FSM)

The noise emission of axial fans for automotive cooling systems has a considerable contribution to the sound emission of the vehicle. The target of many investigations is to find measures to reduce the noise of the fan. The scope of this project is to investigate the influence of skewed blades on the aerodynamic and acoustic behaviour of axial fans. Therefore, axial fans with different skewed geometries were built and measured. The variations include unskewed, backward and forward skewed blades. The strength of the skew is also a variation made in this approach and includes different form for forward skewed axial fans. The aerodynamic comparison between the different skewed fans shows a very satisfactory result, as the prescribed goal, of same aerodynamic condition, has been achieved. The comparison of the acoustic graphs shows the best result with the strong forward skewed fan and the disappearance of the humps next to the blade passing frequency in the spectra. To explain the influence of the skew of the blades on the main and the gap flow of the fan, more experimental and numerical investigations were carried out. The results of these investigations are presented and analyzed.

Thu 16:40 Cult. centre music room Flow acoustics

The flow over a cylinder-plate-configuration: FSI-Simulation of the hysteresis-effect and conclusions for the acoustic phenomenon

Robert Heinze
University of Applied Sciences Düsseldorf

When a cylinder is exposed to a uniform flow, vortices are shed alternately from either side of the cylinder into the wake. In a certain range of the Reynolds number the shedding frequency is dominant in the narrow band spectrum of an acoustic measurement and can be noticed as a whistling-sound. An interaction of bluff bodies can generate higher sound power levels than a single cylinder. Especially for the interaction of the cylinder-plate-configuration the generated noise can be amplified enormously by the insertion of a plate behind a cylinder. There is a critical cylinder-plate-distance where the sound power level reaches its maximum. This distance depends on the Reynolds number, the turbulence intensity and the traverse direction of the plate (flow direction or anti-flow direction). Below a certain distance the alternating vortex separation stops and the system behaves like one body. It was found out that the peak sound power level can be measured at comparatively lower distances when the plate is traversed in anti-flow direction. This hysteresis-effect can be explained by means of a

FSI-Simulation where the plate distance is initially enlarged in flow direction and finally reduced in anti-flow direction. The Q-Criterion is used to visualize these flow phenomena.

Thu 17:00 Cult. centre music room Flow acoustics

Noise Control on Flap Side Edge

Johann Reichenberger
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Efficient aircraft noise reduction is a major factor for the continuing growth of civil aviation. Within the last decades large effort has been spent to successfully reduce the engine noise contribution. During landing approach, however, airframe noise is of comparable importance as the engine noise. Therefore, further noise reduction studies consider also the major airframe sources, i.e. landing gears and high lift devices. High lift device sources are usually differentiated in to the slat sources and the flap side edge source, latter being the main focus of the present paper. Studies have been performed within the last years on the mechanisms and the modelling of high lift device noise sources, providing a number of numerical, semi-analytical modelling approaches for the local flow unsteadiness, which is the drive of the farfield acoustics. Also remarkable reductions of flap side edge noise at the source have been demonstrated by designs such as e.g. flap fences or porous side edges in model scales. The present work shall provide a further step in design optimization of a low noise flap side edge by performing a systematic and parametric wind tunnel study on a large scale wing with deployed slat and flap.

Thu 17:20 Cult. centre music room Flow acoustics

Sensitivity Study of the Sound Radiation of Aircraft Engine Compressors According to Different Inlet Conditions

Sina Witthaus, Michael Bartelt and Joerg R Seume
Leibniz Univ. Hannover, Inst of Turbomachinery & Fluid Dynamics

Since a further increase of air traffic of both passenger and freight transportation is predicted, the sound generation of aircraft engines becomes a main aspect within the design process. In this paper the modal sound transport and the sound emission of an aircraft engine compressor is investigated. For this purpose a simplified two-dimensional compressor inlet, consisting of an open channel segment with an adjacent annular duct, is modeled. The impact of the hub-to-tip-ratio, the flow field Mach-number, and the incident angle of the inflow on the sound radiation of the compressor model is studied. For that only the most dominating modes are regarded, which are implemented into the acoustic domain. A hybrid CFD/CAA-approach is employed to calculate the mode propagation through the geometry into the nearfield of the compressor, while the resulting sound radiation into the farfield is predicted by a farfield approximation. The most influencing parameters are worked out and the results are discussed in detail.

Session "Structure-borne sound and vibration 2"

Thu 8:40 Cult. centre exhib. room Structure-borne sound 2

Determination Of Coupling Loss Factor For Plates Coupled In Right Angle To Form Welded, Riveted And Bolted Joint.

Vinayak Patil and D Manik
Indian Institute of Technology, Bombay

In this study, vibrational energy distribution within the audible frequency range is considered for two plates. The plates are connected to form a welded joint (line connection), riveted and bolted joint (point connection). The mathematical model for the joints is developed using a spring and dashpot model. The wave approach is used to analyze the mathematical model of the coupled plate and the bending wave transmission and reflection efficiencies are determined. The coupling loss factors are determined using these bending wave transmission efficiencies and are compared with experimental results. SEA model of the coupled plates has been presented using the above coupling loss factors. Extensive measurements are carried out to validate the coupling loss factor determined from the wave approach. A fairly good agreement is observed for coupling loss factor by experiment and theory. The weld joint is having the highest coupling loss factor in comparison to rivet and bolt joint at higher frequencies in the range of 3150 Hz to 10000 Hz. This difference is because of high transmission efficiency due to continuous contact between the two plates and high stiffness values of weld joint due to a larger moment resisting area compared to the rivet and bolt joint.

Thu 9:00 Cult. centre exhib. room Structure-borne sound 2

Design and Operation of an Acoustic System for Traveling Wave Excitation

Christopher E Meinzer, Oliver Freund and Joerg R Seume
Leibniz Univ. Hannover, Inst of Turbomachinery & Fluid Dynamics

An important excitation mechanism for vibrations in turbomachinery is forced response which refers to forced excitation by wakes from upstream blade rows or vanes. Due to the cyclic symmetric character of their mounting, turbomachinery blades vibrate in traveling-wave modes wherein each blade executes the same but phase-lagged motion to its neighbor. A challenge in vibration testing of turbomachinery blade-disk assemblies and blade integrated disks so called blisks, is the transfer of measurement signals from the rotating to the stationary domain. This can be overcome by rotating the excitation pattern, while keeping the instrumented specimen fixed. For this an acoustic excitation system that uses phase-shifted sine signals for traveling-wave excitation is designed and built. The signal generation is completed using a field-programmable gate array (FPGA) and one compression driver for each corresponding blade. The acoustic excitation principle has the advantage of working fully contact-free, thus being ideal for investigating structural vibration. Using this principle the eigenfrequencies of the specimen are not changed. The system is calibrated and the traveling-wave excitation is validated using strain gauges and a laser

scanning vibrometer on a simplified blisk specimen. The system is now regularly used in aeroelastic and aeroacoustic research and education at the institute.

Thu 9:20 Cult. centre exhib. room Structure-borne sound 2

Experimental Investigations into the Acoustic Black Hole Effect and its Applications for Reduction of Flexural Vibrations and Structure-Borne Sound

Elizabeth Bowyer and Victor Krylov
Loughborough Univ., Dep. of Aeronautical and Automotive Eng. (UK)

In this paper, a review of experimental investigations into the damping of flexural vibrations and the reduction of radiated sound power using the acoustic black hole effect is presented. The acoustic black hole effect damps flexural vibrations by reducing edge reflections from structures' free edges via the use of wedges or tapered circular indentations of power-law profile. Wedges of power-law profile materialise one-dimensional acoustic black holes for flexural waves that can absorb a large proportion of the incident flexural wave energy. In this connection, the damping of flexural vibrations in turbofan blades with trailing edges tapered according to a power-law profile is described. Tapered circular indentations of power-law profile act as two-dimensional acoustic black holes for flexural waves. Experimental investigation into the addition of such indentations into smooth surfaced composite panels and composite honeycomb sandwich panels are reported. Finally, the results for multiple indentations (arrays) of two-dimensional acoustic black holes in steel plates and the associated reduction in structure-borne sound are given. The reported results demonstrate that the acoustic black hole effect can provide an effective damping of flexural vibrations in the aforementioned blades and panels, as well as an effective reduction of sound radiation from structures.

Thu 9:40 Cult. centre exhib. room Structure-borne sound 2

Data transfer between OEM and supplier: Annotations to the use of operational data amongst different parties

Markus Bauer
Adam Opel AG

Original equipment manufacturers (OEM) develop vehicles in close collaboration with component suppliers. Usually the OEM states certain requirements the component has to fulfill and the development responsibility is with the supplier. In well-defined steps the development status is checked and often agreed of both parties. Nowadays a lot of suppliers work with so-called 'Road-to-Lab-to-Math' (RLM) strategies to develop the components. This results in data of prototypes measured on test rigs, rather than in vehicles. Also the OEMs follow the RLM strategy and do not have an unlimited number of prototype vehicles to test the current state of the components in real life and with subjective evaluation. Measured operational data from supplier test benches shall be used to show the development progress and to decide which measures are to be taken to integrate the component in even different vehicles or vehicle programs. The presentation is to show

certain possibilities of data strategies and their integration in acoustical, vibro-acoustical and dynamic structural environments. Usual operational acceleration, operational forces and sound pressure measurements are discussed, just as advanced techniques like free velocity or blocked force. Ways are shown to predict components in vehicles without assembly and critical spots, known from experience, are discussed.

Thu 10:00 Cult. centre exhib. room Structure-borne sound 2

Approximate Description of Structure-borne Sound Sources with Continuous Line-shaped Contact Interfaces

Sebastian Mathiowetz and Hannes Bonhoff
TU Berlin, Institut für Strömungsmechanik und Techn. Akustik

A majority of research concerning the characterization of structure-borne sound sources focuses on sources with multiple discrete contact points. With respect to the generally complex process of sound transmission between source and receiver, efforts have been made in finding simplified methods for source characterization and calculation of the power injected into adjacent structures. However, there is a lack of studies investigating the applicability of approximate methods to source structures with continuous line-shaped contact interfaces. Existing methods can generally be applied to a continuous connection by means of discretizing the interface. Hereby, proof must be taken that assumptions inherent in approximate methods are valid for continuous installations as well. This work investigates the accuracy of several methods to be expected with regard to power transmission. The study is based on analytical models as well as experimentally collected data from sources with generic line-shaped interface geometries connected continuously to plate-like receiver structures.

Thu 10:20 Cult. centre exhib. room Structure-borne sound 2

Evaluation of Structural Sound Path Modification Methods for the Reduction of Structure-Borne Sound Transmission in Aircraft Fuselage Structures

Felix Langfeldt[a], Fabian Timmo Seebo[a], Wolfgang Gleine[a] and Otto von Estorff[b]
[a] *Hamburg University of Applied Sciences;* [b] *Hamburg Univ. of Technology, Inst. of Modelling and Computation*

State-of-the-art aircraft fuselage design focuses primarily on static and fatigue dimensioning aspects. To reduce cabin noise caused by the exterior sound field, sound reduction means are applied without revamping this fuselage design. Especially with innovative, acoustically much more challenging engine technologies, such as the counter-rotating open rotor, an optimized primary structure considering both mechanical and acoustic design aspects could significantly reduce sound transmission between different fuselage sections compared with the conventionally designed fuselage.
In this paper a modification of a traditional fuselage section interconnection is proposed to increase the vibro-acoustical isolation efficiency of the primary structure. To analyze the effectiveness of the proposal, two steps

were performed: first, the basic vibro-acoustic mechanisms of the modification were investigated physically using experimental, analytical and numerical methods. Second, the structural modification was applied to a finite-element model of a simplified aircraft fuselage. Using the simulation results, the acoustic effectivity of the approach was evaluated and compared with an equivalent traditional design.

Thu 10:40 Cult. centre exhib. room Structure-borne sound 2

Estimating structure borne noise by the kinetic energy

Matthias Klaerner[a], Steffen Marburg[b] and Lothar Kroll[a]
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The sound power is a common measure for the sound emission of radiating components. This requires the determination of the sound intensity in normal direction and - in numerical simulations - the sound pressure on the radiating surface. Neglecting local effects and assuming a unit radiation efficiency all-over the surface, the equivalent radiated power (ERP) is a common approach for an upper bound of structure borne noise. Therein, sound pressure is assumed to be the product of the fluid's characteristic impedance and the surface velocity. Thus, the sound power finally results from the squared velocity integrated over the radiating surface and the fluid impedance. In contrast, the kinetic energy is an important measure of structural dynamic simulations and investigations. As ERP usually requires extra post processing considering the normal surface direction and velocity, the kinetic energy is essential in common FEA results including all velocity components apart from the normal direction, too. Moreover, ERP necessitates the knowledge of the radiating surfaces increasing the effort especially for complex geometries. Thus, the possibilities and limits of estimating the emitted sound power by the kinetic energy will be shown on two simple examples: a rectangular plate and a thin-walled bonded part - both linear isotropic.

Thu 11:00 Cult. centre exhib. room Structure-borne sound 2

Transfer Path Analysis of Multi-Structure Acoustic Systems Using a Simplified Measurement Object

Samira Mohamady, Michael Vorländer and Markus Müller-Trapet
Inst. of Technical Acoustics, RWTH Aachen University

Sound energy produced by heavy machinery surrounds our everyday life. Vibro-acoustic analysis of such a system leads to identify the problem to eliminate unnecessary noise generation. Most of the sound generators can be entitled to multiple structure acoustics system due the coupling of structure and fluid in most of the machines. The flow of vibro-acoustic energy can be obtained using Transfer path analysis (TPA). The aim of the present study is to predict and evaluate the sound energy propagat through multiple structure acoustics system using TPA. The system is a rectangular enclosure with 2 aluminum plates placed perpendicular in the center of the arrangement. In order to perform a full TPA, operational deflection shape analysis of the systems is moreover carried out. The results are also

estimated using the finite element method (FEM). In this study COMSOL Multiphysics© is used as FE software.

Thu 11:20 Cult. centre exhib. room Structure-borne sound 2

Model updating of a fuselage structure by using metaheuristic methods

Simon Stahl and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

The dynamic behaviour of the fuselage affects the interior acoustics of aircrafts significantly and therefore needs to be considered within the design process. To investigate the dynamics, numerical methods like the Finite Element Method (FEM) are often used. The general validation of the FE models has to be done by experiments.

Parameter uncertainties in the simulation due to insufficient material data or varying geometrical dimensions cause discrepancies between the dynamics of the real structure and the FE model. If the correlation is poor, a model updating becomes necessary, whereby selected model parameters are changed. The quality of the updating procedure is influenced by the selection of the parameters as well as by the choice of the objective function and the optimization method. For investigating complex optimization problems metaheuristic methods have proved themselves as they enable an efficient solution nearly independent from the formulation of the objective function.

The model updating results of a fuselage structure are presented by using two heuristic methods: Evolutionary Algorithm (EA) and Simulated Annealing (SA). Thereby the efficiency of these methods is generally investigated. As there are no measurement results for the fuselage model two generic models are compared instead.

Thu 11:40 Cult. centre exhib. room Structure-borne sound 2

Interpretation of velocity orders in the concept of interface mobilities

Agnes Sayer and Hannes Bonhoff
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In former work the interface mobility concept was introduced to characterize structure-borne sound sources. This approach provides a computation of the transmitted power from a source into a receiver for discrete contact points. In this concept, the active and passive characteristics of source and receiver are Fourier transformed into orders, which represent parts of the movement. Furthermore, the source descriptor and coupling function concept can be applied. Recent research deals with manipulation of velocity and interface mobility orders. The aim is eliminating dominant source descriptor and coupling function orders, which can result in a decreased transmitted power. Additionally, velocity orders give a physical insight in the transmission process. With knowledge of the significance of the orders, the method offers potential to derive low-noise design arrangements for machines. In a numerical study the interpretation of orders in typical frequency regions is analyzed and the possibility of low-noise design approaches are shown.

Session "Noise control for machinery and domestic environment"

Thu 15:00 Cult. centre exhib. room Noise control for machinery

Numerical Investigation of Aeroacoustic Sound Sources in Encapsulated Helicopter Tail Rotor

Jae Hun You and Christian Breitsamter
Inst. of Aerodynamics and Fluid Mechanics, TU München

An encapsulated tail rotor, known as Fenestron, consists of a one-stage fan (rotor and stator) mounted in the helicopter fin. In contrast to an open tail rotor, the encapsulated tail rotor ensures peripheral protection and acts as an acoustic shield. Furthermore, the rotor blades are circumferentially distributed with uneven spacing to reduce the acoustic tonal energy at blade passing frequency (BPF). However, accurate and detailed predictions of noise sources remain challenging for such complex configurations. In the framework of the research network FORLärm, numerical aeroacoustic investigations on a light weight transport helicopter with encapsulated tail rotor are conducted with a view to understand the noise generation mechanisms. Unsteady Reynolds Averaged Navier-Stokes (URANS) simulations are performed based on a structured mesh with minimum simplification to calculate the flow field around and inside of the Fenestron. Note that the main rotor and its down wash effects are not considered in the present study. Both forward and hover flight conditions are here analysed. The instantaneous flow quantities obtained by CFD simulations are post processed to extract the radiated sound to the far field. To compute the sound pressure in acoustic far field, the Ffowcs Williams and Hawkings (FW-H) surface integral formulation is adopted.

Thu 15:20 Cult. centre exhib. room Noise control for machinery

Psychoacoustic Aspects of Helicopter Sounds

Hugo Fastl[a], Jakob Putner[a], Jae Hun You[b], Christian Breitsamter[b] and Philipp Krämer[c]
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In the framework of the research network FORLärm, psychoacoustic aspects of helicopter sounds are studied. The partner from industry is Eurocopter, and from the Technische Universität München the groups of Aerodynamics as well as Technical Acoustics are involved. As a first topic of the cooperation, the noise produced by a shrouded tail rotor of a helicopter (Fenestron) is assessed, which essentially can be regarded as a ducted fan. Based on problem specifications by Eurocopter, the Aerodynamics group of TU München performed unsteady Reynolds Averaged Navier-Stokes (URANS) simulations on a structured mesh with minimum simplification to calculate the flow field around and in the Fenestron. To compute the sound pressure in the acoustic far field, the Ffowcs Williams and Hawkings (FW-H) surface integral formulation was adopted. After time-consuming simulations, 170 ms of time-signal were obtained by the Aerodynamics group. These signals were further processed by the Technical Acoustics group. First, they were looped in order to enable the analysis by

algorithms, based on the results of psychoacoustic experiments. Then distributions of instrumental loudness were calculated and analysed in terms of hearing sensations. Data are discussed in view of the loudness and pitch of the simulated helicopter sounds at different spatial positions.

Thu 15:40 Cult. centre exhib. room Noise control for machinery

Computation of Vibro-Acoustic Response caused by Aerodynamic Loads at Low Frequencies for Automotive Industry applications

Andreas Businger and Reinhard Lerch
Chair of Sensor Technology, FAU Erlangen-Nürnb.

The significance of aeroacoustics in the automotive industry has strongly increased within the last years. At current series vehicles, the sound pressure level (SPL) inside the car is predominated by wind noise at speeds of approximately 120 kph and higher. In the past, low frequency range below 300 Hz was dominated by powertrain or tire-road noise. However, nowadays low frequency wind noise can also be perceived disturbingly. The low frequency wind noise is primarily caused by detached flows and eddies in the underbody area and around the car body. If a structural mode and a mode of the interior cavity match at the same frequency, very unpleasant booming effects can occur. This depends on the mode shapes of the structure and of the acoustic cavity and their corresponding damping factors. It is possible to get very exact structural vibration data from simulations or laser-scanning-measurements. In this contribution a method is presented to evaluate the SPL at the driver's ear position that results from this given structural vibration. In order to predict the SPL inside the car, a dedicated finite-element-method is used. Measured and evaluated parameters like absorption and impedance are applied to get realistic SPLs inside the car.

Thu 16:00 Cult. centre exhib. room Noise control for machinery

Investigations on Spatial Coherence of Surface Pressure in the Wake of a Car's Side Mirror

Christoph Gabriel[a], Stefan Müller[b], Frank Ullrich[c] and Reinhard Lerch[a]
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Due to the rising convenience standard, the interior cabin noise gains more importance in car design. One essential parameter is the structure-borne noise of the side window. This noise results from a turbulent boundary layer as well as large eddy detachments and acoustic sources caused by the side mirror and the a-pillar. Therefore, it is of great interest for car manufacturers to understand about coherence characteristics of surface pressure on the side window. To gain a deeper insight into these characteristics, a new kind of sensor array was developed that consists of sparsely positioned pressure transducers mounted on a printed circuit board. Because of its small size it allows measurements at various test areas on the side window, which is a major improvement compared to former investigations. Thereby, the existence of acoustic loads and the position-dependent spatial coherence of the surface pressure can be studied. The measurements were carried out in the anechoic wind tunnel of BMW in Munich, Germany,

on a generic car model with and without side mirror using different wind speeds. Results are presented concerning the identification of coherence parameters of the turbulent boundary layer, flow direction and the separation of hydrodynamic and acoustic pressure.

Thu 16:20 Cult. centre exhib. room Noise control for machinery

Influence of Edge Geometry of Automotive Body Gaps on the Interior Noise

Stefan Schimmelpfennig and Reinhard Lerch
Chair of Sensor Technology, FAU Erlangen-Nürnb.

One of the most severe sources of sound in automotive aeroacoustics is the gap between the car's roof and its rear lid, as can be found at hatchbacks or station wagons. The combination, consisting of the gap and the volume underneath, generates a Helmholtz resonator, which is driven by the grazing flow instabilities during the ride. Up to now, the excitation mechanisms of the resonator are not completely understood. We have performed wind tunnel measurements of a real car, in order to provide more knowledge about the excitation mechanisms. For this purpose the main approach is giving the geometry of the gap's leading and trailing edge a round instead of a sharp shape. The sound pressure levels resulting from that geometric variation were measured inside the resonance volume with surface microphones, inside the passenger compartment with artificial heads and in the far field with an array. The comparison of the pressure fluctuations inside the resonance volume shows the high impact of the mouth geometry and, moreover, it reveals the corresponding frequency bands. Interpretations of the relation between edge geometry and frequency and its meaning for the sound pressure level inside the car will be presented according to the driving velocity.

Thu 16:40 Cult. centre exhib. room Noise control for machinery

Influence of Various Parameters on the Noise Emission of Air-Cooled Systems with Forced Convection

Sven Muensterjohann[a], Stefan Becker[a], Jens Grabinger[b], Stefan Ullrich[c] and Sebastian Weiß[d]
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Forced air-cooling is necessary to transport the heat resulting from the increasing power consumption and higher density of electronic devices. The required air-flow and of course the fans produce noise which is emitted into the surrounding environment. In order to reduce the noise emission it is necessary to identify the influence of various parameters of the cooling-system. Therefore two experimental set-ups have been constructed: one for a single measurement device with an internal fan and one model of a cooling unit of a frequency converter. For both set-ups it is possible to vary a range of parameters like variably perforated sheet metal housings, obstacles controlling the air flow, fan speed and conduction of the air flow. Additionally acoustic simulations of the electronical measurement device

with artificial acoustic sources have been performed. The second set-up has been simulated with plane acoustical waves entering the cooling unit of the frequency converter. The simulations show the acoustic behaviour of the systems excluding the influence of the air-flow. The results include acoustic modes and transfer functions.

Thu 17:00 Cult. centre exhib. room Noise control for machinery

Numerical Investigation of Noise Generation Mechanisms in Ventilation Systems using Scale-Resolving Techniques

Christoph Scheit[a], Peter Horn[b], Johannes Weber[a] and Stefan Becker[a]
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Within the Bavarian Research Cooperation for Noise Reduction in Technical Equipment (FORLärm) one of the aims is the investigation of the noise generation mechanisms in ventilation systems of energy-saving buildings. Both, experimental as well as numerical methods are employed to identify the mechanisms involved. In order to simplify the numerical and experimental model, a generic climate-duct has been designed. A rib of fixed height and adjustable length is mounted inside the channel. Numerical simulations of the turbulent flow over the rib mounted inside the channel are presented based on scale-resolving techniques. Parameters studied include different inflow conditions, the modeling approaches for the unresolved scales and the rib length. Aeroacoustic source generation and propagation is calculated in a second step based on the unsteady velocity field obtained from the flow simulations. The acoustic propagation equation used is Lighthill's acoustic analogy. Simulation results for the different parameters are compared to each other and with experimental results.

Thu 17:20 Cult. centre exhib. room Noise control for machinery

System for Spatial Resolved Sound Field Measurements

Peter Horn[a], Jochen Metzger[b], Michael Wüst[a] and Reinhard Lerch[a]
[a] *Chair of Sensor Technology, FAU Erlangen-Nürnb.;* [b] *Institute of Mechanics and Mechatronics, TU Wien*

The three-dimensional structure of a sound field around a noise source gives information about its noise generation and radiation. Its precise experimental determination is therefore of great interest for many technical applications. Furthermore, a spatial resolved measurement of the sound field allows the comparison between three-dimensional numerical simulations and measurements. However, the acquisition of spatial resolved acoustic data with a single microphone is very time consuming and therefore not suitable for every day measurement tasks. Thereby the main problem is to identify the microphones position in relation to the measurement object. This work presents a system for measuring spatial resolved sound field quantities such as sound pressure. The system consists of a handheld marker equipped with a single microphone. Furthermore, the marker has integrated ultrasonic transmitters sending ultrasonic pulses which are detected by receivers placed at defned positions within the measurement

room. The position of the marker is then calculated by means of triangulation. Thereby the dimensions of the measurement volume can be up to 7x7x7 m. Measurement and simulation examples are presented showing the noise radiation of an air duct excited by the vibrations of a fan and results are compared exemplary.

Session "Numerical acoustics 4"

Thu 8:40 Urania Alton Numerical acoustics 4

Development of approximate calculation rules for the acoustical effect of noise barrier tops

Matthias Weber and Olgierd Zaleski
Novicos GmbH

Diffraction tops on noise barriers can cause a significant improvement of the acoustical screen effect. Tops with various shapes, including the use of absorptive material or resonators, have been examined over the past years. In this paper, a practical calculation scheme is derived that approximates the effect of the most common types of barrier tops. This is achieved in two steps: First, 2D boundary element simulations are performed to simulate the sound pressure distribution in a defined calculation domain behind the barrier, for barriers both with and without top. The difference between these two sound fields represents the position-dependent screen effect of the top. In a second step, the spatial distribution of delta values is approximated by polynomial curve fitting. The error between simulated and reconstructed screen effect is minimized by testing different combinations of variables (in cartesian and polar coordinates) in 1st, 2nd or 3rd order, and a trade-off between small error and compact formula is found. Subsequently the simulation and reconstruction procedure is repeated for T-shaped and cylindrically shaped barrier tops of different dimensions, with both absorbing and rigid acoustic boundary conditions.

Thu 9:00 Urania Alton Numerical acoustics 4

Numerical computation and experimental verification of the emitted sound power of a vibrating baffled piston into a hemi-anechoic room

Martin Schmelzer, Volker Wittstock and Christian Bethke
Physikalisch-Technische Bundesanstalt

If the spatial velocity distribution of a baffled piston, and a few ambient conditions like temperature and static air pressure are measured, the emitted sound power of this piston into a free field can be calculated from entirely non-acoustic measurands. This way, the piston can serve as a standard sound source for the unit Watt. Analytical solutions only exist for a few elementary situations of this setup. In all other cases, the situation has to be treated numerically. One such non-elementary setup is the piston in a hemi-anechoic room whose wall boundaries are not exactly fully absorbing and not necessarily locally reacting.

The unit Watt can be disseminated by substituting the piston for a transfer standard and experimental comparison along an enveloping mesh. When

the field quantities are known by numerical computations, they can be examined with respect to their spatial distribution and thereby dependency on given mesh positions. This way, reliability and uncertainties of the substitution method can be investigated preliminarily.
This paper presents a finite-volume-code for a rotation-symmetrical system in the low-frequency range. The computation results are compared to according measurements in a hemi-anechoic room and are discussed according to the afore mentioned criteria.

Thu 9:20 Urania Alton Numerical acoustics 4

PML Implementation for TLM Propagation Model

Pierre Chobeau[a], David Ecotière[a], Guillaume Dutilleux[a] and Judicaël Picaut[b]
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Time domain methods become more attractive for outdoor acoustic modeling since computational resources are less restrictive. However, such approaches still require substantial computational power. Therefore, it is preferable to reduce the simulation domain using efficient absorbing layers in a way to reduce the computational cost of the simulation. Absorbing layers for the transmission line matrix (TLM) method in acoustics has not been yet investigated with the perfectly matched layer (PML) approach. This paper briefly reminds how PML works for acoustic propagation in time domain and presents a way to implement a PML in the TLM method. The present approach is based on the identification of TLM network parameters from the damped wave equation. The final formulation is equivalent to the acoustic propagation in a medium considered both as heterogeneous and dissipative. Based on numerical simulations the results show the efficiency of the absorbing layer regarding its depth and a wide range of incidence angles. Two dimensional representations of the reflection error function demonstrate that the PML presented here is more efficient than other existing approaches used for TLM method.

Thu 9:40 Urania Alton Numerical acoustics 4

Speed up of 3D-Acoustics in frequency domain by the Fast Multipole Method in combination with Krylov Subspace Recycling based iterative solvers

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[a] *Hamburg Univ. of Technology, Inst. of Modelling and Computation;* [b] *BMW Group, Abt. Akustik und Schwingungen*

Acoustic problems in the frequency domain can be solved by the Boundary Element Method (BEM). In contrast to the Finite Element Method a three dimensional problem is not discretized by volume but by surface elements, which lead to a considerable decrease of the number of degrees of freedom. In the BEM the system matrices are fully populated and a quadratic complexity arises with the use of iterative solvers. The Fast Multipole Method (FMM) allows a reduction to a quasi linear complexity by approximating the matrix vector multiplications. If a frequency depended problem is analyzed, a potentially large sequence of linear systems of equations

has to be solved. The classical procedure is the independent calculation of every frequency with iterative solvers, usually based on Krylov Subspace Methods. In order to further speed up the overall solution process, Krylov Subspace Recycling techniques can be utilized. These are based on the idea to identify the most invariant parts of the solution space and to recycle them between subsequent solution steps, which leads to a faster convergence. In this contribution the FMM in combination with a Krylov Subspace Recycling algorithm is presented and numerical examples are given to show the advantage of this procedure.

Thu 10:00 Urania Alton Numerical acoustics 4

Modeling ultrasonic waves in solid waveguides of arbitrary cross-section

Hauke Gravenkamp[a], Chongmin Song[b], Carolin Birk[b] and Jens Prager[a]
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Ultrasonic guided waves offer a wide range of applications for nondestructive testing, structural health monitoring as well as material characterization. Due to the complex behaviour and the strong dispersion of guided waves, numerical methods are often employed to model the propagation properties as well as the interaction of guided waves with defects. In practical applications, the distribution of material properties on the waveguide's cross-section can be complex, e.g. in composite structures or functionally-graded materials. Additionally, the waveguide can be of complicated geometry or it might be embedded in a fluid or solid media, leading to leaky guided waves. All these cases have been addressed using the Scaled Boundary Finite Element Method (SBFEM). This semi-analytical method combines many adavantages of the Finite Element Method and the Boundary Element Method. A special formulation of the SBFEM has been developed to compute dispersion properties of guided waves in waveguides of arbitrary cross-section. Functionally-graded materials as well as composite structures can be modeled very effectively. The interaction with a surrounding media has been included in the formulation. For most applications no additional elements are required to describe the surrounding media.

Session "Underwater noise due to construction and operation of offshore structures"

Thu 15:00 Urania Alton Offshore structures

The German Bight underwater soundscape - a focus on wind farm construction noise

Andrea Luebben, Thomas Neumann and Joachim Gabriel
DEWI GmbH, Wilhelmshaven

Underwater noise is a significant pressure on marine mammals. Since e.g. ships, seismic surveys and actually the construction of offshore wind farms arise, anthropogenic noise sources cause the underwater sound level to increase. In order to investigate the contribution of wind farm construction noise to the soundscape of the German North Sea, an underwater acoustic monitoring station was installed at the research platform FINO1

in July 2009. To be able to record underwater noise in a wide range, two different hydrophones were built in. Within the last three years the station reliably recorded acoustic data with hardly any gaps. Furthermore an identical monitoring station will be placed at the research platform FINO3. Therefore, also wind farm construction noise occurring in the North of the German Bight, starting probably at the end of 2012, can be detected. We will present examples of pile driving noise from different wind farms and wind turbine foundations. In addition statistics of the long term contribution of construction noise will be shown. Amongst other purposes the data is used as input for the research project "Hyprowind". Within this a prognosis tool for the future noise emission from offshore wind farm deployment is developed.

Thu 15:20 Urania Alton Offshore structures

On the prediction of pile driving noise over long ranges

Tristan Lippert and Otto von Estorff
Hamburg Univ. of Technology, Inst. of Modelling and Computation

With the rising number of offshore wind farm constructions in the North and the Baltic Sea, the effect of pile driving noise on the marine environment has become a crucial topic. To especially protect the already endangered harbor porpoise, German authorities have decreed limiting values for the emitted underwater noise during pile driving. Therefore, the numerical prediction of the occurring sound pressure levels (SPLs) is highly important both for the estimation of the noise emission of planned future wind farms and, moreover, for the optimization of sound mitigation measures, such as bubble curtains. The present contribution focuses on the long range prediction of SPLs, using a wavenumber integration (WI) approach. A recently suggested technique, representing the pile by an array of phase shifted point sources, is combined with the WI approach. Thereby, the main acoustic characteristics are modeled both for the water column and for the seafloor. The resulting propagation pattern of the wave front is discussed and the WI approach is compared with corresponding finite element simulations.

Thu 15:40 Urania Alton Offshore structures

Field Measurements of Pile Driving at BARD Offshore 1

Matthias Schwarz, Katja Reimann and Jürgen Grabe
Hamburg Univ. of Technology, Inst. für Geotechnik und Baubetrieb

Due to the German energy turnaround the expansion of green energy is forced. Currently different sound mitigation techniques are developed to damp the hydro acoustic emissions during pile driving for installation of offshore wind turbine foundations. Since there is no all-in-one acoustic emission damping technique it is desirable to predict the amount of damping for each technique in advance. For this reason the German research project called BORA has the intention to predict the sound propagation. The prediction is based on computational models which are validated nowadays with in-situ measured data. On the one hand strain gauges and accelerometers are used to get data for the later modeling of the piling and on

the other hand hydrophones and ocean-bottom-seismic devices are used to get data of distant monitoring points. This contribution will show the difficulties of this measurement due to the harsh conditions during the piling process. Furthermore, for certain monitoring points some data will be discussed in detail and for other monitoring points the reliability is of particular interest. Since all pile-located measuring points are tethered over long distances, electromagnetic effects due to compressors, electric motors and the on-board power supply are noticeable.

Thu 16:00 Urania Alton Offshore structures

Measurements of Underwater Sound at the Offshore Wind Farms Borkum West II and alpha ventus in the German Bight

Frank Gerdes and Jan Abshagen
Bundeswehr Techn. Centre WTD 71, Research Dep. FWG

This paper presents measurements of underwater noise at the offshore wind farms alpha ventus and Borkum West II in the German Bight. Operational noise at alpha ventus was observed with an autonomous single hydrophone system which was deployed inside the wind farm to measure noise from two different kinds of turbine installations. The same system was used to observe pile driving noise from the wind farm Borkum West II. The measurements were done at a distance of 750 m from the piling location at a height of 5 m above the sea-floor as to roughly follow guidelines given by the German Maritime and Hydrographic Agency. In order to investigate the vertical distribution of sound in the water column additional measurements were carried out with a vertical array of 10 hydrophones covering most of the water column. In order to determine the propagation characteristics of the underwater channel (i.e. propagation loss and multipath structure) an underwater sound transmitter was used to propagate known sound signals (LFM sweeps and pseudo random binary sequences) from different water depths to the single hydrophone system.

Thu 16:20 Urania Alton Offshore structures

Noise Mitigation Systems (NMS) for reducing pile driving noise (Part 1): General overview of existing NMS tested within the last years

Patrick Gerke and Michael Bellmann
ITAP GmbH, Oldenburg

Most offshore wind turbines are constructed by pile driving. Pile driving causes strong underwater noise (hydro-sound) that is potentially harmful to marine animals. In Germany the regulation authority (BSH/UBA) pointed out the following limiting values: (i) Sound Exposure Level (SEL) = 160 dB (re 1μ Pa) and (ii) Peak level (Lpeak): 190 dB (re 1μ Pa) which must be fulfilled in a distance of 750 m to the construction site. The experience over the last years shows that the hydro-sound (pollution) during pile driving depends on pile diameter ($>$ 8.0 m) as well as blow energy and reaches values up to 180 dB for the SEL and up to 210 dB for the Peak Level. Therefore, Noise Mitigation Systems to minimize the hydro-sound are requested. Within this presentation a general overview about existing and tested prototypes of NMS like Hydro-Sound Damper (Elmer), Noise Mitigation Screen

(IHC), Small Bubble Curtain (Menck), BeKa Shell (Weyres), Big Bubbles Curtain are shown ,.... The measured results will be discussed.

Thu 16:40 Urania Alton Offshore structures

Noise Mitigation Systems (NMS) for reducing pile driving noise (Part 2): Experiences with the "Big Bubble Curtain" relating to noise reduction

Michael Bellmann[a], Patrick Gerke[a] and Cay Grunau[b]
[a] *ITAP GmbH, Oldenburg;* [b] *Hydrotechnik Lübeck GmbH*

During the construction of the 40 foundations for the offshore wind farm Borkum West II the Noise Mitigation System "Big Bubble Curtain" was used during pile driving activities. Within this project systematically variations of different influencing factors on noise reductions like air volume, nozzle hose sizes, distance of nozzle hoses, ... were investigated. However, first results with a doubled BBC are also shown and discussed. Additionally, the NMS "Big Bubble Curtain" is in use for the construction phase at the OWF "Meerwind Süd/Ost", "Global Tech I" and "Nordsee Ost". Therefore, the "Big Bubble Curtain - BBC" is at the moment one of the most used and investigated NMS in Germany. Within this presentation experiences and results of the above listed projects will be shown and discussed.

Thu 17:00 Urania Alton Offshore structures

Noise Mitigation Systems (NMS) for reducing pile driving noise (Part 3): Experiences of the hydro-sound reductions with the "Big Bubble Curtain" relating to porpoise behaviour

Michael Bellmann[a], Patrick Gerke[a], Herndrik Pehlke[b] and Ansgar Diederichs[b]
[a] *ITAP GmbH, Oldenburg;* [b] *BioConsult SH GmbH, Husum*

In the last years a number of OWFs were constructed along the European coasts. Investigations reveal clear avoidance behaviour of harbour porpoises in a quite extended area during pile driving due to underwater noise. During the construction phase of the OWF "Borkum West II" the behaviour of harbour porpoises was investigated by use of 26 passive acoustic porpoise detectors (C-PODs) placed at different distances from the construction area. These devices recorded the porpoise echolocation activity and give information on the presence and the density of these animals. The recorded POD-data were analyzed whether there is a difference between the avoidance behaviour of harbour porpoise by pile driving with sound reduction system and without. For both options - with and without Noise Mitigation System - and in different distances to the construction site, it was examined how long it takes until the average value of porpoise acoustic activity of a period prior to the start of pile driving was reached again. Within this project first hearing related acoustic parameters are taken into account for an objective descriptor of the subjective response of porpoise on hydro-sound during pile driving. Within this presentation experiences and results of the above listed investigations will be discussed.

Thu 17:20 Urania Alton Offshore structures

Underwater Pile Driving Noise Reduction by Air Filled Balloons and PE-Foam Elements as Hydro Sound Dampers

Karl-Heinz Elmer

OffNoise-Solutions, Neustadt

Founding of offshore wind turbines by pile driving induces considerable underwater noise emissions, that are potentially harmful to marine life. In Germany, the Federal Maritime and Hydrographic Agency (BSH) has set a standard level of 160 dB (SEL) at a distance of 750 m from pile driving. Effective noise reducing methods are necessary to keep this standard level. The new method of hydro sound dampers (HSD) uses curtains of robust air filled elastic balloons showing high resonant effects, similar to air bubbles, and special PE-foam elements with high dissipative effects from material damping, to reduce impact noise. The resonance frequency of the elements, the optimum damping rate for impact noise, the distribution and the effective frequency range can be fully controlled, if the HSD-elements are fixed to pile surrounding fishing nets. HSD-systems are independent of compressed air, not influenced by tide currents, not expensive and easy adaptable to different applications. The theoretical background, numerical simulations, laboratory tests and offshore tests of HSD-systems show that noise reductions of 20 dB to 30 dB (SEL) of underwater pile driving noise are possible in praxis. The work is supported by the German Federal Environmental Ministry (BMU).

COST Action TD0804

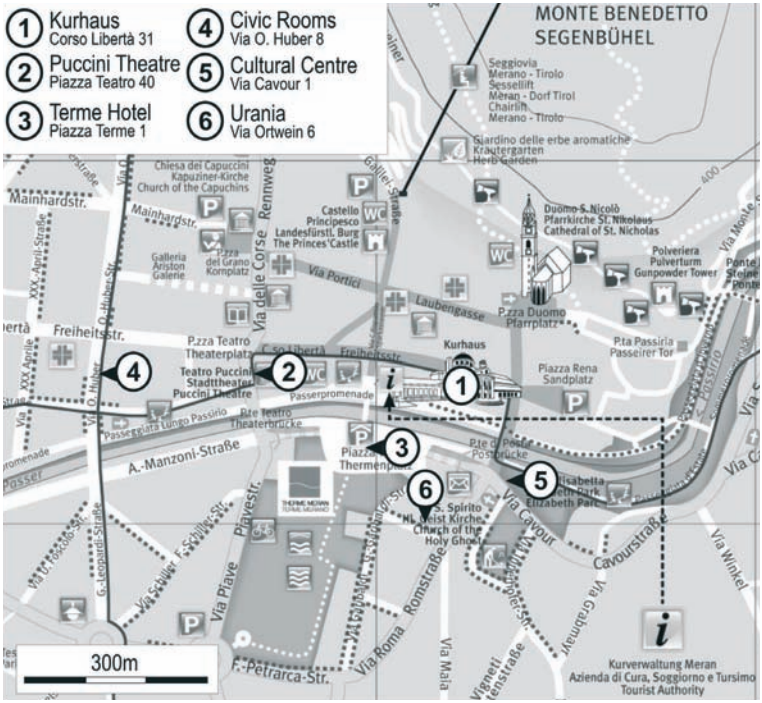
Soundscape of European Cities and Landscapes
Final Conference

Date: Friday, March 22, 2013
Opening 9:00, closing 17:00
Room: Civic room (Via O. Huber 8)

Recent work in Soundscape that provides a new multidisciplinary approach clearly represents a paradigm shift in environmental noise and annoyance research as it is focussing on perception and involves not only physical measurements but also human/social sciences (e.g. psychology, sociology, architecture, anthropology, medicine) to account for the diversity of soundscapes across countries and cultures. It considers environmental noise as a 'resource' rather than a 'waste'. Aiming at providing the underpinning science and practical guidance in soundscape, a number of activities have been carried out through this four-year COST Action. The final conference will show the outcomes of this action. Presentations of results and discussions along with a number of invited speeches will refer to the work of the 5 working groups and therefore focus on Understanding and Exchanging, Collecting and Documenting, Harmonising, Creating and Designing and Good Soundscape Practice.

Orientation plans

Map of Merano with congress buildings



The following lecture rooms can be found in the buildings:

(1) Kurhaus
- Kursaal
- Meeting room 1
- Meeting room 2
- Conference room
- Czerny hall
- Lentner hall

(also exhibition, posters, registration)

(2) Puccini Theatre

(3) Hotel Terme
- Room 1
- Room 2
- Room 3

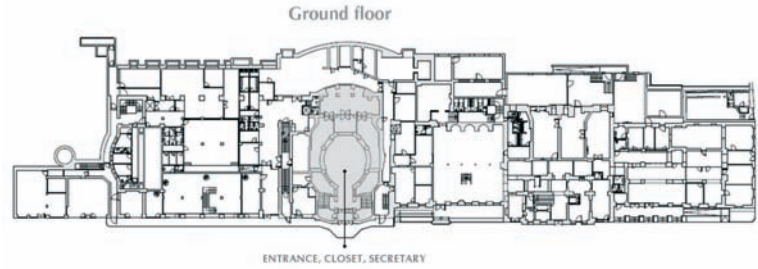
(4) Civic Rooms
- Civic room
- Exhibition room

(5) Cultural Center
- Movie theatre
- Music room
- Exhibition room

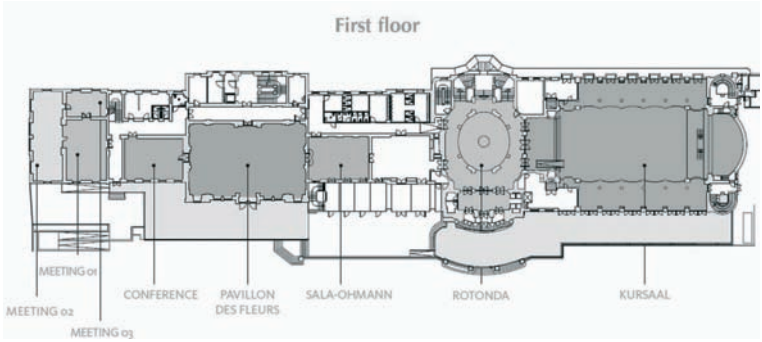
(6) Urania
- Urania Alton

Floor plans of Kurhaus

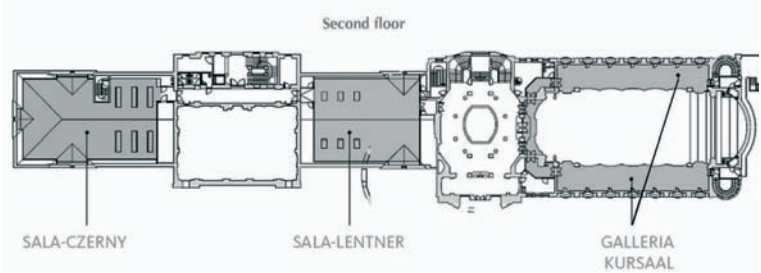
Ground floor



1st floor



2nd floor



Some photos

Kurhaus

Kurhaus, Kursaal

Hotel Terme

Puccini Theatre

Civic Rooms

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Meetings during the conference

Monday, March 18

18:00 - 20:00	AIA members general assembly	Kurhaus Czerny hall
18:00 - 20:00	DEGA-Mitgliederversammlung (DEGA members general assembly)	Puccini Theatre
18:00 - 20:00	Young Acousticians Meeting	Kurhaus Lentner hall

Tuesday, March 19

13:00 - 14:00	AIA-GAM: Musical acoustics	Kurhaus conference room
13:00 - 14:00	DEGA-Fachausschuss Elektroakustik	Terme room 3
13:00 - 14:00	DEGA-Fachausschuss Lehre der Akustik	Terme room 2
13:00 - 14:00	DEGA-Fachausschuss Musikalische Akustik	Kurhaus meeting room 2
13:00 - 14:00	DEGA-Fachausschuss Sprachakustik	Kurhaus meeting room 1
13:00 - 14:00	DEGA-Fachausschuss Strömungsakustik	Kurhaus Lentner hall
13:00 - 14:00	DEGA-Fachausschuss Ultraschall	Terme room 1

Wednesday, March 20

12:55 - 14:00	AIA-GAA: Environmental acoustics	Kurhaus Lentner hall
12:55 - 14:00	AIA-GAE: Building/room acoustics	Terme room 2
12:55 - 14:00	DEGA-Fachausschuss Bau- und Raumakustik	Terme room 3
12:55 - 14:00	DEGA-Fachausschuss Fahrzeugakustik	Kurhaus conference room
12:55 - 14:00	DEGA-Fachausschuss Hörakustik	Kurhaus meeting room 1
12:55 - 14:00	DEGA-Fachausschuss Physikalische Akustik	Terme room 1

Thursday, March 21

12:55 - 14:10	AIA-GAL: Noise and vibration at workplace	Terme room 3
12:55 - 14:10	DEGA-Fachausschuss Lärm: Wirkungen und Schutz	Terme room 2

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