


inter noise

2013 | INNSBRUCK | AUSTRIA

15.-18. SEPTEMBER 2013

NOISE CONTROL FOR QUALITY OF LIFE

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Lärmschutz für Österreich

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Welcome!

Dear Colleagues,

It is with great pleasure that we welcome you to the 42nd International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2013) held in Innsbruck Austria, from 15 – 18 September 2013.

The INTER-NOISE 2013 Congress is sponsored by the International Institute of Noise Control Engineering (I-INCE) and organized by Österreichischer Arbeitsring für Lärmbekämpfung – ÖAL (Austrian Noise Abatement Assosiation). INTER-NOISE 2013 will be held at Congress Innsbruck, which is located in the heart of Innsbruck, Capital of the Tyrol close to all major attractions, Imperial Court, Golden Roof (Goldenes Dachl) medieval town, and several museums.

The Congress features 790 high-level applied technology and research papers from around the world, as well as more than 50 companies exhibiting noise and vibration control materials, and measurement equipment and systems. Additional stimulation for technical sessions and discussions will be provided by eight distinguished plenary and keynote lectures focusing on the Congress theme. We are certain that the Congress provides the venue for the exchange of the most current and relevant information on noise and vibration control, both through the structured technical sessions, committee meetings and I-INCE Technical Study Groups, as well as informal personal discussions.

Because our collective goal of a quieter better world can be realised faster and more effectively through collaboration and partnerships, we hope you will be able to participate in the social events and use these opportunities to forge new working relationships and strengthen existing ones.

It has been an honour, for us, the Organising Committee and the Scientific Committee, to support global noise and vibration control activities through organisation of INTER-NOISE 2013. It is our pleasure to welcome you to INTER-NOISE 2013 and we invite you to participate fully in all aspects of the Congress.

Werner Talasch, Congress President

Welcome from International INCE

Dear Colleagues,

It is my great honour and pleasure to welcome you on behalf of I-INCE, the International Institute of Noise Control Engineering, in Innsbruck to the 42nd International Congress and Exposition on Noise Control Engineering, Inter-Noise 2013. For four days, from September 15 to 18, the charming capital of Austrian Tyrol will host our international scientific community and thus turn to the capital of our important discipline, noise and noise control engineering.

After our latest meetings in Osaka and New York City we are happy to come together in Europe again, in Austria for the first time, in the heart of the Alps, this wonderful and spectacular part of Central Europe. The cosy city of Innsbruck will be an ideal, intimate place for numerous contacts allowing optimal exchange of proven experience and innovative ideas. As this is exactly what our more than forty-year-old series of Inter-Noise conferences is aiming at, the success of our meeting seems to be predictable.

Of course this is due to the self-sacrificing work of the hosting team, the Organising and the Scientific Committees, the Österreichische Arbeitsring für Lärmbekämpfung ÖAL (Austrian Noise Abatement Association) and the many supporting people and institutions around. I am sure they have prepared an optimal platform for our matter and I would like to thank all of them for their related efforts.

Inter-Noise 2013 continues the successful series of Inter-Noise conferences on noise control engineering being started in 1972. Only two years later, in 1974, this series was backed up by the foundation of a worldwide consortium of organisations concerned with noise control, acoustics and vibration and the related engineering disciplines - the International Institute of Noise Control Engineering, I-INCE. Since then, the Institute has grown up to 46 member societies from 41 countries together with 17 sustaining and institutional members.

The primary focus of the Institute is on unwanted sounds and on vibrations producing such sounds when transduced. The engineering aspects of this field involve the application of physical means to analyse and optimize the levels of noise and vibration produced by structures, machines, products, systems, and processes by controlling the generation, transmission, and radiation of fluid borne sound and solid borne vibration. The scientific and socio-economic aspects of the field relate the effects of noise and vibration on individuals and communities to the optimization of the acoustical climate for human activities. This involves psychological and physiological acoustics, social and economic studies of the response of people to sound and vibration, as well as cost-benefit analyses of technical options to control noise and the quality of sounds. Standards, health and safety regulations, ordinances, ecological and governmental policies, such as land-use planning, are included in the Institute's field of interest.

I-INCE is the sponsor of the INTER-NOISE Series of International Congresses on Noise Control Engineering held annually in leading cities of the world. I-INCE also co-sponsors symposia on specialized topics within the I-INCE field of interest. The quarterly magazine Noise/News International is jointly published by I-INCE and the Institute of Noise Control Engineering of the USA (INCE/USA). I-INCE instituted a program to undertake technical initiatives on critically-important issues of international concern within the I-INCE field of interest. This initiative has resulted in several reports and a number of active Technical Study Groups (see http://www.i-ince.org/).

I-INCE actively promotes participation by young noise control professionals. I-INCE has allocated funds to support between ten and twelve Young Scientists Conference Attendance Grants (YS Grants) to assist young scientists/engineers in attending the I-INCE sponsored International Congresses on Noise Control Engineering. The notification of this prestigious YS Grant may be used to obtain additional funding from other sources. In order to meet the expanding needs of the field of noise control engineering, I-INCE has recently also established a Symposium Series. Finally, I-INCE is assuming a leadership role in formulating global noise policies; this includes an on-going collaboration with CAETS (International Council of Academies of Engineering and Technological Sciences).

Dear colleagues, it is up to you now to use the days in Innsbruck for utilizing and further developing this broad platform and thus make them an unforgettable stay in the inspiring environment of your colleagues and the wonderful city of Innsbruck.

Joachim Scheuren, President of I-INCE

Österreichischer Arbeitsring für Lärmbekämpfung (Austrian Noise Abatement Association)

The Austrian Noise Abatement Association (ÖAL) was founded as a section of the Österreichische Arbeitsgemeinschaft für Volksgesundheit (ÖAV) (Austrian Working Group for Public Health) in 1958 October. The administration was done in ÖAV with subsidies from the Ministry for Social Affairs, other Ministries, and the governments of the 9 Austrian Counties.

The founder and head of the Austrian Noise Abatement Association for the first 20 years was Prof. Friedrich Bruckmayer, a well known expert especially in the field of building acoustics. For the next 14 years Prof. Judith Lang managed the Austrian Noise Abatement Association. Her successors were Mathias Stani, Walter Gassner, Wolfgang Khutter and since 2005 Werner Talasch.

The technical activities were led by the Institute for Heat and Sound Technology. The main special tasks undertaken by the Austrian Noise Abatement Association included establishment of guidelines and dissemination of the fundamentals of acoustics and noise control.

Some of the most important guidelines in the first years were measurement of noise emission of machines, measurement of noise emission of vehicles, assessment of noise exposure (in the neighbourhood and in the working place), effects of noise on man, the acoustical basics for the construction of factories, low noise machines, and the psychology of noise production by man. Later, guidelines were established for calculation methods for road traffic noise, aircraft noise zones around airports, rail traffic noise, noise propagation outside and in factories, the basics for noise control in town and country planning, and noise labelling of machines.

In 1987, ÖAL Guideline 29 on low noise trucks was issued. This guideline defined the criteria for low noise trucks in harmony with criteria already existing in Germany. When the problems with high noise levels alongside the transit route from Germany to Italy through Austria became serious, the low noise truck guidelines were applied on the relevant Austrian roads during nighttime (combined with a speed limit to 60 km/h). The importance of low noise trucks grew rapidly in Europe and these trucks are now state-of-the-art.

In 1991, there were some difficulties financing the work of ÖAL within ÖAV, and in 1994 the ÖAV went into bankruptcy. At that time the Österreichischer Arbeitsring für Lärmbekämpfung, was founded as an independent association.

The aim of ÖAL is still unchanged; the dissemination of state-of-the-art information in noise control — especially through the preparation of guidelines in working groups and exchange of experiences in 4 plenary meetings per year.

For more information, contact the ÖAL at www.oal.at or via e-mail at office@oal.at.

Österreichischer Arbeitsring für Lärmbekämpfung

Austrian Noise Abatement Association

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Organizing Committee

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Congress President: Werner Talasch

Congress Vice-President: Christoph Lechner

Congress Secretary: Bok-Hie Kim

Treasurer: Wolfgang Gruber

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Wolfgang Probst, Georg Thomann, Holger Waubke, Volker Wittstock

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Session Chairs

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General Information

About Austria

Austria has been a member of the European Union since 1995, the population is 8,488,00 (official estimate 2013), the capital city being Vienna (Wien). Politically, Austria is a democratic republic with the prime minister as the head of the government and parliament elections every five years. The formal head of state is the president, who has more representative duties than political power. The country is divided into nine federal states, Innsbruck is the capital of the state of Tyrol. The language spoken in Austria is German, but most Austrians speak English and many speak some French or Italian too and are happy to be of service to visitors.

About Innsbruck

Innsbruck, the capital of Tyrol, is located in the Alpine region of Austria, in the valley of the river Inn, at 580 metres above sea level. It is surrounded by mountain ranges and numerous peaks which reach an altitude of approx. 2,700 metres above sea level. The city has 121,000 inhabitants and hosts one of the oldest universities in Europe, founded in the year 1562. Today, over 30,000 students attend the university in Innsbruck. Due to its location, Innsbruck has an excellent tourist infrastructure and is best known for its rich cultural heritage, as well as for its endless opportunities in sports and recreation that include golf, hiking, climbing, rafting, paragliding, canyoning, swimming in lakes, skiing and snowboarding not only in winter time, but also in summer at one of the glaciers nearby. Innsbruck has been the host for Olympic Winter Games twice, in 1964 and 1976. In the town, some 160 restaurants, cafes and bars, most of them in walking distance to the convention centre, offer traditional Tyrolean and Austrian specialities as well as international dishes.

Congress Venue

Congress Innsbruck is combining an international standard with Tyrolean charm. The distances are short, the layout clear and all the facilities under one roof. Above all, we attach great importance to personal service, so that every function is an occasion in itself - a real event.

From classical to modern: It was 1973, when one of the most modern conference centres in Europe was built in Innsbruck. About 20 years later it was extended almost by half. Today, following the merger with the Innsbruck Fairgrounds in 2005, even more facilities and space are available. The varied range of halls offers the right atmosphere for every occasion from 20 to 3000 guests and even more. Starting 2007 a very new location is offered on top next to Innsbruck - congresspark igls.

Coffee Breaks

There will be no designated coffee breaks. However coffee and other refreshments will be available during the entire day at various coffee stations within the Congress Innsbruck.

Lunches

Lunches are not included in the Congress registration fee, however there is a restaurant, the Archiv, located in the Congress Center. There are also various restaurants located in the Old City of Innsbruck nearby the Congress Innsbruck and all within short walking distance, for instance:

Tyrolean Cuisine

Fischerhäusl

Fischerhäusl is a charming family restaurant just behind the Hofburg Museum in the historic old city of Innsbruck. Enjoy the enchanting garden for lunch or dinner, the menu will delight you with European/ Mediterranean cuisine as well as Traditional Austrian fare.
Location: Old City, 2 min. walk from congress center
Herrengasse 8, AT-6020 Innsbruck
Tel. +43 512 583 535

Stiftskeller

As part of the Emperor's palace the Stiftskeller has a long history and tradition. The house itself was first known as "Harnaschhaus" in 1465 , then as 'Wappenhaus' ("House of coats of arms"). In 1929 the brewery Zipf took over part of the building and turned it into a restaurant.
Location: Old City, 2 min. walk from congress center
Stiftgasse 1, AT-6020 Innsbruck
Tel. +43 512 570 706

Löwenhaus

Extensive range of wines and beers. Hot meals served all day. Wide choice of meals to suit all tastes. Daily Specials. Salad Buffet. Magnificent Views. Beer Garden/Patio. Rustic atmosphere.
Location: Along the river “Inn”, 5 min. walk from congress center
Rennweg 5, AT-6020 Innsbruck
Tel. +43 512 58 54 79

Theresienbräu

Popular with the younger crowd.Homebrew and tyrolean cuisine.
Location: city center, 7 min. walk from congress center
Maria-Theresien-Straße 51-53, AT-6020 Innsbruck
Tel. +43 512 58 75 80

Elferhaus

Inn & Pub ; Extensive range of beers. Hot meals served all day. Serving solid and inexpensive Austrian standards. Daily specials. Enduringly popular venue for the studenty, arty set.
Location: Old City, 4 min. walk from congress center
Herzog-Friedrich-Straße 11, AT-6020 Innsbruck
Tel. +43 512 58 28 75

International Cuisine:

Pavillon

The Pavillon was opened in 2006 and has already become one of the culinary highlights in Innsbruck. The elegantly designed glass cube offers a restaurant on the 1st floor, and a café with an appealing view of the Landesmuseum.
Location: opposite the congress center
Rennweg 4, AT-6020 Innsbruck
Tel. +43 512 25 70 00

Sitzwohl

In an almost intimate atmosphere, stylish Tyrolean and Mediterranean dishes are available for guests in search for a quick lunch or planning a relaxed evening out. The attached Deli sells such specialities as chutneys, jams, soups, etc.
Location: city center, 7 min. walk from congress center
Stadtforum, AT-6020 Innsbruck
Tel. +43 512 56 28 88

Cammerlander

The restaurant offers international cuisine, fresh products and a relaxed atmosphere. You can also enjoy your meal in the garden by the river “Inn”.
Location: by the river “Inn”, 4 min. walk from congress center
Innrain 2, AT-6020 Innsbruck
Tel. +43 512 58 63 98

Piano Bar

Wine bar with excellent cuisine - Arguably the best steak in the city, delicious butter Wiener schnitzel and great salads. Has a lovely patio with outdoor dining area. Meeting point for artists.
Location: Old City, 5 min. walk from congress center
Herzog-Friedrich-Strasse 5, AT-6020 Innsbruck
Tel. +43 512 57 10 10

Different Cuisines:

Solo Pasta Solo Vino – Italian Kitchen

SOLO PASTA: Italian 'spaghetteria' near the SOWI faculty.
SOLO VINO: Wine bar with a selection of over 500 wines
Location: SOWI campus, 3 min. walk away from congress center
Universitätsstraße 15b, AT-6020 Innsbruck
Tel. +43 512 58 72 06

Die Pizzerei – Italian Kitchen

Italian restaurant. Great wood-fired pizza and Italian specialties. Reservation recommended!
Location: city center, 8 min. walk from congress center
Boznerplatz 6, AT-6020 Innsbruck
Tel. +43 512 58 37 96

Poseidon – Der Grieche – Greek Kitchen

Offers Greek specialties in relaxed atmosphere, daily changing lunch menu.
Location: CityCenter, 15 min. walk from congress center
Innrain 38, AT-6020 Innsbruck
Tel. + 43 512 90 82 04

Thai-Li-Ba – Thai Kitchen

Exotic dishes, Thai, Indonesian and Vietnamese specialties.
Location: city center, 7 min. walk from congress center
Adolf Pichler-Platz 3, AT-6020 Innsbruck
Tel. +43 512 56 78 88

Teppan Wok – Thai Kitchen

Possibility for "all you can eat" buffet – Asian style.
Location: city center, 18 min. walk from congress center
Bürgerstrasse 2, AT-6020 Innsbruck
Tel. +43 512 56 18 38

Sunrise II – Chinese Kitchen

Chinese food in the city center, offers a wide range of Chinese specialties – daily changing lunch menu
Location: city center, 7 min. walk from congress center
Innrain 11, AT-6020 Innsbruck
Tel. +43 512 58 97 05

Himal – Nepali kitchen

With a smile in your heart, you can climb the highest mountain. Welcome to the little Nepal in the middle of Innsbruck. Himal is a typical nepali Kitchen serving you the best nepali food with a lot of love and care.
Location: SOWI campus, 3 min. walk from congress center
Universitätsstraße 13, 6020 Innsbruck
Tel.+512 588 588

Speaker Ready Room

Speaker must upload their presentations (in PowerPoint or PDF format) at least one day before their scheduled presentation. The Speaker Ready Room is the Serles Room, located on the Ground Floor, and will be open during the following hours:

Sunday, September 15th:	7:30am – 6:30pm
Monday, September 16th:	7:30am – 6:30pm
Tuesday, September 17th:	7:30am – 6:30pm
Wednesday, September 18th:	7:30am – 3:30pm

Registration Desk

The Registration Desk is located in the Hofgarten Foyer on the Ground Floor by the main entrance:

Sunday, September 15th:	7:30am – 6:30pm
Monday, September 16th:	7:30am – 6:30pm
Tuesday, September 17th:	7:30am – 6:30pm
Wednesday, September 18th:	7:30am – 6:00pm

Accompanying Persons

The registration fees for accompanying persons is € 60,00. This registration fee includes:

- Opening and Closing Ceremonies and associated receptions Sunday and Wednesday evenings
- Guided Tour to the City of Innsbruck (Monday morning only)

Banquet Dinner

The Banquet Dinner is scheduled for Tuesday, 17th in the Dogana, on the Ground Floor of the Congress Innsbruck. Tickets are required and must be pre-booked. The banquet fee is €100.

Weather/ Climate

With a mountain chain to protect it from the cold northern winds, Innsbruck enjoys an alpine climate. During September the weather is usually pleasant with temperatures varying between 12 and 21 degrees Celsius. However rain showers are possible and it is advisable to bring a raincoat with you.

Time Zone

Innsbruck is in the Central European Time Zone (Greenwich Mean Time +1)

Currency and Credit Cards

The official currency is the Euro. Major credit cards are accepted in most hotels, shops and restaurants. Automatic teller machines (ATMs) are available throughout the city.

Language

The official language of the Congress is English. No simultaneous interpretation facilities will be provided during the conference.

Electricity

Electricity in Austria is 230 Volts, alternating at 50 cycles per second. If you travel to Austria with a device that does not accept 230 Volts at 50 Hertz, you will need a voltage converter.

Emergencies

If you are experiencing an emergency, telephone **112** immediately to obtain police, fire and ambulance services.

Tax & Tipping

The proper way to pay in Austria is to give your cash and say the amount you wish to pay, including tip. To tip it is appropriate to round up, or to round up +50 cents or 1 euro of the cost for each person (should equal about 5-10% for a full meal). Servers are not dependent on tips, and it is not appropriate to tip a large amount.

ATMs

ATMs in Austria are called Bankomat. Many shops and some restaurants offer the service to pay directly with an ATM card. The majority of ATMs accept cards from abroad. All Bankomats in Austria can easily identified by a sign showing a green stripe above a blue stripe. It does not matter which Bankomat you use; the transaction fee is always zero (excluding any fees charged by your own bank).

Mobile Phones

Non-Austrian attendees should note that local data roaming charges may be relatively high (depending on the service provider). Attendees are cautioned against downloading large files unless you are aware of the fees charged by your provider.

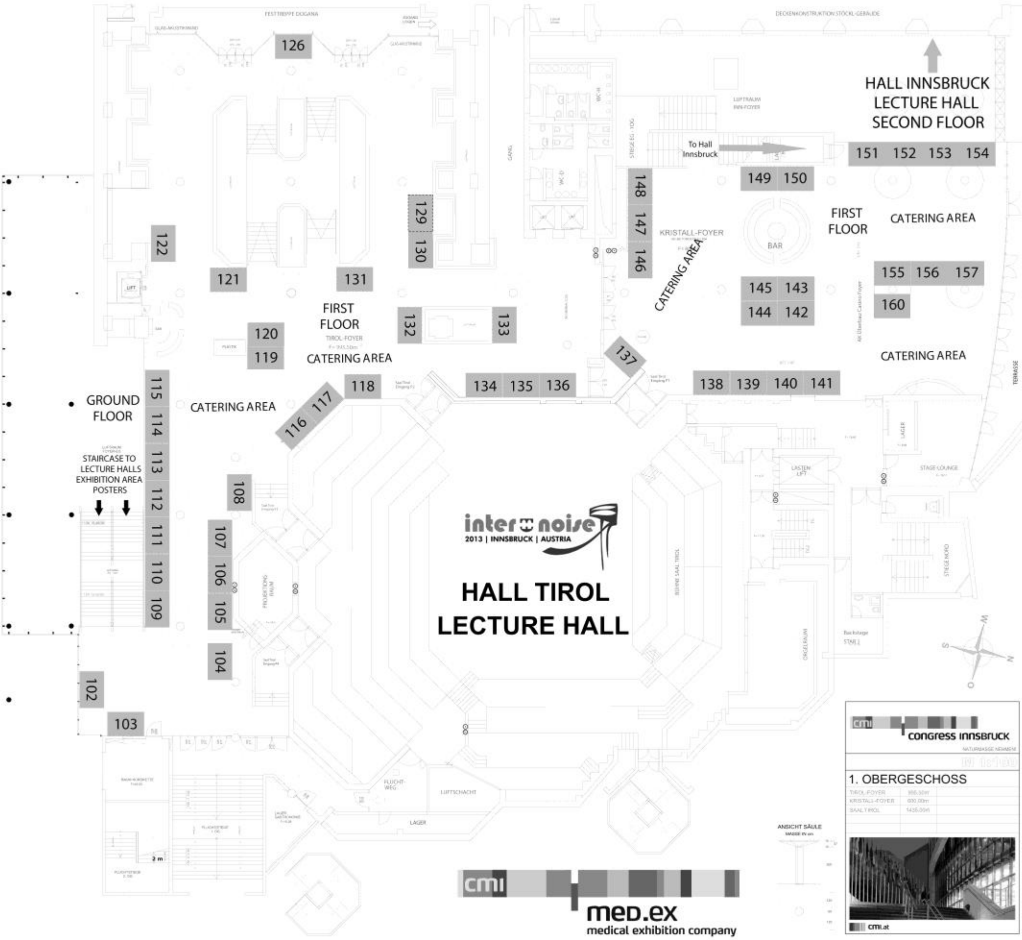
WLAN

WLAN is available for free in the Congress Center.

EXHIBITIONERS LIST

inter noise
2013 | INNSBRUCK | AUSTRIA
NOISE CONTROL FOR QUALITY OF LIFE


G.R.A.S. Type 26CC
Serial No. 78062
G.R.A.S.
Type 26CA
Serial No. 105708
Standards
Specials
Customized



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1. OBERGESCHOSS
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medical exhibition company

102 Internoise 2014 Melbourne, Australia

103 Eurofoam Audiotec GmbH, Austria
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104 GfS Gesellschaft für Sonder-EDV-Anlagen mbH, Germany
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3425 Walden Avenue, 14043 Depew, New York
teyring@pcb.com | 001 716 684 0002 | www.larsondavis.com

113 LB-Acoustics Messgeräte GmbH, Austria
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114 Rion Co., Ltd, Japan
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122 PROCESO DIGITAL DE AUDIO S.L., Espana
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126 GENESIS SA., France
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130 Aximit Pro Ltd, Hungary
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131 Accon GmbH, Germany
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132 SoundPLAN International LLC, USA
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133 BSWA Technology Co., Ltd, China
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134 Softnoise GmbH, Germany
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149 Schrey&Veit GmbH, Germany
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150 NTi Audio AG, Liechtenstein
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151 ViAcoustics / National Instruments, USA
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152 Pyrotek Noise Control, Australia
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153 Wölfel Messsysteme - Software GmbH & Co. KG, Germany
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156 Free Field Technologies SA, Belgium
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157 Castelhano & Ferreira SA, Portugal
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SOCIAL PROGRAMS

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Social Programs

Tours and excursions for accompanying persons

The following tours have been designed especially for the Congress. All tours include the service of a professional guide. The prices indicated are based on a minimum number of 20 participants. If this number is not reached, alternative arrangements or a complete refund will be made. Numbers are limited on some tours and places will be allocated strictly in order of receipt of bookings. You can register for these tours online, when completing your registration for the conference.

The meeting point for all tours is at Congress Innsbruck – main entrance.

Monday, 16 September, 10:00 a.m. OR 1:00 p.m.
City Tour & Bergisel Ski Jump

Our local tour guide first takes you on a walking tour through the charming Old Town of Innsbruck, situated next to the river Inn which gave its name to the city. Take a closer look at its numerous historical landmarks, such as the Golden Roof or the Imperial Castle. After a short bus ride, breathtaking views of Innsbruck as well as the fascination of a ski jumping venue with an Olympic past and modern architecture. Top architect Zaha Hadid designed this landmark of Innsbruck in 2001. The funicular and the tower elevator (included in the excursion cost) comfortably take you up to the Panorama-Restaurant "Café im Turm" and the panoramic view plattform.

Duration: approx. 3 hours - Price per person: € 42,- (incl. VAT)

Tuesday, September 17, 09:00 a.m.
Swarovski Crystal Worlds

A bus takes us through a number of typical Tyrolean villages to Wattens, where the Swarovski Crystal Worlds opened their doors to the public. Through the huge water-spouting head of a botanic giant the visitor enters the mostly subterranean, unique magic World of Crystal. "This place is like a fairy tale come true. People suddenly experience what they previously knew only in their dreams", says Viennese multimedia artist André Heller, creator of the Swarovski Crystal Worlds. You have to experience yourself what is hard to describe: a view of the surreal landscape of a glittering galaxy, the inside of a gigantic crystal dome with changing patterns of light and sound, bizarre scenarios - a world of magic. You will have time to look for a souvenir in the crystal shop or enjoy a cup of coffee and a delicious Austrian cake.

Duration: approx. 4 hours – Price per person € 48,- (incl. VAT)

Wednesday, 18 September, 10:00 a.m.
Mountain Experience "Seegrube"

This is nothing for the faint hearted; the cable car takes you up to Seegrube mountain peak, 1905 meters above sea level. Once you get there, you can enjoy a great panoramic view of the Inn Valley, the Stubai and Zillertal Valley Alps and of the Wipptal Valley up to the Italian border. In no other place in the world is the dividing line between an urban area and rugged mountain terrain so thin. The new Nordkettenbahn transports you directly from the Congress Center to high mountain terrain in just twenty minutes. A visit to the Innsbruck Nordkette offers a unique panorama. Once you get to the mountain station of the funicular Hungerburg you can enjoy a new breathtaking view of the city of Innsbruck. A traditional "Brettljause" (Tyrolean snack) awaits you in the mountain restaurant (already included in the price of the excursion, beverages are at an extra cost!)

Duration: approx. 5 hours – Price per person € 62,- (incl. VAT)

PLANS

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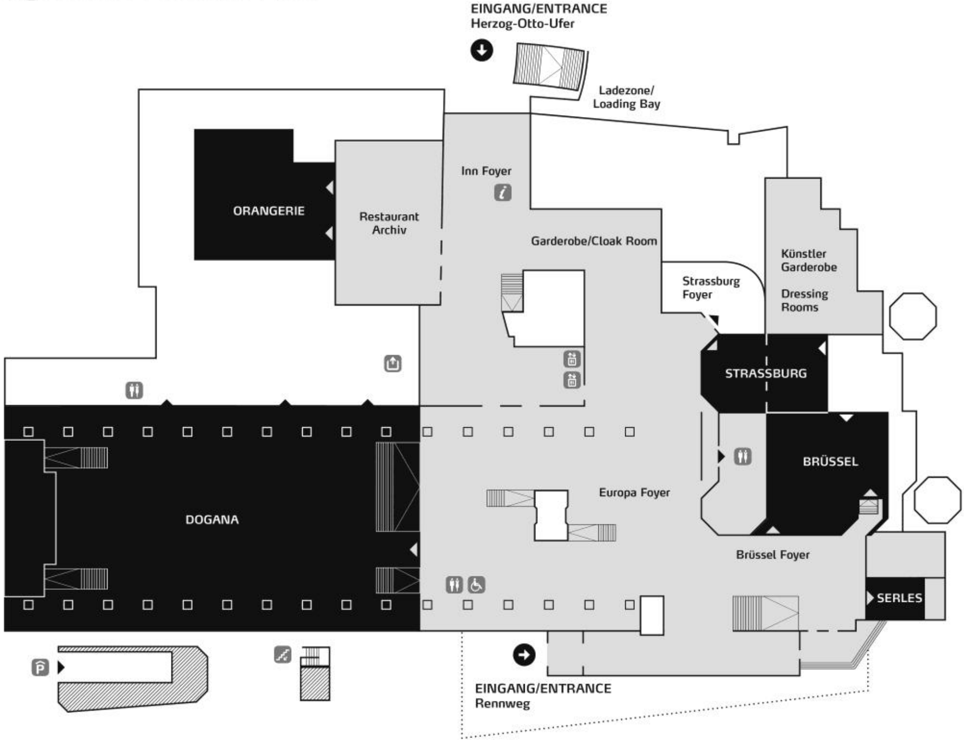
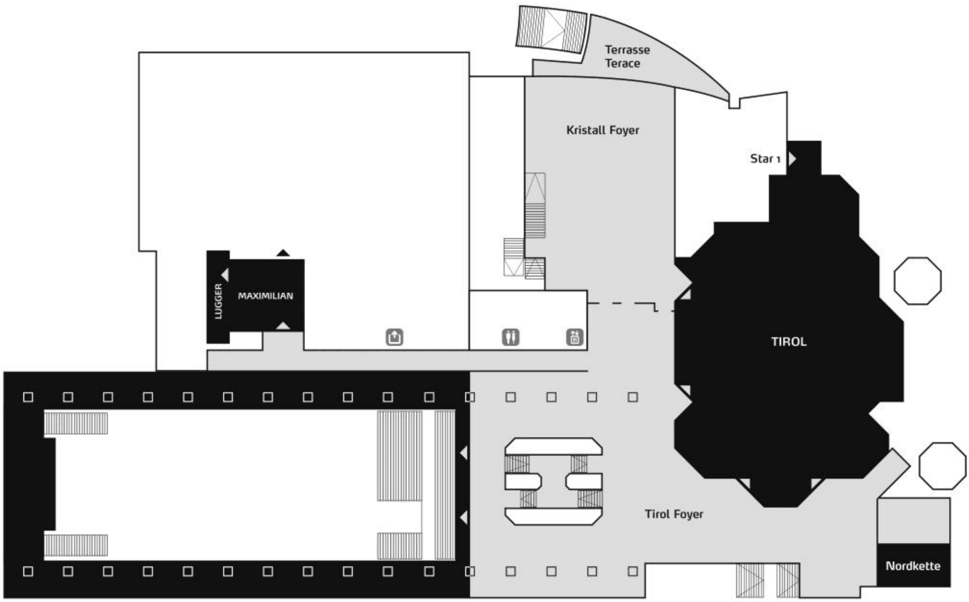
Erdgeschoss / Ground Floor

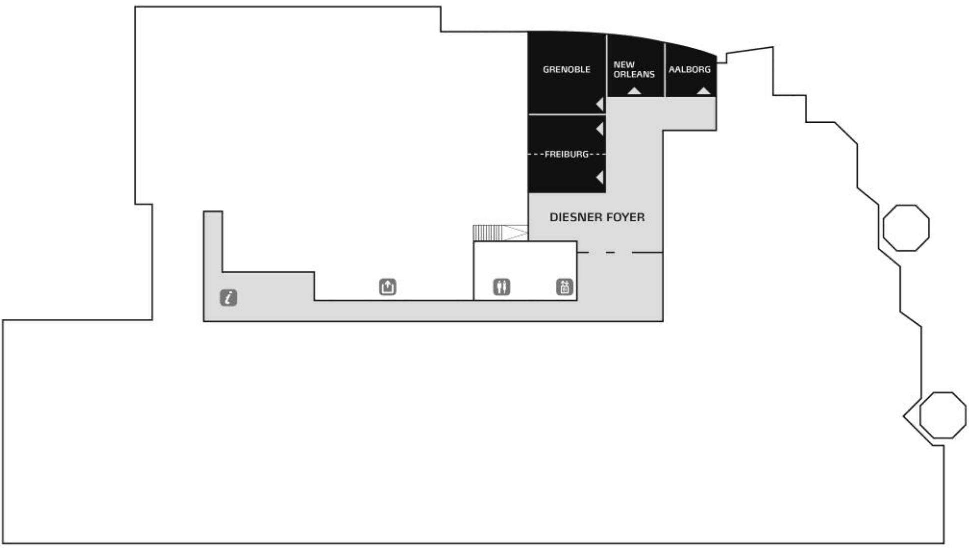


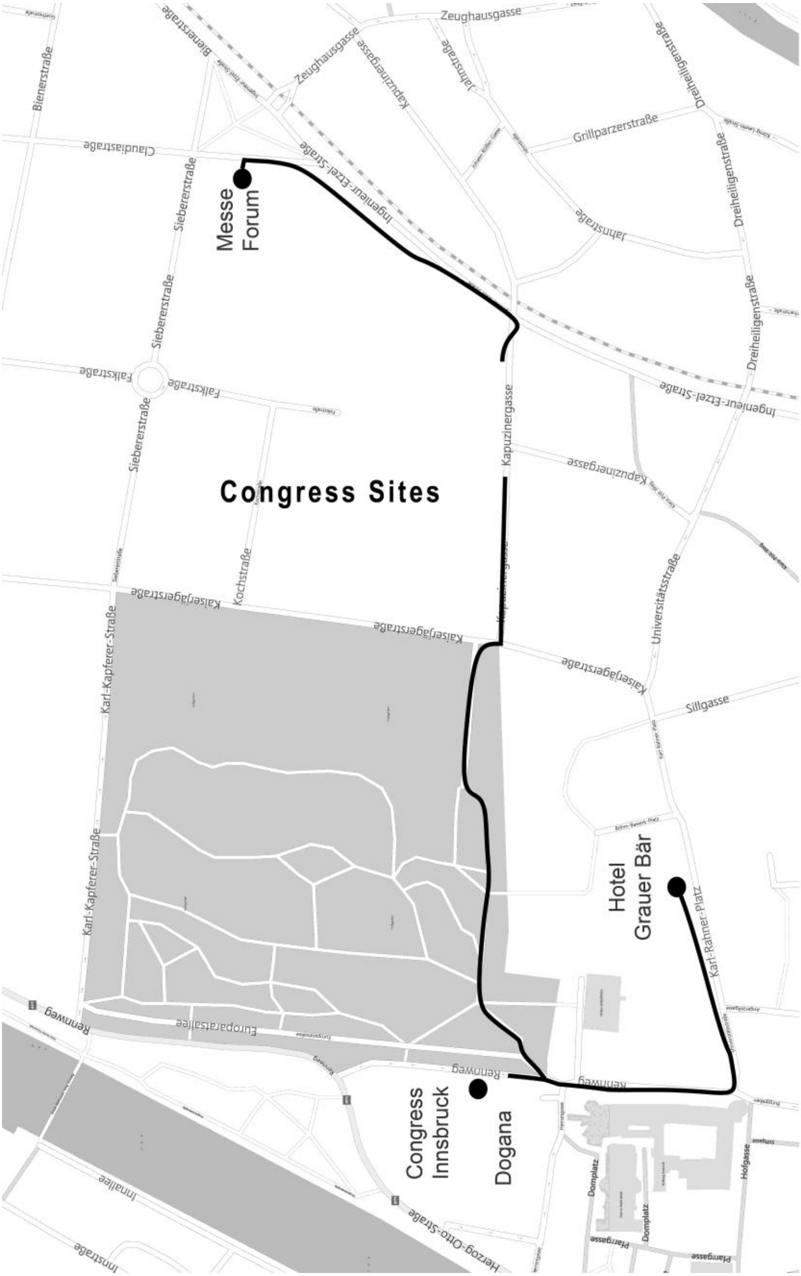
1.Obergeschoss / 1st Floor



2.Obergeschoss / 2nd Floor

3.Obergeschoss / 3rd Floor




Congress Sites
Messe Forum
Hotel Grauer Bär
Congress Innsbruck
Dogana
Zeughausgasse
Bienerstraße
Claudiastraße
Siebererstraße
Kapuzinergasse
Jahnstraße
Grillparzerstraße
Dreiheiligenstraße
Ingenieur-Etzel-Straße
Falkstraße
Kochstraße
Kaiserjägerstraße
Universitätsstraße
Sillgasse
Karl-Kapferer-Straße
Karl-Rahner-Platz
Rennweg
Europaallee
Innallee
Innstraße
Herzog-Otto-Straße
Domplatz
Pfarrgasse
Hofgasse

PROGRAM

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Short Courses

The Short Courses on Sunday 15 September are listed below.

Acoustic Camera - practical workflow and sound source localization (Vendor Course)
Instructors: Heilmann Gunnar, and Bock Magdalena, GFAI Tech

Day: Sunday September 15 2013
Times/Room: 1:00 pm - 5:00 pm/Brüssel
Cost: € 50

Description: The course provides and introduction to phased array technology (beamforming) and a practical workshop.

Course outline:

* Introduction to phased array technology/ beamforming
* Introduction to array design
* Beamforming applications
* Interactive/ hands-on life measurements & analysis, including a. room geometry - 3D Laser Scanner b. sound field of a room – Acoustic Camera c. interpretation of acoustic maps (acoustic phenomena)

Instructor biographies:

Dipl. Wi. Ing. Gunnar Heilmann, started at the gfai tech GmbH as the International Sales and Market Development Manager and is now the CEO of this 100% subsidiary of GFaI e.V. (Society for the Promotion of Applied Computer Science). Gunnar Heilmann has been involved with the Acoustic Camera since 2003. Resulting out of his position and more than 7 years of acoustic imaging measurement experience he has acquired considerable knowledge in several fields and applications. Additionally to his current position, through his intensive involvement in the technical development of the Acoustic Camera system, he published several papers on international academic conferences, self and co-authoring together with some members of the Acoustic Camera team as well as national and international cooperation partners such as Siegfried Meyer (Porsche AG Research Centre, Weissach, Deutschland) or Prof. Mojtaba Navvab (University of Michigan, Ann Arbor, USA). These papers are mainly related to the different implementation of beamforming algorithms and the application of the Acoustic Camera as a system solution as well as extending and improving the beamforming technology.

Magdalena Böck, B.A., is International Sales and Market Development Manager at gfai tech GmbH, a 100% Subsidiary of GFaI e.V., responsible for all international relations. Accountable for the strategic marketing, strategic partnerships, evaluation of market situation and development of the distributor network and sales force for the Acoustic Camera she plans, organises and executes training, support and supervision of all international partners and distributors. Having graduated in Export Management, with a specialisation in International Business and Geopolitical Affairs, Magdalena Böck has been involved with the Acoustic Camera since 03/ 2010. Resulting out of her position and acoustic imaging measurement experience she has acquired considerable knowledge in diverse fields and applications ranging from aerospace and automotive industries to consumer electronic industries and biological field measurements.

Acoustic design of mufflers

Instructors: Elnady Tamer, Ain Shams University, Åbom Mats, Royal Institute of Technology, Stockholm

Day: Sunday September 15 2013
Times/Room: 8:00 am - 5:00 pm/Freiburg I
Cost: € 100

Description: Acoustic Design of mufflers is often required for diagnosis, design validation including qualification and quality control. This course provides a thorough introduction to the behavior of mufflers and silencers including a description of the two-port approach to muffler design. The course covers both the acoustic simulation of muffler and silencer systems and the use of experimental methods to measure muffler performance. The main focus is on IC-engine intake and exhaust systems, but most of the information is also applicable to any pipe or duct system. The course comprises lectures and hands-on software examples where all attendants will have the opportunity to actively participate in simulations using SIDLAB two-port software.

Course Outline:

* Overview of the underlying theory of acoustic simulations of mufflers
* Insight into muffler design principles
* Experimental methods for measuring muffler and silencer performance
* 1D flow simulations and calculation of the pressure drop of muffler systems
* Demonstrate the use of software for linear acoustic two-port analysis
* Design and optimization of complete exhaust systems, including source and termination

Instructor biographies:

Tamer Elnady has a PhD in Technical Acoustics from the Royal Institute of Technology (KTH), Stockholm, in 2004. He is currently working as an Associate Professor at the Faculty of Engineering, Ain Shams University, Cairo, and the Head of ASU Sound & Vibration Laboratory. He is an expert in Duct Acoustics and Muffler Design. He is one of the developers of SIDLAB Software for the simulation of sound propagation in duct systems. He is also working as a consultant for several companies in different countries in the field of Muffler Design for different applications, Noise Control, and Environmental Acoustics modeling.

Mats Åbom is a Professor of Flow Acoustics at the Royal Institute of Technology (KTH), Stockholm. He has received his PhD in Engineering Acoustics from KTH in 1989. He has 30 years of experience in the field in sound generation and propagation in fluid media mainly with application to fluid machines and vehicles. He was employed (1996-2000) as acoustic specialist and main project leader at ABB Corporate Research, Västerås, Sweden. His work involved silencers for gasturbines and ships, whistling noise, fan noise and active control. He is one of the developers of SIDLAB Software.

Calculation of sound inside rooms with CadnaR (Vendor Course)
Instructor: Probst Wolfgang - DataKustik

Day: Sunday September 15 2013
Times/Room: 1:00 pm - 5:00 pm/Aalborg
Cost: € 50

Description: The course is for people interested in the calculation of stationary and transient sound inside rooms. This comprises the aspects of sound levels at work places in machinery halls and at production lines for reasons of minimizing the risk of hearing losses as well as to ensure certain target values for the reverberation time and other parameters describing the room acoustical quality. The participants don't need to be user of any noise calculation program. They get an overview about the underlying physical laws, the influencing parameters and the methods how to apply these relations to assess or optimize a given scenario.

Principles: The methods to describe the sound propagation and the resulting sound field in a room like diffuse field theory, image method and particle method are explained. The most important acoustical properties of separating constructions and of surfaces like specular and diffuse reflection as well as absorption and transmission are treated with clear and easy understandable scenarios. The modeling of technical sources like machinery is treated as well as the inclusion of loudspeakers or other warning devices. It is shown where diffraction by screening objects may be important and how this can be taken into account.

CadnaR: The packages "Industrial" and "Audio" with their tools and features are explained and demonstrated. This part shows the possibilities how to model even complex environments in short time, how to use the very powerful organization tools like groups/variants and object tree well known from CadnaA (noise prediction outside) and how to demonstrate and analyse the resulting distribution of sound levels. The application of CadnaR based on the emission values according to the European machine directive to predict noise levels at work places and the evaluation of reverberation times, clarity indices for speech and music or of speech transmission indices STI is explained and demonstrated.

Practical applications: Some case studies are applied to show the practical use of CadnaR. This comprises industrial environments like machinery halls and production lines with work places as well as administration areas with open plan offices where aspects of speech, privacy or other wanted and unwanted sound effects are of concern.''

Instructor biography:
Dr. Wolfgang Probst is founder, “Head of research and development” and Managing Director of DataKustik GmbH. He is Member of the Technical Board and of the Steering Committee, chairman of the Technical Division 2 “Noise Reduction” of NALS and convener of Technical Committee “Sound propagation and noise control in buildings, at workplaces and outdoors” NALS 001 02 03.

Industrial noise calculations with CadnaA (Vendor Course)
Instructor: Probst Fabian - DataKustik

Day: Sunday September 15 2013
Times/Room: 8:00 am - 12:00 noon/Aalborg
Cost: € 50

Description: The course is for people interested in industrial noise calculation. The participants don’t need to be user of any noise calculation program. During one half day, participants will be shown the state of the art in modeling, organizing and calculating noise according to relevant guidelines such as ISO9613-2.

The course will consist of the three parts modeling, project organization and calculations. For these parts, general concepts will be explained generically and illustrated with the software package CadnaA.

Modeling: during this part of the course, attendees will learn strategies for noise source modeling in industrial contexts as well as how to obtain emission data. It is shown that with modern software packages, emission data can even be obtained when measurements of the spectra aren’t possible; the spectra can automatically be generated from parameters such as the nominal power of a motor.

Project organization for large industrial projects, it is vital to organize objects hierarchically, i.e. in a tree structure. We show the benefit of this approach and how to execute it with CadnaA.

Calculations: Calculations must be fast and reliable. In CadnaA, this is the case. We show calculation possibilities including effects like meteorology.

Instructor biography:

Fabian Probst is the Assistant Managing Director of DataKustik GmbH and involved in many aspects of the software development of CadnaA and CadnaR. Consultation and Research work for different international noise mapping projects provide him with valuable insights about different approaches to noise management.

Innovative microflown based testing solutions for sound and vibration (Vendor Course)
Instructors: Comesaña Daniel Fernandez - Microflown Technologies, and Korbasiewicz Marcin - Microflown Technologies

Day: Sunday September 15 2013
Times/Room: 1:00 pm - 5:00 pm/Grenoble
Cost: € 30

Description: This course will explain the applications of particle velocity for intensity and sound power determination, advanced measurement techniques, combination of scanned noise maps with transfer path analysis methods, application of the techniques for far-fields, and virtual array approaches.

Instructor biographies:

Mr. Daniel Fernandez Comesaña and Mr. Marcin Korbasiewicz are both engineers at Microflown Technologies. Mr. Korbasiewicz has primary responsibility for end of line control applications based on microflown sensor. Mr. Fernandez Comesaña is currently studying a PhD in the University of Southampton focused on exploding all capabilities of scanning measurement techniques for sound visualization.

Intensive Course on Noise Control
Instructor: Gerges Samir N. Y.

Day: Sunday September 15 2013

Times/Room: 8:00 am - 12:00 noon/Grenoble
Cost: € 100

Description:
Learning Outcomes:

* Understand occupational noise and vibration problems based on an acquired fundamental knowledge of vibration and acoustic
* Use basic acoustic and vibration control engineering methods to develop effective occupational noise control solutions.
* Understand and describe the evaluation and selection of hearing protectors in the workplace.

Course Outline:

1 Acoustic parameters and sound propagation, Effects of noise and vibration on humans , Noise measurement equipment, Sound radiation from vibrating structures, Sound Isolation, Materials for sound absorption, Sound propagation in rooms and open air

2 Noise Control technology and Machinery Noise control

* Noise control strategies
* Noise control at the source, path or trajectory, and workers or receivers
* Enclosures calculation
* Noise control for fans and exhaust systems, motors, pumps, compressed air, values, cooling towers, etc.

3 Hearing protectors

* Types of performance of hearing protectors
* Noise attenuation characteristics measured at the laboratory, and real world attenuation
* Double protection
* Effect of hearing protector usage time over total daily dose reduction
* election of hearing protectors

Instructor biographies:

Samir N. Y. Gerges: Obtained his PhD from ISVR, Southampton University, UK, in 1974. Post-doctoral research fellow from 1974 to 1978 at ISVR, Southampton University and Sussex University in the UK. Five years experience in the aeronautical industry from 1964 to 1969. Professor of noise and vibration since 1978 at the Federal University of Santa Catarina (UFSC), Mechanical Engineering Department, Laboratory of Acoustics and Vibration, Brazil, where he teaches the fundamentals of acoustics, noise control, signal processing, environmental noise and instrumentation for noise and vibration measurements and analysis, to undergraduate and postgraduate students. His current interests include industrial, construction and road noise, hearing protectors, environmental noise, experimental and numerical vibro-acoustics analysis for industrial and vehicle applications and general room acoustics. Founder of the Industrial Noise laboratory (LARI) at UFSC and supervisor of LARI. He published several books "Noise: Fundamentals and Control" in 1998 which is available in Portuguese (1st edition in 1992 and 2nd edition in 2000 – 700 pages) and in Spanish. Also author of a 700 (A4) page book on Vehicles, Noise and Vibration 2000. Founder member of the Brazilian Acoustical Society (SOBRAC) in 1983 and President from 1994 to 1997 and again from 2000-2002. Editor of the SOBRAC Journal. Founder member and currently Vice President of the Ibero-American Federation of Acoustics - FIA (A joint federation of 7 acoustical societies of Argentina, Brazil, Chile, Peru, Mexico, Portugal and Spain). He is a member of the IIAV board of directors (Fellow member 1999), INCE-USA (Professional recognition) and ASA. "Non-Tenured Faculty Awards" from 3M. Annual award from CIPA Brazilian journal for safety in 1998. Member of WHO organization - Geneva working group for elaborating a book on "Evaluation and Control of Noise Exposure in the Work Environment" and author of two chapters – 2001 edition. Fellow member of ASA and Ad-Hoc committee for 144 ASA meeting, 9th IMA and 3rd FIA congress held in CANCUN in December 2002 and 2010. Member of the editing board of the Journal of Building Acoustics, Noise control Engineering Journal and International Journal of Acoustics and Vibration. Member of the international advisory committee of Inter-Noise yearly from 2000 to 2013. President and organizer of Internoise2005. President of ICA, Vice President I-INCE for membership. Coordinator of Technical Research Projects for FORD, GM, EMBRAER, FIAT, and other for NVH and Sound Quality projects. Has more than 320 papers published in indexed journals and congresses.

Modeling Acoustics and Mechanical Vibrations (Vendor Course)
Instructor: Andersson Linus, COMSOL

Day: Sunday September 15 2013
Times/Room: 8:00 am - 12:00 noon/Brüssel
Cost: free

Description: This course is about how COMSOL Multiphysics can be used for modeling acoustics and mechanical vibrations. We will explore both fluid acoustics and structural vibrations, and how they link to other physics in mechanical systems. Thermoacoustics and acoustics in porous media are also discussed. We will show a number of examples and demonstrations of applications such as mufflers, porous absorbers, piezoelectric transducers, ear canal simulators, and more.

The seminar lasts for 2 h 30 min and is followed by an optional 1 h 30 min hands-on session. During the hands-on session, you will get to try out the software by working through a couple of tutorial models in the field of acoustics and vibrations. The tutorials are designed to give participants a quick start and make the most out of the included two-week trial license.

As the number of seats is limited, please register today. Pre-registration and a laptop are mandatory for the hands-on session.

Instructor biography:

Linus Andersson received his M.Sc. degree in Engineering Physics at the Royal Institute of Technology in Stockholm, Sweden. He joined COMSOL in 2003, after completing his diploma thesis at CERN, Switzerland. Linus specializes in electromagnetics and acoustics.

Room acoustic modeling with ODEON (Vendor Course)
Instructor: Christensen Claus Lynge & Rindel Jens Holger, ODEON

Day: Sunday September 15 2013
Times/Room: 8:00 am - 5:00 pm/New Orleans
Cost: € 50

Description: This course is an introduction course to the room acoustics simulation and measurement software ODEON. The course combines demonstrations, lectures, and hands-on experience (using your own laptop - please be sure to bring one).

The course will showcase a number of applications of the Odeon software including auditoria, open plan offices, atria, industrial work rooms.

Participants will learn how to create 3D models for use in Odeon by importing in the dxf-format , modeling geometry models from scratch in the ODEON extrusion modeller or in Google Sketchup. Exercises include checking validity of models, input to calculations in terms of surface properties (scattering and absorption) as well as source and receiver definitions. The theory behind the calculation principles is also briefly presented.

Simulations are performed. It is discussed how to verify the quality of results and how to present results so customers can understand them – how to incorporate data, graphics, sounds and animations in reports and presentations; using the auralization options with headphones or with a surround speaker setup.

Finally the measurement facility included in Odeon 12 is presented. It is shown how measurements can be carried out using Odeon and how the integration of simulations and measurements in one application makes it easy to compare reality with simulations.

Instructors biography: Claus Lynge Christensen received his M.Sc. from the Technical University of Denmark. He joined Odeon in 1993 and has since then been in charge of the development of the Odeon software. Jens Holger Rindel received his Ph.D. from the Technical University of Denmark (DTU) in 1977. In 1984 he initiated the development of a room acoustic prediction tool, which later became Odeon. Until 2008 he was a professor in acoustics at DTU, since then part time in Odeon A/S and part time as a consultant in Norway. He has been the convener of several ISO working groups that prepared international standards for room acoustic measurements.

Tools for Noise Mapping and Action Plans (Vendor Course)
Instructor: Berndt Arne, SoundPLAN LLC

Day: Sunday September 15 2013
Times/Room: 1:00 pm - 5:00 pm/Freiburg II
Cost: € 50

Instructor biography:

In 1986, Arne Berndt founded the Braunstein & Berndt GmbH in Germany. Braunstein + Berndt GmbH is an engineering company with the main focus on noise control, air quality assurance and software development. In 1999, he moved to the US and founded SoundPLAN International LLC in Shelton, WA, USA. SoundPLAN International LLC acts as the interface between the development office and the more than 30 international distributors that help distribute and maintain the SoundPLAN software on a worldwide basis. Over the past 25 years Arne has trained acoustic engineers around the world in regards to noise modeling.

Date: Sunday, September 15th, 6 pm	Hall: Tirol
Distinguished Plenary Lecture 1	Paper: 9001
Chair: Werner Talasch	

Burgess Marion
School of Engineering and Information Technology, University of New South Wales, Australia

Community noise management and control: successes and challenges

Over recent decades there have been some clear achievements in the acknowledgement of the importance of addressing noise the community. The focus has been on the major noise sources associated with transportation and industry that globally affect the larger number of people. The publication of guidelines for noise level limits and for establishing noise control policies and approaches to noise management provides a good basis for further applications. This paper discusses some of the successes and also some of the remaining challenges in developing and adopting the most appropriate noise management and control policies.

Date: Monday, September 16th, 10.20 am	Hall: Tirol
Distinguished Keynote Lecture 1	Paper: 9002
Chair: Wolfgang Probst	

Paviotti Marco[1], Dodds Michael[2], Kephalopoulos Stylianos[3], Rapacz Piotr[4], de Vos Koen[5]

[1] European Commission, DG ENV, Belgium

[2] European Commission, DG ENTR, Belgium

[3] European Commission, DG JRC, Italy

[4,5] European Commission, DG MOVE, Belgium

The EU noise policy after the second round of noise maps and action plans

Environmental noise in the European Union is affecting a major part of the population with significant number of premature deaths and impact on the economy. The European regulatory framework provides for different means to tackle the problem and reduce the risk of health implications, by setting obligations for noise mapping, action plans and limits on the source emissions. But still a delayed implementation of the European regulation and the absence of an ambition level in the European Union prevented the possibility to set up an effective policy on noise abatement. The European Commission services are involved in a set of actions and are proposing a set of legislative acts aimed at improving the situation.

Date: Monday, September 16th, 10.20 am	Hall: Innsbruck
Distinguished Keynote Lecture 2	Paper: 9003
Chair: Manfred Haider	

de Roo Foort

TNO Technical Sciences, The Netherlands

New EU and UN/ECE Vehicle noise emission limits and associated measurement methods

In 2013 or early 2014 the European Union will decide upon a new “Regulation onthe sound level of motor vehicles”. It will specify a new type approval test method for noise emission and will give revised limit values for the permissible noise emission per vehicle (sub-)category. The new regulation may be seen as a final stage of a long series of developments towards a more representative way of testing, but at the same time it should be a starting phase of regular reductions of limit values in future in order to achieve a substantial reduction of traffic noise impact and improvement of urban environmental conditions.In this paper the historical development of noise emission test methods,the shortcomings of the current test method and theexpected improvements resulting fromthe new test method are discussed. The possible effects of three alternative proposals for the revision of the limit values and an outlook to future developments concerning vehicle noise emission test methods are presented.

Date: Tuesday, September 17th, 10.20 am	Hall: Tirol
Distinguished Keynote Lecture 3	Paper: 9004
Chair: Georg Thomann	

Genuit Klaus

HEAD acoustics GmbH, Germany

The Need for Transdisciplinary Actions - Psychoacoustics, Sound Quality, Soundscape and Environmental Noise

In spite of long-term endeavors to significantly reduce noise annoyance in cities, a great deal of persons is still suffering from environmental noise. It is very evident that a general rethinking is needed. Different disciplines must work more closely together to achieve a substantial sustainable reduction of noise annoyance. It is more than only about sound pressure levels violating or complying with a regulation. In contrast to this simple way of thinking, in the field of psychoacoustics and "sound quality" different psychoacoustic and hearing-related parameters are available, which allow for describing meticulously various hearing sensations. Moreover, the relatively young discipline "soundscape" can also greatly contribute to tackle recent environmental noise issues. It considers closely human perception including cognitive aspects, context and interaction going beyond physics and psychoacoustics. It involves a concept, where environmental noise is not reduced to an averaged quantity evoking only unpleasantness feelings, but noise is understood as a valuable resource, which can be purposefully utilized. The main ideas of psychoacoustics, sound quality and soundscape will be introduced, the potential interaction of these disciplines will be discussed and finally their benefit to current environmental noise issues will be presented.

Date: Tuesday, September 17th, 10.20 am	Hall: Innsbruck
Distinguished Keynote Lecture 4	Paper: 9005
Chair: Christian Kirisits	

Probst Wolfgang
Datakustik, Germany

Prediction of sounds and noises for a better environment - scientific and political aspects

There is a broad consensus in all civilized communities that environmental noise caused by traffic and industry causes high and partially not acceptable impacts in our more and more technically infused world. The computer supported prognosis of sound impact caused by technical sources and here the calculation of sound propagation are the most important core of these prediction techniques, because they allow checking the acceptance of infrastructure projects in the planning phase or the possible improvement in case of planned mitigation measures. The basis is an exact solution based on wave theory, but it is often not applicable for realistic environments with extended scenarios and complex propagation conditions. Therefore different engineering models have been developed on a national level applying approximations. The models differ in the weighting of the different acoustic phenomena influencing sound emission and propagation. With some examples it is shown that a well-balanced distribution of effort on including these different phenomena optimizes the accuracy of the final result. Due to the complexity of typical environments and the resulting calculation times this balance is important, because with longer calculation times fewer alternatives can be investigated. There is no optimal solution how an engineering model for noise prediction shall be constructed, and therefore it is important to inform the parties concerned about pros and cons, to have an open and transparent discussion and finally to lay down the decided compromises in an unambiguously and clear formulated official documentation. The best way to tackle such technical issues in democratic societies is the well developed standardization process with clear rules for including the concerned parties, with drafting periods and strategies for opposition proceedings and necessary revisions. Well established techniques of quality assurance support the correct implementation of standardized calculation methods in different software platforms.

Date: Wednesday, September 18th, 10.20 am	Hall: Tirol
Distinguished Keynote Lecture 5	Paper: 9006
Chair: Peter Lercher	

Persson Waye Kerstin[1], Ryherd Erica[2]

[1] Occupational and Environmental Medicine, the Sahlgrenska Academy, Gothenburg University, Sweden

[2] Woodruff School of Mechanical Engineering, Georgia Institute of Technology, USA

Achieving a healthy sound environment in hospitals

A large number of studies show that hospitals are unacceptably noisy. Up to date no study has measured noise levels in intensive care units or neonatal wards that comply with the WHO recommendations. Furthermore, sound levels in hospitals have risen since the 1960s. The noise origins mainly from: (1) operational activities generated by the staff in their care giving activities and communication, (2) medical equipment and alarms and (3) structural sounds from the building such as ventilation and closing doors. While some sounds are unavoidable, many are totally or partially unnecessary. Noise in hospitals has been suggested to increase the risk for cardiovascular response, pain, intensive care delirium, fragmented sleep and reduced recuperation. For patients, the cause of these outcomes is multi-factorial, however the impact of the sound environment can, as opposed to most other factors, be abated. For the personnel, noise may cause annoyance, stress, tiredness and lead to more errors however these outcomes are less well investigated. The paper will give a summary of what is known today, specifically focusing on the outcomes from intervention studies of the physical environment and point to the most important areas for further improvements in research.

Date: Wednesday, September 18th, 10.20 am	Hall: Innsbruck
Distinguished Keynote Lecture 6	Paper: 9007
Chair: Rainer Flesch	

Kurita Takeshi

Research and Development Center of JR East Group, East Japan Railway Company, Japan

Reduction of external noise from Shinkansen trains

JR-East has been developing technologies to raise maximum operating speed of Shinkansen to 360 km/h. Wayside noise reduction arises as a major issue when increasing the Shinkansen's operating speed, as it is necessary to keep wayside noise levels within those of existing Shinkansen trains, even at a speed of 360 km/h. In recent commercial trains, it has been acknowledged that pantograph noise and noise from lower part of cars are the main Shinkansen noise sources. In this study, the quantitative contributions of respective noise sources to the overall noise were clarified in order to more effectively reduce Shinkansen noise. Measures were proposed and developed for noise from pantographs and lower part of cars, both sources of which contribute greatly to overall noise. These measures are being used for new generation "Series E5" Shinkansen trains. Series E5 was introduced with a maximum speed of 300 km/h for the Tohoku Shinkansen line in March 2011. In March 2013 the maximum speed was increased to 320 km/h, the highest speed for regular Shinkansen operation in Japan. This paper describes the measures developed for reducing external noise from Shinkansen trains. In addition, an example of research for further noise reduction is presented.

Date: Wednesday, September 18th, 4 pm	Hall: Tirol
Distinguished Plenary Lecture 2	Paper: 9008
Chair: Christoph Lechner	

von Estorff Otto

Hamburg University of Technology, Institute of Modelling and Computation, Germany

Noise Sources: Facts, Fears, Future

Numerical procedures, such as the finite element and boundary element methods, are known to be very suitable tools for the investigation of noise sources. It turned out, however, that early formulations of these methodologies are rather computer time consuming and therefore not used very often in practical applications. The contribution aims to give an overview of the current possibilities of numerical methods to model the noise generated by technical systems. It will show some “facts” of today’s real live applications. Also the “fears” that computer simulations will replace measurements completely, will be addressed by means of representative examples. Finally, it will be discussed how in the “future” modern computations will be performed and which topics will be of particular interest in current research. All methodologies discussed in this contribution are introduced briefly and illustrated by examples which show how the approaches can be used and how accurate they are.

TIMETABLE

Sunday, September 15th

Short Courses

Time	Grenoble	Brüssel	Aalborg	Freiburg I	New Orleans	Freiburg II
08:00 - 12:00	(p. 45) Intensive Course on Noise Control	(p. 47) Modeling Acoustics and Vibrations	(p. 44) Industrial noise calculations with CadnaA (Vendor Course)	(p. 41) Acoustic design of mufflers	(p. 48) Room acoustic modeling with ODEON (Vendor Course)	
13:00 - 17.00	(p. 45) Innovative microflown-based testing solutions for sound and vibration (Vendor Course)	(p. 40) Acoustic Camera - practical workflow and sound source localization GfAI (Vendor Course)	(p. 42) Calculation of sound inside rooms with CandaR (Vendor Course)			(p. 49) Tools for Noise Mapping and Action Plans (Vendor Course)

Internoise 2013

Time	Hall Tirol	Kristall Foyer & Tirol Foyer	Messeforum Innsbruck
05:00 pm	Opening Session		
06:00 pm	Plenary lecture 1 (p.51) - Marion Burgess: Community noise management and control: success and challenges		
07:00 pm		Welcome reception	
08:00 pm			Chair persons Dinner (by invitation only)

Business Meetings Internoise 2013, Hotel Grauer Bär

Saturday, September 14th – I-INCE

08:30-12:00	**Congress Selection Committee**	Seminarraum 1
12:00-13:00	**Lunch for I-INCE Board of Directors**	Seminarraum 2
13:00-18:00	**I-INCE Board of Directors**	Seminarraum 1

Sunday, September 15th - I-INCE

07:30-10:00	**Pre Future Congress Technical Planners Committee**	Seminarraum 1
09:00-11:30	**Technical Study Group # 9**	Seminarraum 2
09:00-11:30	**Technical Study Group # 10**	Seminarraum 3
11:00-12:00	**CAETS Noise Control Technology Committee (NCTC) Panel**	Seminarraum 1
13:00-15:45	**General Assembly**	Seminarraum 3

Wednesday, September 18th – I-INCE

18:00-20:30	**I-INCE Board of Directors**	Seminarraum 1

Thursday, September 19th

Technical Meetings (X-Noise Workshop)

08:00-18:00	**Aviation Noise Annoyance related research**	Seminarraum 1
08:00-12:00	**General Aviation Muffler Design**	Seminarraum 2

Timetable Monday, September 16th, Internoise 2013

Time	Tirol	Innsbruck	Brüssel	Freiburg	Strassburg 1	Strassburg 2
08:20	**SS50 (p.127)** Community Noise Annoyance	**SS11 (p.143)** Aircraft Noise Modeling - from the individual Aircraft to the Airport Scenario	**SS01 (p.157)** Tire/Road Noise - Low Noise Pavements	**SS18 (p.174)** Building Acoustic Properties, Regulations and Comfort Classes	**SS27 (p.191)** Long and Short Range Sound Propagation	**SS32 (p.204)** Noise Mapping and Action Planning
08:40						
09:00						
09:20						
09:40						
10:00						
10:20	**Keynote 1 (p.52)**	**Keynote 2 (p.53)**				
10:40						
11:00	**SS50 (p.131)** Community Noise Annoyance	**SS11 (p.147)** Aircraft Noise Modeling - from the individual Aircraft to the Airport Scenario	**SS02 (p.162)** Tire/Road Noise - Low Noise Tires	**SS18 (p.177)** Building Acoustic Properties, Regulations and Comfort Classes		**SS32 (p.208)** Noise Mapping and Action Planning
11:20					**SS27 (p.194)** Long and Short Range Sound Propagation	
11:40						
12:00						
12:20						
12:40						
13:00	**Lunch break**					
13:20						
13:40						
14:00	**SS50 (p.135)** Community Noise Annoyance	**SS11 (p.149)** Aircraft Noise Modeling - from the individual Aircraft to the Airport Scenario	**SS02 (p.165)** Tire/Road Noise - Low Noise Tires	**SS18 (p.181)** Building Acoustic Properties, Regulations and Comfort Classes	**SS27 (p.197)** Long and Short Range Sound Propagation	**SS32 (p.212)** Noise Mapping and Action Planning
14:20						
14:40						
15:00					**SS28 (p.199)** Sound Propagation in Built-up Areas	
15:20						
15:40	**SS62 (p.138)** Response to change through Interventions - Noise Reduction or Acoustic Enhancement	**SS12 (p.153)** Uncertainty of Aircraft Noise Measurements and Calculations	**SS03 (p.169)** Modelling and Simulation of Road Vehicle, Tire and Pavement Noise			
16:00						
16:20						
16:40						**SS32 (p.216)** Noise Mapping and Action Planning
17:00						
17:20						
17:40						

Timetable Monday, September 16th, Internoise 2013

Time	Grenoble	Igls	Maximilian	New Orleans	Lugger	Aalborg
08:20	**SS16 (p.219)** Measurements in Room and Building Acoustics	**SS58 (p.233)** Psychological Effects, cognitive Effects and mental Health	**SS44 (p.251)** Vibroacoustics and Vibrations	**SS69 (p.266)** Soundscape and Human Resources	**SS40 (p.283)** Signal Processing and Analysis	**SS36 (p.299)** 3D Sound Reproduction
08:40						
09:00						
09:20						
09:40						**SS37 (p.302)** Numerical Techniques
10:00						
10:20						
10:40						
11:00	**SS16 (p.222)** Measurements in Room and Building Acoustics	**SS58 (p.237)** Psychological Effects, cognitive Effects and mental Health	**SS44 (p.255)** Vibroacoustics and Vibrations	**SS69 (p.269)** Soundscape and Human Resources	**SS40 (p.287)** Signal Processing and Analysis	**SS37 (p.303)** Numerical Techniques
11:20						
11:40						
12:00						
12:20						
12:40		**SS59 (p.240)**				
13:00	**Lunch break**					
13:20						
13:40						
14:00	**SS20 (p.226)** Impact Sound	**SS59 (p.240)** Effects on Sleep - Adults & Children	**SS44 (p.258)** Vibroacoustics and Vibrations	**SS70 (p.274)** Soundscape Design and Interventions	**SS40 (p.290)** Signal Processing and Analysis	**SS 37 (p.306)** Numerical Techniques
14:20						
14:40						
15:00						
15:20		**SS60 (p.244)** Cardiovascular and other somatic Effects: Adults & Children				
15:40			**SS44 (p.261)** Vibroacoustics and Vibrations			
16:00						
16:20	**SS 20 (229)** Impact Sound			**SS71 (p.279)** Noise-Control Education Delivery and Technology Transfer Methods		
16:40					**SS42 (p.296)** Measurement of Surface Properties	**SS38 (p.313)** Sound Visualization and Aurealization
17:00						
17:20						
17:40						

Timetable Tuesday September 17th, Internoise 2013

Time	Tirol	Innsbruck	Brüssel	Freiburg	Strassburg 1	Strassburg 2
08:20	**SS52 (p.362)** Environmental Health Impact Assessment of Transportation Noise at different Scales	**SS13 (p.377)** Aircraft Noise Effects		**SS26 (p.407)** Acoustics of Educational Facilities / Classroom Acoustics	**SS29 (p.424)** Standardized Noise Prediction Methods	**SS30 (p.436)** Mitigation Measures and Products
08:40			**SS03 (p.392)** Modelling and Simulation of Road Vehicle, Tire and Pavement Noise			
09:00						
09:20						
09:40						**SS33 (p.439)**
10:00						
10:20	**Keynote 3 (p.54)**	**Keynote 4 (p.55)**				
10:40						
11:00	**SS54 (p.366)** Alternative indicators for Community Noise Effects Assessment	**SS13 (p.381)** Aircraft Noise Effects	**SS04 (p.395)** Measurement Methods for Road Vehicle, Tire and Pavement Noise	**SS26 (p.410)** Acoustics of Educational Facilities / Classroom Acoustics	**SS29 (p.427)** Standardized Noise Prediction Methods	**SS33 (p.439)** Noise Monitoring and Measurement
11:20						
11:40						
12:00				**SS25 (p.413)** Room Acoustics		
12:20						
12:40						
13:00	**Lunch break**					
13:20						
13:40						
14:00	**SS56 (p.370)** Restorative Aspects of Sound Exposure and quiet Areas		**SS05 (p.399)** Road Vehicle Exterior and Interior Noise	**SS25 (p.415)** Room Acoustics	**SS09 (p.430)** Railway Airborne Noise	**SS33 (p.443)** Noise Monitoring and Measurement
14:20		**SS14 (p.385)** Aircraft Noise Management and Mitigation Measures				
14:40						
15:00						
15:20						
15:40						
16:00	**SS56 (p.373)** Restorative aspects of Sound Exposure and quiet Areas					
16:20		**SS14 (p.388)** Aircraft Noise Management and Mitigation Measures				**SS33 (p.447)** Noise Monitoring and Measurement
16:40				**SS21 (p.421)** Insulation of Air-borne and Structure-borne Sound		
17:00			**SS07 (p.405)** Noise from Hybrid and Electric Road Vehicles			
17:20						
17:40						

19.30	**Banquet Dinner**

Timetable Tuesday, September 17th, Internoise 2013

Time	Grenoble	Igls	Maximilian	New Orleans	Lugger	Aalborg
08:20	**SS23 (p.450)** Lightweight Constructions and Systems	**SS61 (p.467)** Noise in Educational Settings	**SS46 (p.485)** Materials for Noise and Vibration Control	**SS72 (p.501)** Fan Noise	**SS43 (p.514)** Sound Power	**SS38 (p.527)** Sound Visualization and Aurealization
08:40						
09:00						
09:20						
09:40						
10:00						
10:20						
10:40						
11:00	**SS23 (p.454)** Lightweight Constructions and Systems	**SS51 (p.471)** Combined Exposures	**SS46 (p.488)** Materials for Noise and Vibration Control	**SS73 (p.505)** Ducts and Mufflers	**SS41 (p.518)** Acoustic Metrology	**SS39 (p.531)** Active Noise and Vibration Control
11:20						
11:40						
12:00						
12:20						
12:40		**SS66 (p.475)**				
13:00	**Lunch break**					
13:20						
13:40						
14:00	**SS23 (p.458)** Lightweight Constructions and Systems	**SS66 (p.475)** Quiet Vehicles	**SS47 (p.493)** Machinery Noise	**SS73 (p.508)** Ducts and Mufflers	**SS41 (p.521)** Acoustic Metrology	**SS39 (p.535)** Active Noise and Vibration Control
14:20						
14:40						
15:00						
15:20		**SS67 (p.479)** Psychoacoustics of environmental and mobile Noise Sources				
15:40				**SS73 (p.511)** Ducts and Mufflers	**SS41 (p.524)** Acoustic Metrology	
16:00						
16:20						
16:40	**SS15 (p.464)** Building Acoustics / Architectural Acoustics - General					
17:00						
17:20						
17:40						

Time	
19.30	**Banquet Dinner**

Timetable Wednesday, September 18th, Internoise 2013

Time	Tirol	Innsbruck	Brüssel	Freiburg	Strassburg 1	Strassburg 2
08:20	**SS55 (p.573)** Noise and Health related Quality of Life	**SS10 (p.587)** Railway induced Vibrations and Vibration induced Airborne Noise	**SS07 (p.595)** Noise from Hybrid and Electric Road Vehicles	**SS25 (p.605)** Room Acoustics	**SS31 (p.616)** Barriers	**SS34 (p.627)** Industrial Noise, Construction Noise
08:40						
09:00						
09:20						
09:40						
10:00	**SS63 (p.577)**					
10:20	**Keynote 5 (p.56)**	**Keynote 6 (p.57)**				
10:40						
11:00	**SS63 (p.577)** Health Care Acoustics	**SS10 (p.591)** Railway induced Vibrations and Vibration induced Airborne Noise	**SS08 (599)** Road Traffic Noise Characterization	**SS17 (p.609)** Prediction Methods for Building and Room Acoustics	**SS31 (p.620)** Barriers	**SS34 (p.630)** Industrial Noise, Construction Noise
11:20						
11:40						
12:00						
12:20	**SS64 (p.581)** Noise Policy and Economic Evalution of Noise Effects					
12:40						
13:00	**Lunch break**					
13:20						
13:40						
14:00	**SS64 (p.582)** Noise Policy and Economic Evalution of Noise Effects		**SS08 (p.602)** Road Traffic Noise Characterization	**SS17 (p.612)** Prediction Methods for Building and Room Acoustics	**SS31 (p.623)** Barriers	**SS35 (p.633)** Noise from Recreation-, Entertainment- and Sporting Facilities
14:20						
14:40						
15:00						
15:20						
15:40						
16:00	**Plenary lecture 2 (p.58)** von Estorff Otto, Noise Sources: Facts, Fears, Future					
16:20						
16:40						
17:00	**Closing Ceremony**					
17:45	**Farewell Reception (by Invitation of Internoise 2014 - Melbourne)**					

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Time	Grenoble	Igls	Maximilian	New Orleans	Lugger	Aalborg
08:20	**SS23 (p.637)** Lightweight Constructions and Systems	**SS68 (p.647)** Applied Psychoacoustics of Machinery noise		**SS74 (p.666)** Aeroacoustics	**SS49 (p.677)** Underwater Noise	**SS76 (p.684)** Noise Annoyance and Communication Problems at the Workplace
08:40			**SS48 (p.657)** Noise from Renewable Energy Technologies			
09:00						
09:20						
09:40						
10:00						
10:20						
10:40						
11:00	**SS22 (p.640)** Characterization of Structure-borne Sound Sources	**SS68 (p.650)** Applied Psychoacoustics of Machinery Noise	**SS48 (p.660)** Noise from Renewable Energy Technologies	**SS74 (p.669)** Aeroacoustics	**SS49 (p.680)** Underwater Noise	**SS76 (p.687)** Noise Annoyance and Communication Problems at the Workplace
11:20						
11:40						
12:00						**SS75 (p.690)** Occupational Noise Exposure and Hearing Protection
12:20						
12:40						
13:00	Lunch break					
13:20						
13:40						
14:00	**SS22 (p.643)** Characterization of Structure-borne Sound Sources	**SS68 (p.654)** Applied Psychoacoustics of Machinery Noise	**(p.664)** FCTP Future Congress Technical Planning Committee	**SS74 (p.673)** Aeroacoustics		**SS75 (p.692)** Occupational Noise Exposure and Hearing Protection
14:20						
14:40						
15:00						
15:20						
15:40						
16:00						
16:20						
16:40						
17:00	**Closing Ceremony**					
17:45	**Farewell Reception (by Invitation of Internoise 2014 - Melbourne)**					

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OVERVIEW

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SS50 Community noise annoyance

Chair: Janssen Sabine, Lee Soogab, Pedersen Eja

Monday 08:20-08:40, Hall Tirol, Paper 0767 (invited)
Pedersen Eja
Current and former residents' perception of environmental stressors in areas with low and medium exposure: a Swedish case study

Pedersen Eja
Environmental Psychology, Department of Architecture and Built Environment, Lund University, Sweden

Urban residents annoyed by environmental stressors in their present dwelling possibly move to other areas of the city if they have the option. The prevalence of annoyance and other measurements of response to exposure to noise, odour, vibrations or unwanted light could therefore be lower than expected due to a spatial selection. Is this true also for areas exposed to low or medium levels of environmental stressors? Current residents (n = 144) were compared with those who had moved out (n = 81) during the past 5 years in two areas dominated by detached and terraced housing. One area was classified as quiet with only local traffic; the other was situated in the vicinity of a harbour and a waste water treatment plant generating heavy road traffic, but only of moderate levels. Perceived or remembered annoyance, resulting from environmental exposure to 15 different stressors possibly intruding into the dwelling, was measured using postal questionnaires together with individual factors. No major differences in prevalence of annoyance between current and former residents were found. The results are discussed in the light of place attachment, life satisfaction, self-reported health, and sensitivity.

Monday 08:40-09:00, Hall Tirol, Paper 1008 (invited)
de Kluizenaar Yvonne
Annoyance and disturbed sleep due to road traffic noise: The importance of the least exposed side – QSIDE

de Kluizenaar Yvonne[1], Gidlöf-Gunnarsson Anita[2], Botteldooren Dick[3], Bockstael Annelies[3], Janssen Sabine A.[1], Vos Henk[1], van den Berg Frits[4], Salomons Erik M.[1]

[1] TNO, Department of Urban Environment and Safety, The Netherlands
[2] Occupational and Environmental Medicine, University of Gothenburg, Sweden
[3] Department of Information Technology (INTEC), Ghent University, Belgium
[4] Public Health Services (GGD), Municipality of Amsterdam, The Netherlands

Introduction: In urban areas, road traffic noise is a dominant source of environmental noise and a major cause of noise annoyance and disturbed sleep. It has been hypothesized that respondents highly exposed to noise at multiple sides of their dwelling, may be expected to be worse off than respondents with the same exposure at the most exposed side, but also having a quiet side to their dwelling. Previous studies provide support for this hypothesis, however to date only a limited number of studies have investigated this hypothesis. There is a need for strengthening existing evidence, and for further quantification of the effects. Methods: Within the EU project QSIDE, the effect of the least exposed facade on annoyance and sleep response is studied in different EU cities in Sweden, Belgium and the Netherlands, including Gothenburg, Stockholm, Antwerp, Gent and Amsterdam. Results: In this paper we discuss the general picture arising from the outcome of these studies. We discuss what the implications may be for new situations (urban planning) and existing high exposure situations (noise abatement measures). Conclusion: The noise environment may be improved by taking into account the exposure levels, and promoting quietness, at the least exposed façade.

Monday 09:00-09:20, Hall Tirol, Paper 0445 (contributed)
Cik Michael
Free field evaluation of the influence of naturalistic road and rail traffic noise on both psychological and physiological parameters

Cik Michael[1], Fallast Kurt[1], Marth Egon[2]

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[2] Institute of Hygiene, Microbiology and Environmental Medicine, Medical University Graz, Austria

The direct effects of sound energy on human hearing are well established and accepted but previous research about the effects of noise exposure on medical parameters has been carried out mainly under laboratory conditions. Such test arrangements are notrepresentative of the real impacts on humans, especially at night during sleep phases. The two main objectives of this designed project are to investigate the influence of road and rail traffic noise on human sleep patterns and additionally to explore the relationship of subjective perception of test subjects with objective measured psychoacoustic and physiological parameters. The crucial point of the designed project is that all measurements will be done in the free field with real-life situations. Based on past experiences of the Graz University of Technology with acoustical measurement techniques in free field areas a standardized method for objective acoustical measurements in residential environments of test subjects will be developed. The goal of acoustical measurements is to achieve a time-synchronicity between the results of the electronic questionnaire (traffic noise annoyance-rating, experiences, feelings and behaviour) and acoustical parameters including sound pressure level and psychoacoustics reflecting the total quantity and quality of the test subject's acoustic exposure. The concept and first results of a preliminary study will be shown.

Monday 09:20-09:40, Hall Tirol, Paper 0470 (contributed)
van Laarhoven Loek
Noise-management in public space with the Laarhoven-index®, Evaluation of a new real life experience index

van Laarhoven Loek[1], Vinken Reinier[2]
[1] LaX Geluid BV, The Netherlands, [2] Ingenieursburo Ulehake BV, The Netherlands

Noise in environmental legislation is based on electro-physical acoustics. The intention is to protect citizens against hearing damage and to guarantee quality of life. If the impact of psycho-acoustic factors is denied, civil servants will be faced with strong complaints in spite of their efforts to reduce noise pollution. This psychological gap in the existing legislation was our reason to begin research into other ways to measure noise pollution in urban situations. A pilot project of 10 "smart" monitors has been installed in downtown Oss in the south of The Netherlands to measure acoustic parameters and to calculate the innovative "Laarhoven-index". This index defines the disturbance of a suitable acoustic climate in a street and can be expressed as the resulting vector in a complex NDR-model (N= Normalization and exposure; D= Dynamics, low frequency and spectrum; R= Response and acceptance). The results of an extensive survey show fewer complaints about noise pollution. The monitor shows the acoustic situation in the street equivalent to real life experience of the inhabitants. The index appears to be a good instrument for noise management in the city centre; have the possibility to cumulate sound from various sources and is suitable to set up future simulations.

Monday 09:40-10:00, Hall Tirol, Paper 0566 (contributed)
Ota Atsushi
Analysis of annoyance and disturbance reaction to traffic noise in Japan with Socio-Acoustic Survey Data Archive, SASDA

Ota Atsushi[1], Yokoshima Shigenori[2], Yano Takashi[3], Kawai Keiji[3], Morinaga Makoto[4], Marihara Takashi[5]

[1] Institute of Urban Innovation, Yokohama National University, Japan
[2] Kanagawa Environmental Research Center, Japan
[3] Graduate School of Science and Technology, Kumamoto University, Japan
[4] Defense Facilities Environment Improvement Association, Japan
[5] Department of Architecture, Ishikawa National College of Technology, Japan

A technical subcommittee at the INCE/JAPAN has managed the Socio-Acoustic Survey Data Archive (SASDA) since 2011. The SASDA authors investigated the relationship between noise exposure and annoyance reactions to traffic noise, such as noises from road traffic, conventional railways, Shinkansen (bullet train) railways, and civil and military aircraft in Japan. Military aircraft noise was found to be the most annoying, and Shinkansen railway and civil aircraft noise were rated as the next highest in annoyance. Road traffic noise was the least annoying. The authors also investigated reactions conversation disturbances, telephone disturbances, TV/radio listening disturbances, reading/thinking disturbances, rest disturbances, disturbances when falling asleep, awakening, reluctance to open windows, and disturbances from house vibration. Military aircraft noise was apt to cause reading/thinking disturbances, Shinkansen railways led to house vibration, while conventional railways led to listening disturbances. Road traffic noise rarely caused disturbances compared with other noise types, but it was a factor in deciding whether to open windows.

Monday 10:00-10:20, Hall Tirol, Paper 0356 (contributed)
Notley Hilary
The UK national noise attitude survey 2012 – the sample, analysis and some results

Notley Hilary[1], Grimwood Colin[2], Raw Gary[3], Clark Charlotte[4], Van de Kerckhove Rik[5], Zepidou Georgia[6]

[1] Department for Environment, Food and Rural Affairs Nobel House, UK
[2] CJG Environmental Management, Bureau Veritas Associate, UK
[3] GR People Solutions, Bureau Veritas Associate, UK
[4] Wolfson Institute of Preventive Medicine, Queen Mary University London, UK
[5] Defra, UK
[6] Bureau Veritas, UK

The UK Department for Environment, Food and Rural Affairs has embarked upon the third in a series of National Noise Attitude Surveys designed to allow the UK Government to understand current attitudes to noise (environmental, neighbour and neighbourhood) and to detect any substantive changes in attitudes to noise in the UK since previous surveys conducted in 1991 and 1999/2000. The survey has been designed to provide the Government with information about attitudes to various aspects of environmental, neighbour and neighbourhood noise; and to monitor the implementation of the Governmernt's Noise Policy as set out in the Noise Policy Statement for England. More detailed descriptions of the survey method and questionnaire design have previously been published, whilst the survey was being conducted. This paper summarises the design and describes the final sample obtained and the analysis undertaken. Some main strategic findings are presented. It is anticipated that a fuller description of these results will be available in the presentation.

Monday 11:00-11:20, Hall Tirol, Paper 0853 (contributed)
Brink Mark
Annoyance assessments in postal surveys using the 5-point and 11-point ICBEN-scales: effects of scale and question arrangement

Brink Mark
D-MTEC Public and Organizational Health, Ergonomics & Environment, Switzerland

Background: The type of noise annoyance scale and its presentation (question location, order of answer alternatives etc.) in questionnaires or interviews as well as other contextual factors potentially affect annoyance responses and explained variance in socio-acoustic surveys. Methods: By means of a balanced experimental design, we investigated the effect of type of scale (5-point vs. 11-point ICBEN scale), presentation order of answer alternatives (ascending vs. descending) and question location (early vs. late) within a postal questionnaire on annoyance responses and model fit characteristics. The survey was carried out on a stratified sample of 1217 residents affected by road traffic noise between 50 und 70 dB(A) Ldn. Results: Early appearance of annoyance questions was positively associated with a higher annoyance score as well as with a higher probability of reporting "high annoyance". The order of answer alternatives had no effect. Annoyance responses on the 11-point scale were slightly higher and yielded larger R-squareds in linear exposure-effect models than responses on the 5-point scale, as determined by bootstrap resampling. Conclusion: The placement of annoyance questions

within a postal questionnaire has an effect on the level of reported annoyance, with early appearing annoyance questions resulting in higher annoyance scores. The order of answer alternatives has no effect. Statistical exposure-annoyance models fit slightly better using the answers from the 11-point scale. Whether these findings also apply to face-to-face or telephone interviews remains to be investigated.

Monday 11:20-11:40, Hall Tirol, Paper 0614 (contributed)
Nguyen Thu-Lan
A method to compare the prevalence of annoyance measured with different scales

Nguyen Thu-Lan[1], Yano Takashi[1], Morihara Takashi[2]

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[2] Ishikawa National College of Technology, Japan

Inconsistency on the definition of % highly annoyed as well as the use of various scales cause difficulties in comparing the outcomes among noise studies. The European Union's position paper recommended a transformation of various annoyance scales to a 0 to 100 basis and usage of a cut-off at the scale value 50 for % annoyed or 72 for % highly annoyed, respectively. Though ICBEN (International Commission on Biological Effects of Noise) proposed to use 5-point verbal and 11-point numeric scales in socio-acoustic surveys, generally either of the scales may be used. For example, Acoustical Society of Japan proposed a standardized questionnaire on living environment with only 5-point verbal scale. When only the 5-point verbal scale is used for surveys, it may be difficult to precisely compare the prevalence of annoyance with % highly annoyed extent (top 28%) accumulated so far. In this paper, a method is proposed to estimate % highly annoyed based on the top three of 11-point numeric scale (top 27%) from prevalence of annoyance based on 5-point verbal scale by using data sets obtained from socio-acoustic surveys carried out in Japan and Vietnam.

Monday 11:40-12:00, Hall Tirol, Paper 0414 (contributed)
Yokoshima Shigenori
Effects of house vibrations on community response to ground transportation noise

Yokoshima Shigenori[1], Matsumoto Yasunao[2], Shiraishi Hidetaka[3], Ota Atsushi[4], Tamura Akihiro[4]

[1] Kanagawa Environmental Research Center, Japan
[2] Saitama University, Japan
[3] Center for Environmental Science in Saitama, Japan
[4] Yokohama National University, Japan

Many studies in Japan have clarified no railway bonus unlike Euro-American countries. To clarify a factor of the difference, the authors examined effects of house vibrations on annoyance due to ground transportation noise. Community responses to noise and vibration were obtained from the surveys which were separately carried out along trunk road, conventional and Shinkansen railways in Japan. Noise and vibration ground were measured on a site-by-site basis for each survey. As for the comparison of dose-response relationship among the modes of ground transportation, the percentage of highly annoyed persons (%HA) due to noise from Shinkansen railway was the highest, followed by conventional railway and road traffic. Likewise, ground vibration from Shinkansen railway was highest and that of road traffic was lowest at the same noise level. Then comparison of %HA according to the level of ground vibration indicated that %HA with high level vibration increased in comparison to low level vibration in each mode. In addition, rattling also contributed to the %HA; the order of the incidence was identical to that for of ground vibration. From these findings, higher annoyance induced-by railways than road traffic in Japan is contributed to the difference in house vibrations.

Monday 12:00-12:20, Hall Tirol, Paper 0399 (contributed)
Oka Shuhei
Community response to a step change in railway noise and vibration exposures by the opening of a new Shinkansen Line

Oka Shuhei[1], Murakami Yasuhiro[2], Tetsuya Hiroyuki[1], Yano Takashi[1]

[1] Graduate School of Science and Technology, Kumamoto University Japan
[2] Department of Architecture, Sojo University, Japan

Noise and vibration from Shinkansen Line has been a serious social problem in Japan since the opening of Tokaido Shinkansen Line in 1964. Under the development of Shinkansen network Kyushu Shinkansen Line was opened in 2011. The purpose of this study is to compare the community responses to railway noise and vibration between before and after the opening of Kyushu Shinkansen Line and to compare the community response with those of the other Shinkansen Lines. Socio-acoustic surveys were carried out in areas of

Kumamoto, where conventional railway and Shinkansen lines are close and parallel each other, before the opening (2008-2010) and after the opening (2011-2012). After the opening, the limited express trains were retired and more super-express trains run. Though the noise and vibration exposures were almost the same before and after the opening, the annoyances were decreased after the opening. The annoyances and daily activities caused by conventional railway noise and vibration were greater than those of Shinkansen Line. The dose-response relationship of Kyushu Shinkansen Line was lower than the other Shinakansen Lines. This may indicate that the noise and vibration countermeasures have been efficiently treated.

Monday 12:20-12:40, Hall Tirol, Paper 0819 (contributed)
Janssen Sabine A.
A meta-analysis of surveys into vibration annoyance from railway

Janssen Sabine A.[1], Vos Henk[1], Koopman Arnold[1,2]

[1] TNO (Netherlands Organization for Applied Scientific Research), The Netherlands
[2] Level Acoustics, Eindhoven University of Technology, The Netherlands

The EU-project CargoVibes aims to describe the expected annoyance due to vibration among residents living near (freight) railway lines. Compared to the state of knowledge on the annoyance response to noise, relatively little is known about the relationship between vibration exposure and annoyance. Existing evaluation criteria in use are not consistent and not always based on relevant surveys. Although in several countries surveys were done on railway-induced vibration, the results are not readily comparable due to the use of different exposure metrics. In the present study, a meta-analysis was done on all available exposure-response datasets from railway vibration surveys, eight in total including two new surveys. A statistical method taking into account the multilevel structure of the sample was used, and a conversion matrix was developed that allows to convert different vibration metrics into each other. Despite differentiation in the annoyance response between studies, partly explained by source of vibration, an exposure-response relationship could be derived, showing the expected percentage of residents annoyed or highly annoyed at a given vibration level. This exposure-response relationship may form the basis of criteria for the evaluation of adverse effects of railway vibration.

Monday 12:40-13:00, Hall Tirol, Paper 0705 (invited)
Kuwano Sonoko
Social survey on community response to wind turbine noise in Japan

Kuwano Sonoko[1], Yano Takashi[2], Kageyama Takayuki[3], Sueoka Shinichi[4], Tachibana Hideki[5]

[1] Osaka University, Japan
[2] Kumamoto University, Japan
[3] Oita University of Nursing and Health Sciences, Japan
[4] Sueoka Professional Engineer Office, Japan
[5] Chiba Institute of Technology, Japan

A committee of Research on the Evaluation of Human Impact of Low Frequency Noise from Wind Turbine Generators conducted a serie sof physical measurements, laboratory psychological experiments and social surveys of wind turbine noise under the auspice of the Ministry of the Environment of Japan. In this paper, a design of questionnaire used in the survey and a part of the results are introduced. The questionnaire is based on the proposal of the Acoustical Society of Japan, which was planned to make the results of socialsurveys conducted by various researcherscomparable. Social surveys were conducted in 36sites where wind turbine noise is audible and in 16sites where wind turbine noise is inaudible. The number respondents were 747 and 332, respectively. The results of the survey are introduced from various viewpoints.

Monday 14:00-14:20, Hall Tirol, Paper 0598 (invited)
Yano Takashi
Dose-response relationships for wind turbine noise in Japan

Yano Takashi[1], Kuwano Sonoko[2], Kageyama Takayuki[3], Sueoka Shinichi[4], Tachibana Hideki[5]

[1] Graduate School of Science and Technology, Japan
[2] Osaka University, Japan
[3] Oita University of Nursing and Health Science, Japan
[4] Sueoka Professional Engineer Office, Japan
[5] Chiba Institute of Technology, Japan

In order to obtain a base for wind turbine noise policy, a socio-acoustic survey was carried out throughout Japan from Hokkaido to Okinawa over three years (2010-2012). In total 747 responses were obtained with face-to-face interview method. The wind turbine noise was measured at several points in each site for successive five days. The $L_{A,eq,n}$, which was precisely measured outdoor in a day, was taken as noise exposure. A representative

exposure-annoyance relationship was drawn based on all data. The trend was consistent to those from Swedish and Dutch surveys. People at sites with sea wave sound were less annoyed by wind turbine noise than those at sites without. The effects of moderating factors such as interest in environmental problems, disturbance of landscape and sensitivity to noise were also investigated.

Monday 14:20-14:40, Hall Tirol, Paper 0595 (contributed)
Seong Yeolwan
An experimental study on rating scale for annoyance due to wind turbine noise

Seong Yeolwan[1], Lee Seunghoon[1], Gwak Doo Young[1], Cho Yoonho[1], Hong Jiyoung[2], Lee Soogab[3]

[1] Department of Mechanical and Aerospace Engineering, Seoul National University, Korea
[2] Korea Railroad Research Institute, Korea
[3] Center for Environmental Noise and Vibration Research, Engineering Research Institute, Korea

Wind turbine noise referred to as “swishing sound” causes annoyance due to the amplitude modulation of the aerodynamic noise from the blades. For that reason, many studies for rating scale realizing annoyance from the noise have been examined, but show little coherence with change of noise level. In the present study, an appropriate index for describing the annoyance tendency is suggested with jury test and correlation analysis. Twenty-eight stimuli created by numerical simulation for the test were provided and thirty-two subjects assessed noise-induced annoyance based on 7 point numerical scale. Additionally, a correlation analysis between sound descriptors and subjective annoyance was performed by using regression analysis with statistics software. This study shows that the maximum sound pressure level with fast time A-weighting (L_{AFmax}) explains well the annoyance characteristics compared to the other descriptors considered.

Monday 14:40-15:00, Hall Tirol, Paper 1098 (invited)
Bockstael Annelies
Exploring underlying mechanisms for human response to wind turbine noise

Bockstael Annelies, Van Renterghem Timothy, De Weirt Valentine, Botteldooren Dick
Ghent University, INTEC, Acoustics Research Group, Belgium

This paper investigates underlying mechanisms for human response to wind turbine noise by studying the effects in terms of source detection, recognition and annoyance with and without road traffic noise. Recordings from a single

1.8-MW wind turbine have been mixed with samples of highway noise and of local roads at different signal- to-noise ratios. These fragments have been presented to 50 normal-hearing participants in a two-stage experiment. First, annoyance and source recognition have been evaluated during quiet leisure activities in background noise, with people unaware of the actual purpose. Secondly, wind turbine noise had to be identified in a paired comparison test. The second focused identification task indicates that wind turbine noise detectability in background noise at different signal-to-noise ratios is clearly different in highway noise than in noise from local roads. Furthermore, individuals with higher detection scores are also more capable to recognize wind turbine noise in the non-focused listening experiment, and better recognition could be linked with higher annoyance reports. These findings suggest that higher level appraisal, emotional and/or cognitive processes contribute to reported wind turbine noise annoyance, but further research is needed to consolidate this hypothesis.

Monday 15:00-15:20, Hall Tirol, Paper 0050 (contributed)
Boegli Hans
Rating of special noise sources

Boegli Hans, Brink Mark
Federal Office for the Environment FOEN, Switzerland

According to a number of recent surveys, about two thirds of the Swiss population feel disturbed by noise. Among them there are a considerable number of people who are annoyed by special community noise sources such as pets, bells, lawn mowers etc. Although these sources fall under the Swiss noise legislation, there are no general limit values established in the Noise Abatement Ordinance (NAO). As the effect of non-acoustic moderating factors is too strong, experts have to examine each single case on an individual basis. In order to simplify and unify the assessment of special noise sources, an attempt was made to implement theory and practical experience into a three step procedure that guides authorities of communities and municipalities in their effort to solve problems related to the above mentioned special sources. The procedure includes a simple rating system that is based on a few input parameters and that yields an indication of the noise impact compatible with the definition of the limit values of the NAO. The system leaves sufficient space to consider the influence of individual aspects such as tradition, local customs etc. by allowing to fully document these aspects, which ultimately leads to more transparency and acceptance of the noise assessment.

SS62 Response to change through interventions - noise reduction or acoustic enhancement

Chair: Brown Lex, van Kamp Irene

Monday 15:40-16:00, Hall Tirol, Paper 1078 (invited)
Brown A.L.
The importance of response to change in intervention studies

Brown A.L.[1], van Kamp Irene[2]

[1] Griffith School of Environment, Urban Research Programme, Griffith University, Australia
[2] Netherlands Institute of Public Health and the Environment, Centre for Sustainability, Environment and Health, The Netherlands

Strategies to manage environmental noise are usually directed at changing the level of noise to which people are exposed. Interventions that result in step changes in level can occur through different mechanisms: Type 1 changes result from a new or eliminated sources or changes in source intensity; Type 2 from mitigation interventions which change exposure but not source levels (eg barriers); Type 3 from a person's relocation from one dwelling to another. In our 2009 reviews we reported the complex nature of the change effect in annoyance responses to step changes in transport noise exposure and the range of diverse interpretations that attempt to explain this. The current paper provides a partial update to these reviews by considering the limited number of more recent change studies. The proven existence of a change effect has, appropriately, influenced the design of further studies of change and the analysis of data sets where change has occurred. "Response to change" findings have application in noise exposure management interventions and, we suggest, also in interventions designed to enhance positive experience of the acoustic environment.

Monday 16:00-16:20, Hall Tirol, Paper 1050 (invited)
Gidlöf-Gunnarsson Anita
Noise reduction by traffic diversion and a tunnel construction: Effects on health and well-being after opening of the Southern Link

Gidlöf-Gunnarsson Anita, Svensson Helena, Öhrström Evy
Sahlgrenska Academy at University of Gothenburg, Occupational and Environmental Medicine, Sweden

A large problem in urban areas is the increasing traffic causing congestion, noise and air pollution. In some cases, far-reaching interventions can drastically change the situation for the traffic exposed inhabitants. A step change in noise exposure can result in a change effect with an excess response of annoyance to the new exposure over that predicted from exposure-response curves for steady-state conditions. A longitudinal socio-acoustic survey was conducted to investigate changes in health and well-being after opening of Sweden's longest road tunnel – the Southern Link. A total of 658 people responded to a questionnaire both before and after the interventions (493 in the exposure area and 165 in the control area). Noise levels from road traffic in the exposure area ranged between $L_{Aeq,\ 24h}$ 48 dB and 71 dB and noise annoyance was high. After the opening of the Southern Link, noise levels decreased by 3-17 dB in the exposure area and annoyance were reduced from 60 to 20 %. In the control area, limited changes in noise exposure occurred and annoyance was basically unchanged. A comparison with predicted annoyance for a steady-state situation indicated no change effect; however, for groups with a minor and a large change in noise levels, a potential change effect was seen.

Monday 16:20-16:40, Hall Tirol, Paper 0983 (invited)
Liepert Manfred
The impact of rail grinding on noise levels and residents' noise responses – Part I: Study design and acoustical results

Liepert Manfred[1], Möhler Ulrich[1], Schreckenberg Dirk[2], Schuemer Rudolf[3]
[1] Möhler + Partner Ingenieure AG, Germany, [2] ZEUS GmbH, Germany, [3] Germany

Rail grinding is widely used as a noise mitigation measure. In order to assess the impact of rail grinding a socio-acoustical field survey was carried out. In two sections along a railway line between Bavaria and Baden Württemberg railway grinding was conducted to reduce noise emission. In both sections rail condition before grinding were worse than average. Before and after the rail grinding both acoustical measurements and interviews of the residents were done. In order to investigate the influence of active information about the rail grinding measure the residents have been informed only in the Baden Württemberg section. The acoustical measurements before and after rail grinding were analyzed separating the effectiveness of the rail grinding for each type of train. As expected noise reductions were best for disc-braked trains (e.g. ICE and passenger trains about 5 to 7 dB) and less effective for freight trains (about 1 dB). Due to the failure of the rail grinding vehicle the noise reduction in the Baden Württemberg section with information was less than in the Bavarian section. The effect of grinding on the noise annoyance of the residents is described in part II of this contribution by Dirk Schreckenberg [2].

Monday 16:40-17:00, Hall Tirol, Paper 0250 (invited)
Schreckenberg Dirk
The impact of railway grinding on noise levels and residents' noise responses – Part II: The role of information

Schreckenberg Dirk[1], Möhler Ulrich[2], Liepert Manfred[2], Schuemer Rudolf[3]
[1] ZEUS GmbH, Germany, [2] Möhler + Partner Ingenieure AG, Germany, [3] Germany

A socio-acoustical field survey (see Internoise 2013 paper of Manfred Liepert et al. for study design and acoustical results) was carried out to assess the impact of rail grinding on noise levels and noise responses of residents living along the grinded railway line. This contribution deals with the role of information about the potential noise reducing effects of rail grinding given to residents. The rail grinding was done on a railway line connecting Baden-Wuerttemberg with Bavaria in South Germany. On the Baden-Wuerttemberg side communities were informed about the rail grinding and its noise-reducing effect before the grinding was done ('informed' area). On the Bavarian side this information was not given ('uninformed area'). 340 residents were interviewed about 3 months before and 1-2 months after the grinding. Noise levels were assessed for the address of each participant. The effect of grinding on noise levels was low because of technical problems: L_{Aeq} for daytime and night-time was reduced on average about 1-2 dB after grinding. Only residents from the 'informed area' showed a significant decrease in annoyance and disturbances, whereas noise responses of participants from the 'uninformed area' did not change significantly. The results indicate that informing residents considerably supports the impact of noise abatement measures on residents' noise responses.

Monday 17:00-17:20, Hall Tirol, Paper 0658 (contributed)
Pedersen Torben Holm
Community response to noise reducing road pavements

Pedersen Torben Holm[1], Le Ray Guillaume[1], Bendtsen Hans[2], Kragh Jørgen[2]
[1] DELTA SenseLab, Denmark, [2] Danish Road Directorate, Denmark

Noise annoyance was investigated by social and socio-acoustic surveys before and after the replacement of old pavements by new noise reducing wearing courses on primary roads in two areas of Copenhagen. Questionnaires were sent out and the results are based on answers from 2870 respondents (41% of the questionnaires that were sent out). For each residence, the traffic noise exposure (L_{den}) was calculated before and after the repaving. The community responses were analysed together with the noise levels. Statistical significant reductions of the noise annoyance were found by replacing the pavement with a noise reducing type. Even if the traffic noise still was the major cause of annoyance from the traffic the fraction of very annoyed and extremely annoyed persons was reduced. In general there were 10% fewer persons annoyed from the traffic noise in the after situation. It was also found that the dose-response curves were by respondents' noise sensitivity, age and concerns about accidents. The general dose-response curves were the same in the before and the after situation. The curves were compared to the international ("Miedema") dose response curves. It was found that the Danish respondents were 3-6 dB more sensitive to noise.

Monday 17:20-17:40, Hall Tirol, Paper 0936 (invited)
Weber Miriam
Assessing impacts of interventions: acoustics and perceptions of low noise road pavement

Weber Miriam[1], Odink Jennie[2]

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[2] GGD Rotterdam-Rijnmond Public Health Service, The Netherlands

Various interventions are applied in cities with the aim to improve living and acoustic environments, and thereby well-being and health of citizens. Low noise road pavement is a common noise abatement measure which can locally reduce noise emission levels with approximately 3 dB at municipal roads. Additional costs, compared with normal asphalt types, weigh well up regarding the health benefits. Although abundant studies are available on the acoustic and physical characteristics of low noise pavement, very limited research has addressed the effects on perception of well-being, acoustic and/or environmental quality. In order to examine health and other benefits of this and other road traffic noise abatement measure, Rotterdam recently initiated two studies. In 2013 and 2014 the effects of low noise road pavement on the perception of well-being, health and soundscape will be evaluated at citizens' home environment and when visiting a relatively quiet area (cf. END). Although both studies are set up within different frameworks (ROAM resp. LIFE+ QUADMAP project) methodologies and approaches are aligned where feasible and possible. In short, noise calculations, in situ noise measurements and field surveys will be carried out, both before and after low noise pavement has been applied.

Monday 17:40-18:00, Hall Tirol, Paper 1201 (invited)
Newman Peter
Monitoring and Managing Anthropogenic Noise in National Parks: Lessons Learned From Field and Laboratory Studies

Newman Peter[1], Taff Derrick[1], Weinzimmer David[1], Lawson Steven[2], Trevino Karen[3], Fristrup Kurt[3], McKenna Megan[3]

[1] Pennsylvania State University, Department of Recreation, Parks and Tourism Management, USA, [2] Resource Systems Group, Inc., USA, [3] National Park Service Natural Sounds and Night Skies Division, USA

For more than ten years, collaborative social science research initiatives between university researchers, environmental consulting planners, and federal agency programs have advanced understanding of soundscape management in parks. The results of these efforts have been integrated into management processes, enabling managers to monitor and manage acoustic resource and experiential conditions in protected areas. During this time, research methods have been developed and improved. These include measuring and evaluating sounds both in the field and laboratories, using messaging to alter perceptions and behaviors related to sounds, and using a vast array of technologies for measuring and demonstrating sound modeling, replication, presentation, and effects on human physiological response. Case studies demonstrating methodological developments for evaluating perceptions and effects of sounds and measuring and managing visitor soundscape experiences are discussed. Key research findings are presented, suggesting the continued importance of research and management strategies that promote protection of natural sounds and associated visitor experiences.

SS11 Aircraft Noise Modeling - from the individual aircraft to the airport scenario

Chair: Isermann Ullrich, Yamada Ichiro

Monday 08:20-08:40, Hall Innsbruck, Paper 1091 (invited)
Makino Koichi
Development of the precise aircraft sound source model based on direction-of-arrival estimation using cross-correlation technique

Makino Koichi[1], Yokota Takatoshi[1], Okubo Tomonao[1], Matsumoto Toshio[1], Yamamoto Kohei[1], Kawase Yasuaki[2], Shinohara Naoaki[2], Ishii Hirokazu[3]

[1] Kobayasi Institute of Physical Research, Japan, [2] Narita International Airport Promotion Foundation, Japan, [3] Japan Aerospace Exploration Agency, Japan

Japan Aerospace Exploration Agency (JAXA) is conducting a research on a path-optimization system to manage aircraft noise contour. As one of the key functions in the path optimization, a precise aircraft noise prediction model is being developed. In the model, sound source is described by sound power levels and three-dimensional directivity patterns of aircraft noise radiation in octave bands. In order to develop the precise aircraft sound source model, a series of measurements was carried out to obtain the longitudinal directivities of aircraft in approach to Narita airport. Three measurement points were lined up perpendicularly to the approach flight path at elevation angles of 90, 60 and 30 degrees. At each measurement point, sound pressure levels in 1/3-octave bands were measured. In addition, the sound arrival direction was detected by applying a cross-correlation technique to sound pressure signals through a four-channel microphone array. This paper outlines the measurement method, and discusses the procedure to define the source model based on the measurement results in conjunction with aircraft positions and attitudes. It also shows NPD (Noise-Power-Distance) data derived from a simulation using the developed aircraft sound source model.

Monday 08:40-09:00, Hall Innsbruck, Paper 0898 (invited)
Kawase Yasuaki
Field experiment on the relationship of engine thrust and aircraft noise emission during take-off roll

Kawase Yasuaki[1], Shinohara Naoaki[1], Yoshioka Hisashi[2], Makino Koichi[3], Yokota Takatoshi[3], Anzai Kyoko[4]

[1] Narita International Airport Promotion Foundation, Japan, [2] Aviation Environment Research Center, AEIF, Japan. [3] Kobayasi Institute of Physical Research, Japan, [4] Narita International Airport Corporation, Japan

Calculation of noise contours is usually performed using noise-distance database and performance data under assumptions of constant engine thrust and aircraft speed at each segment of a flight path. It is not certain whether those assumptions apply to the initial segment of take-off roll because of high power and acceleration. Thus, we made a field measurement, in which a lot of microphones were set up along the runway, to investigate the relationship among sound exposure level, aircraft speed and engine thrust. This paper discusses a practical procedure of calculating sound exposure level applicable to such situation, based on the result of measurements and calculations.

Monday 09:00-09:20, Hall Innsbruck, Paper 0649 (contributed)
Bisping Rudolf
Combined flight path and acoustical measurements for psychometric analysis of aircraft sounds

Bisping Rudolf[1], Janssens Karl[2], Dubail Patrick[3], Thirard Christophe[3]
[1] SASS GmbH, Germany, [2] LMS International, Belgium, [3] ACOEM, France

Within the EU-FP7-project COSMA combined flight path and acoustical measurements of aircrafts were performed at Munich Airport in order to relate the sound propagation of aircrafts to their position in space. Applying time varying back-propagation radiant from the microphone position on the ground to the aircraft position in space this procedure allows to isolate spectral components of the sounds without atmospheric damping effects. Using a new synthesis methods as developed in COSMA (ANCS: **A**irport **N**oise **C**limate **S**ynthesizer) the separated components can be varied experimentally e.g., in level and/or spectral shape to test the psychometric effects of these manipulations in the laboratory. In addition to these source related changes different environmental variables like atmospheric conditions and/or flight path modifications can be imposed on the sounds, too, which may help to e.g., optimize the quality of aircraft sounds. The paper will demonstrate the measurement procedure and subsequent processing of the sounds. Finally a 3D-auralization method will be presented which has been used in COSMA to test the sound quality of synthetic versus natural aircraft sounds.

Monday 09:20-09:40, Hall Innsbruck, Paper 0347 (invited)
Zaporozhets Oleksandr
Aircraft noise calculation needs for detailed flight operation input data

Zaporozhets Oleksandr[1], Zbrozhek Vadim[1], Rojek Marta[2], Kartyshev Oleg[3]

[1] National Aviation University, Ukraine
[2] Institute of Aviation, Poland
[3] Centre of Ecological Safety of Civil Aviation, Russia

Usually the aircraft fleet and air traffic with appropriate distribution of flights between the routes are necessary input data for aircraft noise calculations. Aircraft performance and noise data base together with operational weights (depending on flight distances) and operational procedures (including low noise procedures) influence huge on results of contour assessment in real atmosphere conditions. Current recommendations allow to define the flight profiles via solutions of balanced motion equations. But the difference still exists between the measurement noise level data and calculated ones. Some of them are well explained by differences between balanced flight parameters (thrust and velocity first of all) and monitored by the traffic control system. Statistical data was gathered to make more general view on these differences and some proposal to use them in calculations has being proved.

Monday 09:40-10:00, Hall Innsbruck, Paper 1172 (contributed)
Janssens Karl
Synthesis of aircraft noise operations

Janssens Karl[1], Dubail Patrick[2], Thirard Christophe[2], Leotardi Cecilia[3], Iemma Umberto[3], Márki Ferenc[4], Bisping Rudolf[5], Bauer Michael[6]

[1] LMS International, Belgium, [2] ACOEM, 200, France, [3] Universita Degli Studi ROMA TRE, Italy
[4] Budapesti Muszaki es Gazdasagtudomanyi, Hungary, [5] SASS GmbH, Germany
[6] EADS Innovation Works, Germany

This paper provides an overview of the aircraft noise synthesis techniques that were developed within the European FP7 project COSMA (Community Orientated Solutions to Minimize Aircraft Noise Annoyance). The main ambition of COSMA is to develop engineering criteria for aircraft design and operations in order to reduce the annoyance within airport communities due to aircraft exterior noise. As a basis for this activity, a powerful aircraft flyover noise synthesis tool was developed, allowing psychometric studies and the

analysis of community noise annoyance in relation to aircraft design and flight procedures. The sound synthesis tool integrates dedicated interfaces for on-line interactive sound quality analysis and for simulating complex airport noise scenarios based on aircraft source and noise propagation models. The main tool features are described and an example case study is presented, illustrating the noise modeling and audio synthesis. Next to that, an overview is given of the different airport noise scenarios that were synthesized in the COSMA project, considering standard and optimized procedures, existing aircraft and target sounds, as well as first examples of design optimizations, innovative concepts and low noise technologies.

Monday 10:00-10:20, Hall Innsbruck, Paper 0672 (invited)
Yokota Takatoshi
Experimental study of meteorological effects on sound propagation from an elevated source

Yokota Takatoshi[1], Okubo Tomonao[1], Makino Koichi[1], Matsumoto Toshio[1], Yamamoto Kohei[1], Ishii Hirokazu[2], Harada Kenya[2]

[1] Kobayasi Institute of Physical Research, Japan
[2] Japan Aerospace Exploration Agency (JAXA), Japan

JAXA is conducting a research on a path-optimization system to manage aircraft noise contour. Two aircraft noise prediction models which can take account of the meteorological effects on the noise propagation are being developed. In order to study sound propagation characteristics from air to ground under various meteorological conditions, a series of outdoor sound propagation experiments has been conducted. To obtain excess attenuations for air-to-ground sound propagation precisely, impulse responses from an elevated source to receivers at ground level have been measured by using time stretched pulse method. In the experiments, a loudspeaker is set at several altitudes up to 500 meters hanged by a tethered balloon and the receivers are lined up on flat terrain in the horizontal range up to 500 meters from the source. Experimental results show that variation in sound pressure level due to the influences of meteorology at distant point from the source position is small in cases of air-to-ground sound propagation compared with that in cases of ground-to-ground sound propagation. It has been also confirmed that the prediction results of our propagation model under development are in good agreement with experimental results.

Monday 11:00-11:20, Hall Innsbruck, Paper 0648 (invited)
Ishii Hirokazu
Development of an aircraft noise prediction model considering the effect of meteorological conditions in JAXA's DREAMS project

Ishii Hirokazu[1], Harada Kenya[1], Makino Koichi[2], Yokota Takatoshi[2], Shinohara Naoaki[3], Sugawara Masayuki[4]

[1] Japan Aerospace Exploration Agency, Japan
[2] Kobayasi Institute of Physical Research, Japan
[3] Narita International Airport Promotion Foundation, Japan
[4] Airport Environment Improvement Foundation, Japan

The Japan Aerospace Exploration Agency (JAXA) has been conducting a research project called DREAMS which aims to develop key technologies for future air traffic management systems. A topic examined by the project is noise abatement technology to maintain aircraft noise at current levels even in the view of 50% air traffic increased forecast for the period from 2005 to 2027. Approach paths are to be optimized according to predicted noise exposure considering the effects of meteorological conditions on noise propagation. This paper presents an overview of the method in DREAMS to develop a noise prediction model including a source model and a propagation model. The source model is an improvement of common available models based on Noise-Power-Distance data by including measured noise data. The propagation model, on the other hand, has been developed based on Green's function parabolic equation (GF-PE) method to take the effects of meteorological conditions into account. In order to verify the developed propagation model, a noise measurement test was conducted using a tethered balloon to locate a sound source in the air and to obtain air-to-ground noise propagation data. The experimental results are in good agreement with the GF-PE computation results. This paper also introduces a test scheduled to measure the planar distribution of noise exposure around approach paths at an existing airport, which is to be conducted in the near future.

Monday 11:20-11:40, Hall Innsbruck, Paper 0790 (contributed)
Yoshioka Hisashi
Developing a revised method of excess ground attenuation calculation for aircraft noise modeling in Japan

Yoshioka Hisashi[1], Shinohara Naoaki[2], Yamada Ichiro[1]

[1] Aviation Environment Research Center, AEIF K5 Bldg., Japan
[2] Narita International Airport Promotion Foundation, Japan

This paper discusses why and how to develop a revised equation of evaluating excess ground attenuation (EGA) for aircraft noise modeling in Japan. Firstly, it makes a brief review of our past investigation to develop a revised EGA equation 1751M, similar to SAE/AIR1751, using measured frequency spectra of B747, following the way to construct AIR1751 and considering the influence of meteorological conditions on sound propagation. Secondly, it discusses why we should consider further development of a newer EGA equation. When we constructed 1751M, the greater part of aircraft movements were operated using one of the largest jet aircraft B747, but afterwards alternation of ship generations to smaller in size and quieter in sound radiation has progressed. Besides, SAE developed a newer EGA equation AIR5662, which proposes equations dependent on engine mounting, but without considering meteorological conditions. In Japan, the national noise guideline Environmental Quality Standards for Aircraft Noise" enforced in April, 2013 requires taking account of noise contributions due to aircraft ground activities, but meteorological conditions strongly affect sound propagation of such ground operation noise. Thus, finally, we describe an experiment for revision of 1751M and study about an EGA equation considering the influence of meteorological conditions.

Monday 11:40-12:00, Hall Innsbruck, Paper 0857 (contributed)
Da Silva R.
New method for helicopter noise mapping

Da Silva R.[1], Ribeiro C.[1], Mietlicki Fanny[1], Favarel E.[2], Crozat A.[2]
[1] Bruitparif, Noise Observatory in Ile-de-France, France, [2] DGAC DSAC NORD, Athis-Mons France

Due to the highly discontinuous nature of helicopter traffic, noise maps based on average indicators (Lden, Lday, Levening and Lnight) defined by the European Directive 2002/49/EC or used in other regulatory documents in France are insufficient to describe appropriately the noise exposure of residents living near heliports. Consequently it is essential to focus on indicators more relevant to reflect the noise events related to helicopter overflights. In order to provide additional elements to quantify the acoustic impact of the activity generated by the heliport of Paris - Issy-les-Moulineaux (France), Bruitparif developed in partnership with the Directorate General for Civil Aviation (DGAC/DSAC Nord), a new mapping method for the noise levels and peaks generated by helicopter overflights. The indicators mapped are the following: - the maximum level (LAmax) on the ground for each overflight, - the noise peaks for each overflight (difference

between the LAmax and the background noise), - the number of overflights generating an LAmax of above 62 or 65 dB(A) (NA62 and NA65) during an average day, - the number of overflights generating a noise peak of over 10 or 15 dB(A) during an average day. This article presents the methodology used and the maps produced.

Monday 12:00-12:20, Hall Innsbruck, Paper 0669 (contributed)
Hughes Richard
Fly-over noise measurements and simulation for a turboprop aircraft

Hughes Richard, Filippone Antonio
School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, UK

The study of aircraft noise started in earnest in the 1960s, however, the validation of comprehensive noise models for existing commercial aircraft using well-defined experimental data have since produced modest advances. Considerable focus appears to have been placed on aircraft conceptual design, with relatively little effort considering aircraft currently in use, for which we believe there is a growing need. This study investigates the fly-over noise from a commercial turboprop aircraft, using noise measurements taken both on airport departure and approach for the validation of noise simulations. Predictions are carried out using a software system described elsewhere in the literature. It is shown that, for the examples considered, predicted overall noise levels such as SEL and EPNL display modest agreement, and are within 4.3dB/EPNdB of measured values. One-third octave band analysis shows discrepancies to be due to a general under prediction at low to mid frequencies. Through an analysis of noise source subcomponents, the most likely candidates are identified for which an alteration in the model best improves agreement. By applying these alterations – in particular, by increasing the contribution of the landing gear and airframe noise – an average error in one-third octave band SPL of less than 3.2dB is achieved.

Monday 14:00-14:20, Hall Innsbruck, Paper 0567 (invited)
Yamada Ichiro
Recent progress in airport noise modeling taking account of noise due to aircraft ground activities in Japan

Yamada Ichiro
Aviation Environment Research Center, Japan

This paper makes a review of recent progress in developing an airport noise model taking account of noise contributions due to aircraft ground operations. In Japan, a revised noise guideline “Environmental Quality Standards for Aircraft Noise” was enforced in April, 2013. The new guideline requires evaluation of sound exposure situation around airports using L_{den}, instead of WECPNL, and by taking into account noise of aircraft ground operations such as taxying and the use of APU, if necessary. For that purpose, we have been engaged in the preparation of noise modeling tools and database as well as in the renewal of noise monitoring devices. However, evaluation of aircraft ground operation noise requires a practical solution to consider effects of terrains/buildings and meteorological conditions on sound propagation. This paper also discusses progress of our examination about these issues.

Monday 14:20-14:40, Hall Innsbruck, Paper 0743 (invited)
Yamamoto Ippei
Military aircraft noise prediction model in Japan

Yamamoto Ippei[1], Morinaga Makoto[1], Tsukioka Hidebumi[1], Makino Koichi[2], Yamada Ichiro[3], Matsumoto Mitsuo[4]

[1] Defense Facilities Environment Improvement Association, Japan, [2] Kobayasi Institute of Physical Research, Japan, [3] Aviation Environment Research Center, Airport Environment Improvement Foundation, Japan, [4] Japan Ministry of Defense, Japan

In Japan, “Environmental Quality Standards for Aircraft Noise” was revised by Ministry of Environment and the evaluation index for aircraft noise was changed from WECPNL to L_{den}. According to the modification, Ministry of Defense updated the evaluation framework of military aircraft noise and they also revised "Act on Improvement of Living Environment of Areas around Defense Facilities". It is performed for various environmental measures such as monetary compensation for relocating houses and subsidies for soundproofing of dwelling around airbases. Such environmental measures are applied following Noise Zones decided by predicted noise contour using L_{den} metrics. The military aircraft noise prediction model in Japan was developed as a means of calculating the L_{den} contour, taking account of aircraft ground operation noise such as taxiing, APU (Auxiliary Power Units) and engine run-up at the end of runway before take-off. The prediction model is based on flight path segment model. Fundamental components of the model are NPD (Noise Power Distance) data of L_{AE}, noise fraction adjustment for finite flight path segment and corrections for sound radiation directivity. This paper introduces

outline of the prediction model and the investigation contents such as preparation NPD data for military aircraft in Japan, reference operation number and ground operations duration representing a year that is characteristic of military aircraft operation.

Monday 14:40-15:00, Hall Innsbruck, Paper 0455 (invited)
Zellmann Christoph
sonAIR – data acquisition for a next generation aircraft noise simulation model

Zellmann Christoph, Wunderli Jean Marc, Schäffer Beat

Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Acoustics/Noise Control, Switzerland

The acoustic optimization of flight procedures requires sophisticated models that account for flight configuration parameters as they can have a major influence on the resulting sound exposure. For these purposes a new aircraft noise simulation model, denoted sonAIR, is being developed. Its semi-empirical emission model shall deliver a detailed spectral description of the sound source to account for configuration changes. The aircraft shall be modelled by separate sound sources for engine noise and airframe noise, each featuring different spectra and directivity patterns and possibly being assigned to different locations. As sufficiently detailed sound source data is not available, extensive measurements under real air traffic are planned. In this paper an overview on the sonAIR project is given and the measurement layout is presented. The latter comprises the optimal placement of the microphones in terms of longitudinal and azimuthal emission angles as well as directional uncertainty.

Monday 15:00-15:20, Hall Innsbruck, Paper 0206 (contributed)
Bertsch Lothar
Noise prediction toolbox used by the DLR aircraft noise working group

Bertsch Lothar, Isermann Ullrich
Institute of Aerodynamics and Flow Technology, German Aerospace Center (DLR), Germany

Focus of the activities of the aircraft noise working group of the German Aerospace Center (DLR) is the development and application of aircraft noise calculation models. The different tools currently in use are covering the range from *best practice models* like FAA's INM or the German AzB up to the

sophisticated partial-sound-source models SIMUL and PANAM, which were developed at DLR during the last years. Consequently, the field of application is very large – reaching from the classical aircraft noise prediction tasks for land-use planning up to a noise optimization already during conceptual vehicle design. This paper gives an overview on these tools, typical applications as well as their advantages and limitations. Special attention will be paid on the SIMUL and PANAM models, which are currently used mainly for scientific applications.

SS12 Uncertainty of Aircraft Noise measurements and calculations

Chair: Vogelsang Berthold, Granoien Idar

Monday 15:40-16:00, Hall Innsbruck, Paper 0044 (invited)
Thomann Georg
Measurement and Calculation Uncertainty of Aircraft Noise Exposure

Thomann Georg
Amt für Natur und Umwelt Graubünden, Switzerland

Nowadays, noise is usually calculated over entire areas by means of computer programs. However, infor- mation concerning the uncertainty of such calculations is rarely available. This article presents some ideas to solve these problems using the example of measured and calculated aircraft noise. The following topics are covered: • Identifying the most important influences in the calculation of aircraft noise and quantifying the uncertainty of the calculated aircraft noise exposure; • Representing the determined calculation uncertainties in form of maps; • Identifying the significant factors and systematic effects in the measurement of aircraft noise and the quantifying of the uncertainties in the measured aircraft noise exposure; • Validating the calculations and identifying the systematic effects in the calculation by means of compa- rison of the measured and calculated sound levels in consideration of the calculation and measurement uncertainties; • Presentation of proposals with regard to the uncertainties in the evaluation of aircraft noise exposure.

Monday 16:00-16:20, Hall Innsbruck, Paper 0473 (invited)
Asensio César
Uncertainty derived from the discrimination of events in aircraft noise monitoring

Asensio César, Ruíz Mariano, Pavón Ignacio, Recuero Manuel

Universidad Politécnica de Madrid (UPM) – Grupo de Investigación en Instrumentación y Acústica Aplicada (I2A2) EUITT, Spain

Airport authorities devote important sums of money to noise management, trying to find a balance between noise pollution and airport operational capacity. Among others, aircraft noise monitoring remains one of the most implemented tools for fighting airport noise all over the world. Noise-monitoring units must record sound levels to measure sound events from aircraft, discriminating them from residual noise. The latter is one of the main handicaps in commercial noise monitoring units. Therefore, we

expanded the uncertainty model described in ISO 20906 to estimate the contribution to the uncertainty of the discrimination modules in a monitor. We have defined two new concepts to allow for two independent contributions: detection and identification uncertainties. The error rates in the detection, classification or identification modules are responsible for the identification uncertainty. For instance, radar tracking of aircraft will minimize this contribution. The detection uncertainty will occur even in the case of an error-free discrimination module. The detection module generates uncertainty, derived from the location of the starting and ending times in every sound event, which is closely influenced by human factors in the detection algorithms and their setup.

Monday 16:20-16:40, Hall Innsbruck, Paper 1007 (invited)
Rosin Christophe
Uncertainty of Aircraft Noise Measurements: Evaluation for an Aircraft Noise Monitoring Network

Rosin Christophe
Acoustics Department, Aéroports de Paris, France

Generally, an aircraft noise monitoring network complies with Class 1 templates from the standard IEC 61672-1 about specifications on sound level meters. In addition, some specific standards such as ISO 20906 or NF EN 31-190 provide ways to evaluate uncertainty. Aéroports de Paris operates 50 noise monitoring systems on several airports. Specifically at Paris Charles de Gaulle airport, the noise management is based on a noise budget index calculated from measured maximum noise level of all aircraft movements on the airport. In this context, it is important to know exactly the instruments metrology in order to exceed the standards templates and to assess its own uncertainty. To do this, it is necessary to know all the parameters which can influence the measure. The objective is to improve the robustness of measurements. This article lists all the influence factors and presents an uncertainty calculation using specific values, standards values or documented values. This approach is consistent with the French standard draft about the evaluation of the uncertainties of environmental noise.

Monday 16:40-17:00, Hall Innsbruck, Paper 1102 (contributed)
Schaal Jochen
Optimized and quality assured aircraft noise calculation on the basis of radar tracks

Schaal Jochen[1], Liepert Manfred[2], Mühlbacher Maximilian[2], Vogelsang Berthold[3], Zollitsch Dieter[4]

[1] SoundPLAN International LLC, Germany
[2] Möhler + Partner Ingenieure AG, Germany
[3] Niedersächsisches Ministerium für Umwelt und Klimaschutz, Germany
[4] Braunstein + Berndt GmbH, Germany

Modern aircraft noise prediction methods afford a tremendous amount of work to convert flown flight patterns into model data which can be used for calculations. Especially for existing situations this procedure could be much quicker and errors could be avoided, if prediction methods would allow the direct use of radar tracks. During this study the efficient use of radar tracks (STANLY and FANOMOS) was evaluated and compared against measurement results. There were several difficulties to overcome, such as automatic conversion of coordinates, automatic conversion of UTC time to local time (including DST), assignment of tracks to the correct runway, assignment of emission data, the use of spline and filter functions to adopt the tracks and reduce at the same time the amount of track points, selection of unusable tracks (to short, pattern flights, no emission data).

Monday 17:00-17:20, Hall Innsbruck, Paper 1001 (contributed)
Hebly S. J.
Noise attenuation directly under the flight path in varying atmospheric conditions

Hebly S. J.[1], Sindhamani V.[2], Arntzen M.[1,2], Bergmans D.H.T.[1], Simons D.G.[2]

[1] National Aerospace Laboratory Environment & Policy Support, The Netherlands
[2] Delft University of Technology, Faculty of Aerospace Engineering, Air Transport & Operations, The Netherlands

When measuring aircraft noise, variations of up to 12 dB occur for identical aircraft types flying the same procedure directly over the same microphone position. It is assumed that these variations are the combined effect of variations at the source and in the atmospheric propagation, both not accounted for in standard noise calculations. This paper presents experimental results of the variation in noise levels due to a varying atmosphere. In 2010, an experiment was started to study the atmospheric effects on vertical propagation. A sound source was installed up in a weather-measurement-

tower. This setup simultaneously recorded the atmospheric conditions and the variation in sound attenuation over an extended period of time. More than a year later, all measurement results were collected and multiple linear regression analysis was applied with the intention of deriving weather dependent correction factors to improve aircraft noise predictions methods. However, the result of the regression analysis shows that the obtained relations are weak and a significant part of the excess transmission loss remains unexplained. The main question, which part of the 12 dB can be attributed to variations in atmospheric conditions, could therefore not be answered.

SS01 Tire/Road Noise - Low Noise Pavements

Chair: Sandberg Ulf, Rasmussen Robert

Monday 08:20-08:40, Hall Brüssel, Paper 0622 (contributed)
Mietlicki Fanny
Experiment of low-noise road surfaces on the Paris ring-road

Mietlicki Fanny, Ribeiro C., Sineau M.
Bruitparif, Noise Observatory, France

At the end of June 2012, the City of Paris started up an experiment on a 200 m portion of the Paris ring-road so as to test the relevance of low-noise road surfaces (Rugosoft® and Nanosoft® produced by Colas company) and its sustainability over time from an acoustic as well as from a mechanical point of view, in a context of great constraints related to the large number of vehicles using the ring-road daily (over 1,2 million vehicles with up to 270,000 vehicles per day in some places). Within the framework of the project HARMONICA [2] supported by the European program LIFE+, Bruitparif has set up five noise measurement stations so as to monitor the acoustic effectiveness of the product tested over a long period. The first station was set up on the central reservation, the three next ones are on the front of buildings adjacent to the ring-road at the level of the experimental section and the last one was positioned outside the perimeter of experiment so as to be used as a control station. In addition to this, digital audio recordings were made in front of buildings and inside a moving vehicle. The results obtained three months after the beginning of this experiment will be presented and discussed in this paper. For the oral presentation, they will be completed with updated results obtained during the summer of 2013, one year after the beginning of this experiment.

Monday 08:40-09:00, Hall Brüssel, Paper 0591 (contributed)
Lee Chee Kwan
Application on low noise road surface material to reduce road traffic noise of local roads in Hong Kong

Lee Chee Kwan, Leung Joe C.S., Ng Isaac, Yeung Maurice
Environmental Protection Department, Hong Kong

Similar to other metropolitans, the major environmental noise problem encountered is excessive road traffic noise in Hong Kong. Due to the past neglect in planning of the city in the past, about 1.1 million of population is

estimated to expose to traffic noise levels exceeding the planning criterion of 70dB(A)L10(1hr) in Hong Kong. There is limited scope for retrofitting noise barriers to address the traffic noise problems of existing roads in Hong Kong due to various technical constraints including space requirement and social or aesthetic considerations. Application of low noise road surface would have advantage over barriers on many situations. Porous road surface is currently standard surface material of high speed roads in Hong Kong. To test out the noise reduction and the durability of porous materials on low speed local roads, a trial programme for laying some identified road sections is carried out in Hong Kong. This paper summarizes the experience gained in Hong Kong in respect of the noise reduction achieved and the durability problems for porous material in high speed roads and low speed local roads.

Monday 09:00-09:20, Hall Brüssel, Paper 0109 (contributed)
Praticò Filippo G.
Permeable friction courses: area-based vs. line-based surface performance and indicators

Praticò Filippo G.[1], Vaiana Rosolino[2]

[1] DIMET - DIIES Department University Mediterranean of Reggio Calabria, Italy
[2] Department of Civil Engineering, University of Calabria, Italy

The objective of this study is to investigate acoustic absorption and surface texture in porous friction courses. The in situ measurement of sound absorption properties of road surfaces permits to derive acoustic information on different types of road surfaces. When the extended surface method is used, the method is based on the analysis of several square meters of surface, under several hypotheses and conditions. In contrast, the characterization of pavement texture (in spectral or aggregate terms, by using surface profiles) essentially refers to line segments. The relationship between the indicators which can be derived from the two different approaches (area-based or line-based) poses several practical and theoretical issues in terms of interpretation and surface homogeneity. In pursuing the above objects, experiments were carried out in order to: i) study the variability of in situ acoustic measurements in normal and non-normal conditions; ii) study pavement surface texture in terms of aggregate and spectral indicators, by varying measurement direction. The acoustic absorption coefficient was measured according to the ISO 13472-1, Acoustics - Measurement of sound absorption properties of road surfaces in situ – Part 1: Extended surface method, 2002. Surface texture was investigated according to the standards ISO 13473-1 and 4. A dependence of the absorption coefficient on the angle was found in

terms of both absolute maximum and maximum point. On average, an increase of the maximum acoustical absorption and a reduction of the maximum frequency were found. The assessment of surface texture indicators permitted to derive that the dependence on angles was not affected by texture-related issues or systematic variations.

Monday 09:20-09:40, Hall Brüssel, Paper 1225 (contributed)
Rasmussen Robert Otto
Designing and constructing pavements to comply with the ISO 10844:2011 exterior noise test track standard

Rasmussen Robert Otto
The Transtec Group, Inc., USA

As the ECE and other regulations worldwide continue to evolve, the ISO 10844:2011 exterior noise test track standard will be an important component of vehicle and tire noise testing in the coming years. Tracks that had previously complied with the 1994 version of the standard are not necessarily conforming to the new standard, which has led to many owners to seek out resurfacing projects. With pavements, the design, materials selection and proportioning, and construction techniques all affect the end result. Pavement engineering is often focused on pavement life, and for test tracks, this is defined by functional performance including changes in friction, rolling resistance, ride, and in this instance, noise. Designing and constructing ISO 10844 surfaces can be challenging. In addition to the balance between initial cost and durability, there are several unique requirements that are uncommon in highway pavements. Acoustical absorption and texture requirements, for example, challenge even the most experienced road builders. However, meeting these new challenges can also lead to new opportunities. Desired texture and absorption can be realized through an understanding of the myriad of design and construction variables. The result is not only more predictable and consistent test outcomes, but increased longevity of these surfaces.

Monday 09:40-10:00, Hall Brüssel, Paper 0210 (contributed)
Bendtsen Hans
The first poroelastic test section in PERSUADE

Bendtsen Hans[1], Andersen Bent[1], Kalman Björn[2], Cesbron Julien[3]

[1] Danish Road Directorate, Denmark, [2] Swedish Road and Transport Research Institute, Sweden
[3] LUNAM Université, IFSTTAR, LAE, France

The PERSUADE project aims at developing poroelastic road surfacing (PERS). A small size field test of PERS was constructed before constructing full scale test sections to gain experience from mixing and laying the PERS material outside the laboratory and to monitor the performance of the pavement over a winter as well as to investigate the performance of the PERS by measuring the characteristics of the surface. The test section was constructed in Denmark on a ramp from a parking area with low traffic volume and driving speed. The test section is 7 meter long and 1.5 meter wide. It is not possible to perform noise measurements using the SPB or the CPX method. Instead absorption, mechanical impedance, texture and drainability have been measured and used as indicators for the acoustical properties of the pavement. At the test site there is also an old dense asphalt concrete with 11 mm maximum aggregate size as well as a new single layer porous asphalt concrete pavement with 8 mm maximum aggregate size which are both used for comparison. The results all indicate that the PERS pavement has a good potential for noise reduction.

Monday 10:00-10:20, Hall Brüssel, Paper 1203 (invited)
Mioduszewski Piotr
Noise measurements on low noise pavements - problems with inhomogeneity of wearing course

Mioduszewski Piotr[1], Gardziejczyk Władysław[2]
[1] Gdansk University of Technology, Poland, [2] Bialystok University of Technology, Poland

During the last several years, when performing numerous CPX noise measurements on low noise pavements, significant inhomogeneity of the wearing course was observed in numerous cases. Similar problems were almost not existing regarding to the dense pavements. In general three main reasons of inhomogeneity can be defined. The first one are imperfections in technology of production of a asphalt mix or/and errors made already during the laying process of the wearing course. The second is clogging that takes place during operation of the pavement. The third reason is related to uneven and/or excessive wear of the pavement (ravelling and stripping of the aggregate may appear in this case). The findings of analysis of noise data acquired on low noise pavements (based on 10m long segments) during measurements performed by the Gdansk University of Technology was presented and discussed in the paper. Problems related to the selection of

representative section of inhomogeneous pavement when calculating the CPX Index were also discussed. Additionally, results of noise measurements of inhomogeneous wearing course performed by the Bialystok University of Technology using SPB method were presented. The influence of selection of SPB measuring point within the length of inhomogeneous pavement section was discussed.

SS02 Tire/Road Noise - Low Noise Tires

Chair: Saemann Ulrich, Sandberg Ulf

Monday 11:00-11:20, Hall Brüssel, Paper 0265 (invited)
Kragh Jørgen
NordTyre – Car tyre labelling and Nordic traffic noise

Kragh Jørgen, Oddershede Jens
Danish Road Directorate, Division of Technology, Denmark

Labelling new vehicle tyres is mandatory in all EU and EEC countries. The label includes wet grip, rolling resistance and noise. Noise labels are based on measurements made on standard test tracks with asphalt concrete having small aggregate. Nordic road administrations initiated a project on the tyre/road contribution to traffic noise emission from their roads. The long term aim is to clarify which combinations of tyres and pavements yield the lowest noise emission throughout their lifetime. In the initial stage it shall be clarified if labelled noise levels are representative of the tyre/road noise emission from new tyres on typical Nordic roads, and if there is correlation between the noise emission and tyre abilities concerning rolling resistance, wet grip, snow grip and ice grip. 31 sets of car tyres were procured to represent the tyre population. CPX trailer noise measurements were made on 31 different road surfaces in Denmark, Norway and Sweden. The preliminary main conclusions are that the labelling system needs to be improved to obtain noise levels representative of real noise emission, and that low noise levels are not contradictory to high fuel efficiency or road grip.

Monday 11:20-11:40, Hall Brüssel, Paper 0709 (invited)
Berge Truls
Noise performance of the SRTT tyre compared to normal passenger car tyres

Berge Truls
SINTEF ICT, Dept. of Acoustics, Norway

Within the NORDTYRE project, the tyre/road noise from a range of passenger car tyres has been measured on 10 normally used dense asphalt concrete road surfaces (SMA and DAC) in Norway. The aim of the project is to compare the noise behaviour of commonly used passenger car tyres with the noise on an ISO surface, which is the basis of the newly introduced tyre labelling system in Europe. A total of 31 tyres from the NORDTYRE project including the Uniroyal Tigerpaw SRTT tyre and 9 tyres from a previous project have

been measured on the same road surfaces. CPX measurements have been made on road surfaces in Norway, Sweden and Denmark, as well as on an ISO surface. Only the measurements on the Norwegian road surfaces are reported in this paper. The quietest tyres are about 4-5 dB quieter than the noisiest tyre on all 10 road surfaces. The quietest tyre on the quietest dense road surface is approximately 8 dB quieter than the noisiest combination of tyre and road surface. The measurements confirm that the SRTT tyre is a good choice of a tyre to represent tyre/road noise from passenger car tyres on Norwegian dense surfaces.

Monday 11:40-12:00, Hall Brüssel, Paper 0637 (contributed)
Wehr Reinhard
A glimpse on the noise reduction potential due to lower tyre noise emission limits

Wehr Reinhard, Haider Manfred, Conter Marco
Austrian Institute of Technology, Austria

The introduction of the EU regulations 2009/661/EG and 2009/1222/EG provides a new chance to achieve traffic noise reduction directly at the source. Due to a 3-6 dB decrease in the emission limits for type approval, the potential for a comprehensively lowered immission level arises, allowing cost savings in noise protection measures without compromising the level of protection. The objective of the project presented in this paper is thus to apply the EU regulations to Austrian conditions in order to find the actually feasible noise reduction. Therefore, controlled pass-by measurements have been performed on typical Austrian highway pavements with a focus on tyres with low noise emission labelling.

Monday 12:00-12:20, Hall Brüssel, Paper 1059 (contributed)
van Vliet Willem Jan
Noise reduction of silent tyres on different road surfaces

van Vliet Willem Jan[1], van Blokland Gijsjan[2]
[1] Rijkswaterstaat, The Netherlands, [2] M+P – consulting engineers, The Netherlands

It is generally acknowledged that abatement of traffic noise is most cost effective by measures at the noise source. This explains the EU policy for limiting the noise emission of cars and tyres and also the application of noise reducing road surfaces in heavy populated regions.Tyres and road surfaces are evaluated independent from each other and earlier studies demonstrated that

a combined effect of application of a low noise tyre on a low noise road may be less than the sum of individual estimated tyre effect and road surface effect. The national Road Authority in the Netherlands has instigated a research project to study the combined effects on a large number of tyre/road combinations. In total more than 500 combinations are included, with road surfaces ranging from coarse and porous ones, to smooth and dense, and tyres ranging from slick to coarse off-road patterns. The study included tyres for both cars and heavy vehicles.The tyre noise levels on a specific surface are compared to those on the ISO 10844 surface since that is the type approval test track surface. The results will be presented and the consequences for expected noise reduction in the future will be evaluated.

Monday 12:20-12:40, Hall Brüssel, Paper 1062 (invited)
Sandberg Ulf
Relation between tyre/road noise and ice and snow friction of winter tyres

Sandberg Ulf, Hjort Mattias
Swedish National Road and Transport Research Institute (VTI), Sweden

It is often assumed that low noise emission from car tyres implies a sacrifice of frictional properties. This study explores the relation between tyre/road noise with friction coefficients on ice and snow surfaces for a number of winter tyres, designed either for central European or for Nordic winter roads. Measurements of noise were made by the coast-by method in accordance with the EU regulation on a test track having an ISO surface. Measurements of ice friction were made on a long straight climate controlled indoor test track in Sweden which was covered by ice. Snow friction tests were made with a car braking on an outdoor test track in northern Finland. Ten different tyres were tested for all the conditions. The results show that the correlation between noise levels and ice friction coefficients is consistently negative, which means that tyres having lower noise have higher friction. The tested tyres ranked with respect to noise in this order (from high to low noise level): summer tyres, tyres designed for central Europe winter roads, and tyres designed for Nordic winter roads. The relation between noise level and friction on snow was less clear, but it was obvious that the summer tyres were much worse than the winter tyres. It is concluded that the design principles for winter tyres at large are favourable also for achieving low noise emission.

Monday 12:40-13:00, Hall Brüssel, Paper 0550 (invited)
Bekke Dirk
Tire-road noise: an experimental study of tire and road design parameters

Bekke Dirk[1], Wijnant Ysbrand[2], Weegerink Thijs[1], de Boer Andre[2]

[1] Apollo Tyres Global R&D B.V., The Netherlands, [2] University of Twente, Faculty of Engineering Technology, Department of Mechanical Engineering, Chair: Structural Dynamics & Acoustics, The Netherlands

It is widely known that road traffic noise has negative influences on human health. Hence, as tire-road noise is considered to be the most dominant cause of road traffic noise above 30-50 km/h, a lot of research is performed by the two involving industries: road authorities/manufacturers and tire manufacturers. Usually, the parameters influencing exterior tire-road noise are often examined separately, whereas it is the tire-road interaction which obviously causes the actual noise. An integral approach, i.e. assessing possible measures to reduce tire-road noise from both the road and the tire point of view, is needed to further reduce traffic noise. In a project Silent Safe Traffic, this tire-road interaction is studied in more detail without focusing on either tire or road but looking at the tire-road system. In this publication we present experimental results of tire and road design parameters influencing tire-road noise from a fixed reference tire-road configuration. The influence of tire tread pattern, compound and construction as well as the influence of road roughness, acoustic absorption and driving speed on the exterior tire-road noise, measured by a CPX-set up, is reported.

Monday 14:00-14:20, Hall Brüssel, Paper 0415 (invited)
Hung Wing-tat
Identifying noise levels for various tyre and road surface combinations in Hong Kong

Hung Wing-tat[1], Lam Yat-ken[2], Leung Randolph Chi-kin[2]

[1] Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, China
[2] Department of Mechanical Engineering, The Hong Kong Polytechnic University, China

Recent studies show that tyre/road noise level is significantly influenced by the combinations of tyre and road surfaces. Three popular brands of tyres comprising Michelin Primacy LC, Dunlop SP Sport LM703, Dunlop Direzza DZ101 and Yokohama C.drive AC01 which have various tyre patterns

(directional, bi-directional and asymmetric) and sizes (rim size ranges from R14 to R18) were tested on a dense bituminous surface and a porous asphaltic surface with a CPX vehicle according to the ISO/DS 11819-2. The tests were performed at two driving speeds of 50 and 70 km/h (the posted speed limit of the roads is 70 km/h). It was found that the Michelin Primacy LC was the quietest while the Yokohama C. drive was the noisiest in both road surfaces and driving speeds. This phenomenon was more prominent for the porous asphalt. The peak noise was found at around 1000 Hz frequency band for the dense asphalt surface but at around 500 – 630 Hz frequency bands for the porous asphalt at both driving speeds. The aged tyres may not be nosier depending on tyre interactions on the road surfaces. The rubber hardness and tread depth have opposing effects on tyre/road noise. The tyre size has no significant effect on road noise.

Monday 14:20-14:40, Hall Brüssel, Paper 0165 (invited)
Schnieders Lars
Optimization of tire/road noise for C3 drive axle tires in regional application

Schnieders Lars, Saemann Ernst-Ulrich
Continental Reifen Deutschland GmbH, Germany

With the revision of the regulations for tire/road noise in 2012 new legal limits for the various kinds of tires became valid. As the rolling noise of commercial vehicle tires will become critical in respect to the new limits, it is necessary to deepen the understanding of the mechanisms of rolling noise excitation especially for drive axle tires in regional applications. A robust tread pattern design with many lateral orientated grooves is the reason why the whole structure of such a tire is excited to strong vibrations, when the tire is rolling. The source of these structural vibrations can be found in the contact patch. From there the vibrations propagate around the tire and thus cause the emission of sound from the tires surface mainly in the horn area. Furthermore lateral orientated sipes as a second element of tread pattern design have a strong influence on the vibration excitation as well as on the vibration characteristics. The main target within the scope of this sub-project of the joint project “Leiser Verkehr 3” (funded by the German Federal Ministry of Economics) is to deepen the general understanding of the origin and spectral composition of rolling noise for commercial vehicle tires. This can directly lead to an improved tire/road noise for future products, in which other requirements in terms of safety and cost effectiveness are not harmed.

Monday 14:40-15:00, Hall Brüssel, Paper 0201 (invited)
Ishihama Masao
Numerical analyses of high-frequency vibration propagation on a tire tread

Ishihama Masao, Kagaya Takayuki, Wachi Junya
Kanagawa Institute of Technology, Japan

This paper reports a study for reducing tire radiation noise in high frequency range caused by tire and road surface shingle contact. The authors have already reported a method to quantitatively predict this contact excitation, and have showed the high-frequency vibration waves excited propagate on tire tread as in a wave guide. The problem remaining is to reduce or dissipate the vibration power flowing out from tire-road contact lines. In this study a couple of methods were tried to model the vibration propagation. They were based on finite element analyses in time domain. A group of the finite element models (FEM) has composite structure flat plate with several layers representing tread rubber, carcass, belt, cap, etc. Direct time-domain response analysis of these models revealed the contributions of each layer on the wave propagation along the tread. Effects of belt were found to be strong. The other FEM models have three dimensional real tire shapes with a single layer shell having anisotropic material properties obtained experimentally by shaker tests. The time domain analyses using this model showed three types of vibration waves from low to high frequency both in time and space. The deformation shape animations provide illustrative understandings of tire vibration.

Monday 15:00-15:20, Hall Brüssel, Paper 0078 (contributed)
Hoever Carsten
A comparison between Finite Element and Waveguide Finite Element Methods for the simulation of tire/road interaction

Hoever Carsten[1], Tsotras Achillefs[2], Saemann Ernst-Ulrich[2], Kropp Wolfgang[1]

[1] Division of Applied Acoustics, Chalmers University of Technology, Sweden
[2] Continental Reifen Deutschland GmbH, Germany

Due to increasing road utilization and tightening regulations, an increasing effort is made by the tire and automotive industries for accurate modeling of tire/road noise. It is well known that finite element (FE) based methods describing the vibration response of a rolling tire are computationally expensive while analytical models do not offer the necessary accuracy in the structural description of the tire. The recently proposed waveguide finite element (WFE) method combines the detailed description of a discretized tire cross section with a computationally efficient wave approach in the circumferential direction. The method has been successfully applied for tire dynamics and rolling noise simulations. An important aspect for the modeling of rolling noise is an accurate description of the road induced excitation. Both the high frequency vibration field and the lower frequency or quasi-static contact area need to be accurately captured. In this work we compare FE and WFE models of a tire in terms of traditional NVH properties such as mobility and modal frequencies, and in term of contact behavior such as footprint shape and structural stiffness. This way the potential of the WFE method for the modeling of both the excitation and the response of a rolling tire is critically examined.

SS03 Modelling and Simulation of Road Vehicle, Tire and Pavement Noise

Chair: Pluymers Bert, Haider Manfred

Monday 15:40-16:00, Hall Brüssel, Paper 1253 (contributed)
Kropp Wolfgang
Sound generation and sound radiation from tyres

Kropp Wolfgang[1], Winroth Julia[1], Hoever Carsten[1], Beckenbauer Thomas[2]
[1] Applied Acoustics, Chalmers University of Technology, Sweden, [2] Müller BBM, Germany

The tyre/road interaction model developed by Chalmers during the last years is utilised to exam both sound generation mechanisms and sound radiation properties of rolling tyres. The model is based on a very advanced tyre model, a fully non-linear contact model, and a radiation model including the surface of the road. The model is successfully validated. The two main mechanisms, tyre vibrations and air-flow related mechanisms – often called air-pumping – are analysed from measurements and from simulation results. The results indicate the strong influence of air-flow related mechanisms. Different tyre/road combinations influence this result. The so gained insight is essential for the optimisation of tyres and road surfaces. The simulations show that the lateral structure of the surface roughness can have strong influence on the generated sound at higher frequencies. The analysis of pass-by measurements also underlines the findings that at these frequencies, low order modes with respect to the cross section determine the sound radiation. Finally the influence of the road surface is investigated and the horn effect for a rolling tyre is calculated.

Monday 16:00-16:20, Hall Brüssel, Paper 1206 (invited)
Vercammen Stijn
Analyses on the effects of rolling on the tire dynamics

Vercammen Stijn[1,2], Kindt Peter[1], Gonzalez Diaz Cristobal[1], Desmet Wim[2]

[1] Goodyear Innovation Center Luxembourg, Luxembourg
[2] KU Leuven Department of Mechanical Engineering, Belgium

Although tire/road noise has been studied for several decades, there are still some missing links in the process of accurately predicting the noise that results from the interaction between the rolling tire and the road surface. An

important link is the effect of rolling on the dynamic behavior of a tire. Both experimental as well as numerical analyses have been performed in order to examine the effects of rolling on the tire dynamics. The experimental analysis is based on accelerometer measurements on the inner liner of a tire, whereas the numerical analysis is based on a highly detailed tire model, which includes all the complex material behavior. The results show that a rotating tire is subjected to Coriolis accelerations which make the wave speed of the positive- and negative-going wave to diverge from each other. This leads to complex or travelling wave mode shapes. The analyses also show how the footprint contact, established due to loading of the tire, acts as a boundary condition for the structural waves and thus influences the dynamic behavior of the rolling tire. In addition a comparative analysis is performed to evaluate the correspondences and differences between experimentally and numerically obtained modal parameters of a rolling tire.

Monday 16:20-16:40, Hall Brüssel, Paper 0441 (invited)
Lundberg Oskar
Non-linear contact forces for beam/ball-interaction and its influence on the dynamic response of the beam

Lundberg Oskar[1], Finnveden Svante[1], Lopez Ines[1], Björklund Stefan[2]

[1] KTH, Dept. of Aeronautical and Vehicle Engineering, Sweden
[2] KTH, Dept. of Machine Design, Sweden

A well-defined rolling contact problem is studied with the intention to cover interesting aspects of tyre-road contact modeling and rolling contact in general. More specifically, the dynamic response in a steel beam caused by a steel ball rolling over it is studied by theoretical modeling of the beam- and ball dynamics as well as the contact forces. Validation of the dynamic response simulations is achieved by comparison with measurements. The contact model is shown to be greatly dependent on an accurate estimate of the real contact stiffness. A method to estimate the contact stiffness which leads to good accuracy in dynamic response simulations is presented. Although the contact stiffness is significantly lower for rubber-asphalt interaction than for steel-steel contact, the results give useful insight for tyre-road contact modeling.

Monday 16:40-17:00, Hall Brüssel, Paper 0724 (contributed)
Conte Frédéric
3D CFD modelling of air pumping noise from road cavities with constant volume

Conte Frédéric, Klein Philippe
IFSTTAR, LAE (Environmental Acoustics Laboratory), Université de Lyon, France

In the aim of reducing noise emissions, it is important to better understand and model tyre rolling noise which is the main source of traffic noise at medium and high speed. Air pumping is a major source of tyre/road contact noise. This noise source is still not well understood and includes several mechanisms. In this context, a modelling approach using computational fluid dynamics (CFD) is presented. The approach consists of highlighting some mechanisms of air pumping occurring in the cavities at the contact area without any volume variation. The dynamic deformation of the rubber is not considered. The goal is to model some phenomena such as air compression and air drainage by considering air flow in the contact zone. A 3D CFD model of air compression and release phenomena caused by the rolling of a smooth tyre over road cavities is implemented. The model is applied to academic configurations such as a cylindrical cavity and an open transversal groove. The noise reduction due to the ventilation of the contact zone by a longitudinal groove is also investigated. This work shows the relevance of modelling air flow to study air pumping, and gives further insights into this phenomenon.

Monday 17:00-17:20 Hall Brüssel, Paper 0860 (contributed)
Hoever Carsten
The influence of lateral road surface resolution on the simulation of car tyre rolling losses and rolling noise

Hoever Carsten, Kropp Wolfgang
Division of Applied Acoustics, Chalmers University of Technology, Sweden

CO_2 emissions and traffic noise are two major environmental issues associated with road traffic. Increased efforts are made to develop suitable simulation tools for the prediction of tyre rolling losses and rolling noise. The accurate description of the tyre/road interaction under rolling conditions is crucial for these simulations. Besides an accurate contact model, input data of sufficiently high quality is required. Accordingly, the measurement effort for the road roughness profiles is high: in the rolling direction distances of several meters need to be scanned at positions less than a millimetre apart. While in the lateral direction a lower resolution can be accepted, still between ten

and twenty parallel profile tracks are required under perfect conditions. Yet, in reality road surface scans are typically restricted to very few lateral tracks due to limited resources. This study evaluates how rolling resistance and rolling noise simulations are affected if the number of independent lateral road scans is less than the number of lateral tracks in the contact model. Different schemes for extrapolating the missing lateral information from the available data are tested for several tyre/road combinations. It is shown that a certain number of parallel road surface scans is necessary for accurate prediction of rolling noise and rolling resistance.

Monday 17:20-17:40, Hall Brüssel, Paper 0715 (invited)
Gilotte Philippe
Tyre road noise acoustic reduction due to rear wheel arch absorption

Gilotte Philippe[1], Surowiec Benjamin[1], Van Antwerpen Bernard[2], Zhou Ze[2]
[1] Plastic Omnium Auto Exterior, France, [2] Free Field Technologies, Belgium

This paper deals with acoustic pressure reduction in the automotive wheel envelop due to replacement of plastic by textile wheel arch. A previous study [3] has shown a direct link between pressure reduction in the wheel envelope and at the rear seat of the vehicle. However, transmission path has not been fully analyzed, especially between pressure inside the wheel envelope and beside the vehicle. This paper proposes methods to understand the acoustic wave structure through computed pressure map outside the vehicle at the specific road noise frequency. Tyre road noise will be represented by a monopole source; Textile absorption will be modeled using Biot parameters. Available acoustic pressure measurements will be first used to validate computations performed with plastic and textile wheel arch. Partial power transmission will then follow the presentation of these validations, in order to quantify absorption efficiency of textile wheel arch for acoustic pressure level reduction beside the vehicle.

Monday 17:40-18:00, Hall Brüssel, Paper 0115 (contributed)
Sen Osman Taha
An improved brake squeal source model in the presence of kinematic and friction nonlinearities

Sen Osman Taha[1], Dreyer Jason T.[2], Singh Rajendra[2]

[1] Department of Mechanical Engineering, Istanbul Technical University, Turkey

[2] Acoustics and Dynamics Laboratory, NSF Smart Vehicle Concepts Center, Department of Mechanical and Aerospace Engineering, The Ohio State University, USA

The goal of this paper is to investigate the source characteristics of brake squeal. An improved model is suggested where a point mass is in contact with a belt moving at constant velocity. First, the governing equations with kinematic and friction nonlinearities are formulated. The kinematic nonlinearities arise from an arrangement of the springs that support the point mass, as well as from a loss of contact between the belt and the mass (due to its vertical motion). Second, the nonlinear equations are numerically solved, and a wide range of dynamic responses are observed. Results show that some assumptions made in prior articles, where a linearized model was utilized, are not valid. Third, the nonlinear equations are simplified by ignoring the contact loss nonlinearity, and then linearized about an operating point for stability considerations. Instability regimes are then obtained for a set of parameters. Further, coupled modes are found even though some contradictions between the model assumptions and linearized system solutions are observed. It is concluded that the contact loss nonlinearity is crucial, and it must not be ignored for squeal source investigation.

SS18 Building Acoustic properties, Regulations and Comfort Classes

Chair: Rasmussen Birgit, Machimbarrena Maria, Scholl Werner, Gerretsen Eddy, Patricio Jorge

Monday 08:20-08:40, Hall Freiburg, Paper 1255 (invited)
Ordoñez Rodrigo
Objective and subjective evaluation of façade sound insulation

Ordoñez Rodrigo[1], Visentin Chiara[2], Marković Miloš[1], Fausti Patrizio[2]

[1] Acoustics, Institute of Electronic Systems, Aalborg University, Denmark
[2] Department of Engineering, University of Ferrara, Italy

Façade insulation of several different construction types were subjectively evaluated using three psychoacoustic methods: paired comparisons using a two alternative forced choice (2-AFC) paradigm and two versions of direct scaling using a visual analogue scale (VAS). The stimuli used in the evaluations were obtained by filtering recordings of traffic noise with the frequency response of sound insulation measurements. The measurements were performed in typical Italian buildings in accordance with the ISO 140-5 standard. The objectives of the present paper are to compare the subjective evaluations obtained with the two psychoacoustic methods, and to investigate the correlation between subjective assessments and objective ratings in different construction types.

Monday 08:40-09:00, Hall Freiburg, Paper 0489 (contributed)
Masovic Drasko
Analysis of façade sound insulation field measurements - Influence of acoustic and non-acoustic parameters

Masovic Drasko[1], Miskinis Kestuti[2], Oguc Mete[3], Scamoni Fabio[4], Scrosati Chiara[4]

[1] School of Electrical Engineering, University of Belgrade, Serbia, [2] Institute of Architecture and Construction of Kaunas University of Technology, Lithuania, [3] Mechanical Engineering Department, Yeditepe University, Turkey, [4] ITC-CNR, Construction Technologies Institute of Italian National Research Council, Italy

This paper presents the results of a research study undertaken as part of two Short Term Scientific Missions (STSM) of European COST Action TU0901, carried out at the Construction Technologies Institute ITC CNR of Milan with the aim to review, analyse and interpret substantial field data relating to the façade sound insulation. The host institution ITC has collected a database that can be considered unique of its kind taking into account that on-site

façade sound insulation measurements are less frequent and more complicated than interior walls sound insulation measurements. To collect data for this database the many prominent Bodies have cooperated with ITC and provided its own data in the context of the STSM work. This paper focuses on the analysis of the influence of acoustic and non-acoustic parameters on the insulation performance of façades; the different building intended use, the typology of the façade, the layers and mass of the wall, the portion of window surface and their Rw together with all the other features provided a basis for complex division of data in key categories.

Monday 09:00-09:20, Hall Freiburg, Paper 0486 (contributed)
Masovic Drasko
Analysis of façade sound insulation field measurements – Comparison of different performance descriptors and influence of low frequencies extension

Masovic Drasko[1], Miskinis Kestuti[2], Oguc Mete[3], Scamoni Fabio[4], Scrosati Chiara[4]

[1] School of Electrical Engineering, University of Belgrade, Serbia, [2] Institute of Architecture and Construction of Kaunas University of Technology, Lithuania, [3] Mechanical Engineering Department, Yeditepe University, Turkey, [4] ITC-CNR, Construction Technologies Institute of Italian National Research Council, Italy

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Monday 09:20-09:40, Hall Freiburg, Paper 0523 (contributed)
Masovic Drasko
Comparison between the spectrum shape of traffic noise in Belgrade and the ISO 717-1 reference spectrum

Masovic Drasko, Mijic Miomir, Sumarac Pavlovic Dragana
School of Electrical Engineering, Serbia

ISO 717-1 standard defines a reference traffic noise spectrum used for the calculation of traffic noise spectrum adaptation term (C_{tr}). The latter one is then added to the single number sound insulation descriptors in order to quantify the protection against this type of noise more accurately. However, traffic noise and its spectral content depend on many factors and are expected to show strong variations in real circumstances, making the appropriateness of the reference spectrum arguable in some cases. The aim of this paper is, therefore, to compare the measured spectra of the traffic noise in Belgrade and the ISO 717-1 reference spectrum. Noise recordings were made at various locations in the city's urban area and then statistically analysed. The results should also point to some noise characteristics which can influence the spectrum shape variations and can cause large deviations from the reference spectrum.

Monday 09:40-10:00, Hall Freiburg, Paper 1108 (contributed)
Scholl Werner
ISO 16717 – Revision of single-number quantities for sound insulation in buildings: state of discussion

Scholl Werner
Physikalisch-Technische Bundesanstalt (PTB), Braunschweig

In 2009, the revision of ISO 717 "Acoustics — Rating of sound insulation in buildings and of building elements" started. The task was, besides updating, a reduction of the amount of selectable sound insulation descriptors, which was caused by different selectable frequency ranges, reference source spectra and weighting systems (R_w and R_w + C). The necessary choice seemed quite easy and clear: to keep all single-number quantities starting at 50 Hz, to keep the "R_w + C"-system and to remove the rest. The revision also offered a good chance, to harmonize the impact and airborne sound insulation, which are contrary so far (impact sound levels versus airborne sound insulation indices). This paper will summarize the state of discussion in and around the ISO working group, give a survey of the problems like

inclusion of low frequencies, and discuss the advantages of impact sound reduction indices instead of impact sound levels.

Monday 10:00-10:20, Hall Freiburg, Paper 1017 (invited)
Gerretsen Eddy
European variety of descriptors for building acoustic performance and translation into proposed harmonized descriptors

Gerretsen Eddy
Level Acoustics BV, The Netherlands

Though based on the same measurement principles, many different descriptors are used in Europe to quantify the acoustic performance of buildings. Over the last years this situation has been presented in literature (i.e. Rasmussen) and proposals have been formulated for more harmonization in this field. This has lead to a so-called COST Action, a fruitful platform for discussions and coordination of research in Europe. To facilitate harmonization in the area of acoustic descriptors it is not only needed to know and define the variations and the harmonized goal, but also to translate existing descriptors in new proposed descriptors. Such new descriptors can than be used to define a classification system by which different levels of performance can be adequately grouped for the various aspects. In this paper these three aspects will be addressed: an update of existing descriptors, the proposed new descriptors and the translation from one into the other. The focus will be on airborne and impact sound insulation, though also the situation for façade insulation will be sketched, as well as the current situation concerning classification systems.

Monday 11:00-11:20, Hall Freiburg, Paper 1303 (invited)
Rasmussen Birgit
Sound insulation performance in Danish multi-storey housing 1850-2009 and upgrade possibilities to meet current regulations

Rasmussen Birgit[1], Hoffmeyer Dan[2]

[1] SBi, Danish Building Research Institute, Aalborg University (AAU-CPH), Denmark
[2] DELTA Test & Consultancy, Denmark

Denmark has 1 million dwellings in multi-storey housing and 2.7 million dwellings in total. According to a social survey in 2010, about 35% of

occupants in multi-storey housing are disturbed by neighbour noise, while for other housing types, it's less than 10%. Thus, there is a strong need to improve sound insulation in multi-storey housing. The paper quantifies dwellings built in different periods of 1850-2009 and summarizes key characteristics of building types and constructions as well as related sound insulation performance, some being far from fulfilling the limits in the latest Danish regulations. Sound insulation data from selected building types are presented, and improvement potential and feasibility based on benefits and drawbacks of different solutions are discussed. To include practical experience in development of solutions, several housing associations have been contacted, but even when carrying out major refurbishment work, focus is on energy issues, building maintenance and visual qualities, and sound insulation improvement almost never considered. Thus, it is clearly a challenge to change the mind-set of involved parties to apply a more holistic approach and include sound insulation improvement, when upgrading dwellings in other aspects, implying reduced risk of acoustic slum and increased quality of life for occupants.

Monday 11:20-11:40, Hall Freiburg, Paper 1250 (invited)
Kurra Selma
Source-specific sound insulation descriptors for transportation noise and proposal for insulation classes

Kurra Selma
Bahcesehir University, Department of Environmental Engineering, Turkey

The standard normalized traffic noise spectrum referred in both ISO 717-1 and ISO/TC 43 16717, has been assumed to represent all types of transportation noise sources for rating sound insulation of external building elements. A study aiming to obtain a database about spectral content of railway, aircraft and seaway noise in addition to traffic noise, was conducted within a national project parallel to COST TU 0901. The A-weighted normalized reference spectrums were obtained for each type of source at different operational conditions based on the field measurements on building facades in urban and suburban areas. Statistical analyses revealed that the standard reference spectrum could not represent all type of sources because of the uncertainties at certain third octave bands. The proposed spectrums were applied to ISO/TC 16717-1 procedure to derive the source-specific sound insulation descriptors (R_{wt}, R_{wa}, R_{wr}, R_{ws}). During the study, a survey was performed on common building elements, materials and constructional details

and, the insulation performances of 287 sample building elements (of which is 78 external elements) were computed in terms of the new and standard descriptors and the results were compared. As an outcome of the project, the insulation categories were proposed and the class numbers for various descriptors were determined.

Monday 11:40-12:00, Hall Freiburg, Paper 1216 (invited)
Patrício Jorge
A classification scheme for rehabilitated buildings - The Portuguese case

Patrício Jorge, Antunes Sónia
LNEC, Portugal

In Portugal, the construction sector has been recently subjected to an unexpected adjustment process. The construction of new buildings has almost stopped and what is envisaged for the future is a trend of moving from the new buildings construction to the rehabilitation of old ones, aiming to facilitate and improve the renting market. In this context, and to assure some knowledge of buildings performance, a methodology to assess the acoustic quality of these rehabilitated buildings has been proposed. This methodology complements the one conceived for the new buildings, by extending the same concepts to the lower performance side of the buildings behavior, thus contributing for their classification in terms of acoustic comfort, and consequently for their acoustic sustainability. The proposed methodology, which has 5 classes (D+, D-, E, F, and G; the A, B and C are reserved for the new buildings or for those complying with the existing legal requirements), will allow users and renters to decide the best options based on the class of the dweeling they want to rent. Whenever possible, this classification scheme was correlated with subjective data on the perception of noise inside the dwelling, obtained through socio-acoustic surveys.

Monday 12:00-12:20, Hall Freiburg, Paper 1229 (invited)
Izewska Anna
Acoustic classification of dwellings in Poland

Izewska Anna
Building Research Institute, Poland

Current building regulations in Poland regarding acoustic quality of dwellings are relatively lenient compared to regulations in other European countries. At

the time of their setting in the 90s both the technical possibilities and economic situation of the country were considered. Currently, the need to introduce new requirements along with sound classification scheme for dwellings is becoming more and more noticeable. Because of that, a draft standard defining acoustical classes is being prepared. The requirements are set for: protection against neighbors' and external noise, maximal noise levels from building equipment and protection against reverberation noise (implemented by setting minimum absorption in entry halls and common spaces). Four classes related to different quality levels of acoustic comfort are defined. The lowest class refers to the regulatory requirements which shall be met in accordance with Polish Construction Low, higher classes are voluntary. It is proposed that the acoustic classification scheme can refer to new and to existing (old or renewed) buildings. This paper presents the classification schemes for each type of noise protection as well as the multi-stage process of determining the acoustic class of new or existing residential house (or individual flat) and the validation methods of this assessment.

Monday 12:20-12:40, Hall Freiburg, Paper 1072 (invited)
Turunen-Rindel Iiris
Norwegian acoustic classification of buildings

Turunen-Rindel Iiris
Standards Norway, Norway

The first Norwegian Standard on acoustic classification, NS 8175, was published 1997 with four quality classes. Classes for dwellings were harmonized with those of other Nordic countries; class C was related to building codes. The standard concerns dwellings, hospitals, schools, kindergartens, work premises etc. Indoor noise and sound insulation criteria and outdoor noise limits nearby buildings were specified. After some years of experience, criteria were revised and new editions were published 2005 and 2008. In 2012 additional criteria for universal design were finalized for public and work buildings. In order to follow up needs for aging population, children, hearing and visually disabled and others, new criteria were adopted. A socio-acoustic survey was conducted among hearing and visually disabled. Their experiences of acoustics in spaces were applied as basis for selected criteria on room acoustics and noise levels. Acoustic quality for universal design is defined by measures for reverberation time vs. room height, acoustic absorption, noise level, speech intelligibility etc. Also, sound amplifying systems and devices for assisted listening are applied. Latest classification

concerns acoustics in museums, lobbies, assembly halls, restaurants, transport terminals, commercial buildings etc. As the standard is closely connected to building codes, changes are harmonized with the codes.

Monday 12:40-13:00, Hall Freiburg, Paper 0798 (invited)
Bailhache Simon
Elements for an acoustic classification of buildings in France

Bailhache Simon, Guigou-Carter Catherine, Rougier Christophe, Schmich Isabelle
CSTB, France

The aim of the study is to present elements for an acoustic classification of different types of buildings: dwellings, office buildings, hotels, health dedicated buildings and educational buildings. The goal would be to have similarly to energy performance of building a classification of the acoustic performance from A (very good) to F (very bad) for example that would be easily understandable by a common person. The medium class C of acoustic comfort corresponds to the level of the French acoustic regulation. For dwellings, legal requirements are modified by an improvement with respect to impact noise and acoustic treatments in building common hallways. Since office buildings are not concerned by the French legislation, four comfort classes based on French standard NF S31-080 are proposed. A reflection on defining indicators relative to the acoustic ambiance in which the building is located (i.e. building exposure to external noise) was undertaken; indicators are proposed. A classification that could be implemented in France is proposed for discussion.

Monday 14:00-14:20, Hall Freiburg, Paper 0835 (invited)
Hongisto Valtteri
Acoustic satisfaction in multi-storey buildings built after 1950 – preliminary results of a field survey

Hongisto Valtteri[1], Mäkilä Maria[2], Haapakangas Annu[1], Hakala Jarkko[1], Hyönä Jukka[2], Kylliäinen Mikko[3]

[1] Finnish Institute of Occupational Health, Laboratory of Acoustics, Finland
[2] University of Turku, Dept. of Behavioral Sciences, Finland
[3] Tampere University of Technology, Dept. of Civil Engineering, Finland

The revision of both the Finnish building code (C1:1998) and the voluntary classification scheme (SFS 5907:2004) will be topical after the

COST TU0901 project. The revision work regarding apartments would benefit from better knowledge of the acoustic satisfaction in the existing Finnish buildings. The aim of this study was to determine the acoustic satisfaction in different multi-storey apartment buildings built after 1950 and to determine the most disturbing noise sources and the effects of noise. The aim was also to compare the results between different building types to see the effects of prior revisions of the Building Code. The survey was made in 19 selected buildings representing six building types. They were different in respect of between-dwelling sound insulation, environmental noise level and façade sound insulation. Altogether, 597 participants participated in the survey. The disturbance caused by neighbour noise was reasonably low in all building types. It seems that the tightening of the sound insulation requirements between dwellings after 1998 has not had an indisputable positive effect on neighbour noise perception. Instead, the improvement of façade sound insulation in environmental noise areas in new buildings seems to have reduced noise problems. There does not seem to be any reason to tighten the Building Code regarding future buildings. However, the improvement of the façade sound insulation in the older buildings might be worth a discussion. The negative effects of environmental noise in old buildings could most probably be reduced by an adequate design of the façade structures during façade renovations.

Monday 14:20-14:40, Hall Freiburg, Paper 1138 (contributed)
Liebl Andreas
Evaluation of acoustic quality in wooden buildings

Liebl Andreas[1], Späh Moritz[1], Bartlomé Olin[2], Kittel Maria[1]

[1] Fraunhofer Institute for Building Physics IBP, Germany
[2] Lignum Holzwirtschaft Schweiz, Switzerland

It has often been shown that the correlation between standardized evaluation methods and human perception of acoustic quality in wooden buildings can be poor. Within the European research project AcuWood, the acoustic quality of wooden buildings is investigated. The aim of the reported study is twofold. On the one hand it is intended to gain insight into the acoustic satisfaction of inhabitants of wooden buildings depending on building and construction type. On the other hand it is intended to derive objective acoustic descriptors which better correlate with subjective human perception and which are capable to provide a classification of the acoustic quality of wooden buildings. A special focus is put upon impact noise of different

technical and human sources. To achieve this, a questionnaire-based field study in Germany and Switzerland as well as laboratory listening tests were conducted which reconsidered different building and construction types. Besides impact noise other acoustic qualities and additional building properties were addressed in the field survey. The laboratory listening tests partly included recordings from buildings that were included in the questionnaire-based field study. Therefore it is possible to compare the long-term acoustic satisfaction of inhabitants with the short-term subjective impression during the laboratory listening tests.

Monday 14:40-15:00, Hall Freiburg, Paper 0098 (invited)
Novacek Jiri
Experiences from the use of European prediction models for airborne sound insulation in new residential buildings

Novacek Jiri
Czech Technical University, Faculty of Civil Engineering, Czech Republic

Existing need for saving material resources and improving acoustical comfort in buildings requires the use of optimized design methods in building acoustics. This paper deals with prediction models described in the standard EN 12354-1. Overall comparison between measured and calculated results is presented for 24 different situations in five new residential buildings. This comparison includes common frequency-dependent quantities as well as single-number quantities and spectrum adaptation terms. The obtained results confirm that the European prediction models provide good estimate in many situations, despite their limitations. Experiences with the use of models for building with high sound insulation and for reconstruction of existing building are also presented as two short case studies. Finally, a comparison of selected results with those obtained using more general prediction model, which does not neglect the influence of forced transmission on overall flanking sound transmission between rooms, is briefly done.

Monday 15:00-15:20, Hall Freiburg, Paper 0878 (invited)
Hongisto Valtteri
Effect of measurement method on the reproducibility value of the single number quantities or airborne sound insulation

Hongisto Valtteri[1], Keränen Jukka[1], Kylliäinen Mikko[2], Mahn Jeffrey[3]

[1] Finnish Institute of Occupational Health, Indoor Environment Laboratory, Finland
[2] Tampere University of Technology, Department of Civil Engineering, Finland
[3] University of Canterbury, Mechanical Engineering Department, New Zealand

A proposal for new single-number quantities (SNQ) for airborne sound insulation has been recently presented in ISO CD 16717-1. The proposed SNQs, R_{traffic} and R_{living}, are determined within 50-5000 Hz while their present counterparts, R_w+C_{tr} and R_w, are determined within 100-3150 Hz. There is concern that the high reproducibility values of sound reduction indices (SRI) determined by ISO 140-3 below 100 Hz could result in an increase in the reproducibility values of the proposed SNQs. The aim was to compare the reproducibility values of the proposed and the present SNQs. The second aim was to test if the reproducibility values depend on the test method of SRI, i.e. pressure method (ISO 140-3) or intensity method (ISO 15186-3 below 200 Hz). The SRI of a window was measured in five laboratories applying both test methods. The present and the proposed SNQs, and their reproducibility values, were determined according to relevant standards. When the SRI measurement was based on ISO 140-3, the reproducibility values of R_w+C_{tr} and R_{traffic}, were 3.1 dB and 3.6, respectively. Similarly, the reproducibility values of R_w and R_{living} were 1.5 and 2.1 dB, respectively. When the SRI was based on intensity method below 200 Hz, the values changed from 1.5 to 1.9 dB and 2.5 to 2.1 dB, respectively. Based on these results, the inclusion of frequency band 50-80 Hz to the most important SNQs, R_{living} and R_{traffic} is not supported because it will increase the uncertainty of the SNQs compared to R_w and R_w+C_{tr}.

Monday 15:20-15:40, Hall Freiburg, Paper 0954 (invited)
Guigou-Carter Catherine
Acoustic performance indices and low frequencies –A French study

Guigou-Carter Catherine[1], Bailhache S.[1], Villenave M.[2], Maillet A.[3]
[1] CSTB, France, [2] FCBA, France, [3] GINGER CEBTP, France

In the context of new ISO standard drafts for evaluating acoustic performance indices (ISO 16717-1 and -2 projects), questions have been raised concerning the choice of these indices as well as the integration of the low frequencies in theses indices calculation. In order to assess the compliance of the ISO/NP 16717 drafts to the European needs, the European technical committee CEN/TC 126 has launched applicability studies in October2012 concerning airborne sound insulation related to external noise, airborne sound insulation

related to internal noise and impact sound insulation. French acoustic laboratories and institution involved in building acoustics standardization have decided to work together in order to investigate the relevance of the ISO proposed indicators and eventually suggest new ones. The goal in defining new acoustic indices is indeed to more closely evaluate building occupantscomfort. The work to be conducted concerns mostly extended listening tests. Noise sources from outside and inside a building will be chosen so they correspond to those for which inhabitants mostly complain, but also so that their frequency spectrum is different. Representative façades including windows, separating walls and floors with their usual complements (linings, floor coverings, etc…) will then be selected. Listening sequences will be prepared for different levels of the different noise sources and the different building components (only direct field will be considered). It is expected to carry listening test on a minimum of 20 persons of different agesand backgrounds. Results will be presented and discussed.

Monday 15:40-16:00, Hall Freiburg, Paper 0699 (contributed)
Lee Pyoung Jik
Evaluation of floor vibrations induced by walking in reinforced concrete buildings

Lee Pyoung Jik[1], Lee Byung Kwon[2], Griffin Michael J.[3]

[1] Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland, [2] Daelim Industrial Co., Korea, [3] Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, UK

Floor vibrations induced by human walking were investigated in a reinforced concrete structure. Six experimental floor structures were built in laboratories with the same dimensions and boundary conditions. Subjective tests were performed to assess the vibration serviceability of the floor structures. First, the subjects were asked to walk across a floor and then to rate the intensity of the vibrations, acceptability, and serviceability of the floors. In the second part of the tests, the subjects were seated on a chair placed in the middle of the floor and asked to rate floor vibrations when the walker passed the subjects. Floor vibrations induced by human walking were analyzed using peak acceleration, root mean square (r.m.s.) acceleration, and the vibration dose value (VDV), and four weighting functions (W_b, W_k, W_g, and W_m) were applied. Significant differences in the measured floor vibration were found across the floor structures, larger floor vibration lead to greater perceived vibration intensity, lower acceptability and serviceability. The W_b and W_k were found to be more applicable than W_g and W_m to explain

perception of floor vibration. It was observed that the impact noise induced by walking did not influence the evaluation of floor vibration.

Monday 16:00-16:20, Hall Freiburg, Paper 0189 (contributed)
Lietzén Jesse
Evaluation of impact sound insulation of intermediate floors on the basis of tapping machine and walking

Lietzén Jesse[1], Kylliäinen Mikko[1], Kovalainen Ville[1], Hongisto Valtteri[2]

[1] Tampere University of Technology, Department of Civil Engineering, Finland
[2] Finnish Institute of Occupational Health, Finland

The aim of this research was to find out how the single-number quantities for rating of impact sound insulation defined by the standard ISO 717-2 correspond with the sound levels and loudness levels produced by walking. Measurements were done with nine floor coverings on the same concrete slab. In the walking tests, three male test persons walked along the same track with soft-and hard-heeled shoesand socks. Three indicators were defined from walking sounds: equivalent sound level $L_{A,eq}$, maximum sound level $L_{A,max}$ and loudness level L_N. As a result of standard measurements, single-number quantities $L'_{n,w}$, $L'_{n,w}+ C_I$ and $L'_{n,w}+ C_{I,50-2500}$ were defined as well as the suggested impact sound reduction index R_{impact}. These single-number quantities did not rank the floors in the same order as the indicators based on walking. The indicators based on impact sounds produced by walking with hard-heeled shoescorrelated best with the single-number quantities, but there was no linear correlation between the single-number quantities and walking with socks. In Finland, shoes are usually not used at homes. Therefore, the present single-number quantities do not provide a solid basis for building acoustic design if it is suggested that walking sounds are the dominating impact sounds at homes.

Monday 16:20-16:40, Hall Freiburg, Paper 0271 (contributed)
Lang Judith
The importance of music as sound source in residential buildings

Lang Judith, Muellner Herbert
Technologisches Gewerbemuseum Wien, Austria

The required sound insulation in dwellings has to be based on the sound levels produced by the inhabitants. Recent studies showed that noise spectra with considerable low frequency content could be recorded if residents were listening to music and if hi-fi-appliances and loudspeaker systems of state of the art quality were used. So it seemed advisable to investigate how long and at which time of the day which type of music people produce in their home with different types of modern equipment. A questionnaire was designed on these topics and published in Austria, Germany and Switzerland. It was mainly answered by colleagues in the relevant standard committees, acoustic associations, but also by students and by employees in some factories. From the answers the preferred music category, the time of day and the number of hours people hear music, the preferred reproduction quality and volume and the used equipment were analysed, distinguishing different groups of education degree. The respondents living in multifamily houses were also asked if they reduce the loudness after 10 p.m. The answers regarding the different types of music can be compared with the frequency response of different types of music.

Monday 16:40-17:00, Hall Freiburg, Paper 0643 (contributed)
Rychtáriková Monika
Influence of temporal and spectral features of neighbour's noise on perception of its loudness

Rychtáriková Monika[1,2], Müllner Herbert[3], Urbán Daniel[2], Chmelík Vojtech[2], Roozen Nicolaas Bernardus[1], Glorieux Christ[1]

[1] Laboratory of Acoustics and Thermal Physics, KU Leuven, Belgium
[2] Department of Building Structures, STU SvF Bratislava, Slovakia
[3] Versuchsanstalt TGM, Fachbereich Akustik und Bauphysik, Austria

Ongoing discussions on building acoustic standards have brought a number of interesting research questions that concern not only the development of more accurate simulation and measurement methods, but also suitable methodologies for the assessment of acoustic comfort through laboratory listening tests. Validation of the proposed single number ratings in

listening tests, require not only perfect auralisation and laboratory with low sound levels, but also investigations on most suitable psychoacoustic method. This article presents the effect of temporal and spectral features of the presented stimuli on loudness perception.

Monday 17:00-17:20, Hall Freiburg, Paper 1099 (contributed)
Muellner Herbert
Empirical evaluation of the contemporary living noise spectrum in multi-family houses – a preliminary study

Muellner Herbert[1], Rychtáriková Monika[2]

[1] Technologisches Gewerbemuseum TGM, Department of Acoustics and Building Physics, Austria
[2] Lab. of Acoustics and Thermal Physics, KU Leuven, Belgium

There is evidence that the currently applied sound insulation requirements and descriptors do not consider the residents' experience of the building acoustical comfort sufficiently. Appropriate rating systems are about to be improved in close relation to current country and social related living aspects by consideration of the frequency range at least down to 50 Hz. Despite the expected improved correlations it still remains an open topic of investigation if the currently applied adaptation term spectra are really representing the given contemporary sound spectra in multi family houses of today. Recordings were carried out with the aim to screen a contemporary living noise spectrum in dwellings of multi storey buildings. All the living noise relevant sound events of the recordings were specified and analyzed afterwards. A wide range of so called living noise events have been recorded. Living noise spectra with considerable content in the low frequency range have been mostly recorded when the residents were listening to particular pieces of music and if hi-fi-appliances and loudspeaker systems of sophisticated quality were used. The analysis of the recorded range of spectra led to a proposal for an alternative living noise spectrum, which is discussed in the paper.

Monday 17:20-17:40, Hall Freiburg, Paper 0849 (invited)
Hongisto Valtteri
Disturbance caused by airborne living sounds heard through walls – preliminary results of a laboratory experiment

Hongisto Valtteri, Oliva David, Keränen Jukka

Finnish Institute of Occupational Health, Laboratory of Acoustics, Finland

AIM. The aim was to determine the correlation between the most topical single-number quantities (SNQ) of airborne sound reduction index and perceived disturbance in domestic context. Special care was taken to design the experiment so that different living sounds, realistic sound levels and a wide spread of typical party walls were used. The focus was within 50 and 5000 Hz. METHODS. 26 subjects participated in the experiment. Each participant evaluated the disturbance of 54 sounds while imagining that they were at home relaxing and reading a magazine. Six spectrally different living sound types were examined. The sounds were filtered through an audio filter corresponding to the sound reduction index (SRI) of the wall. Nine different walls were examined. Six well-known SNQs were determined for the walls. The correlation coefficients of the SNQs and disturbance were determined for each sound type. In addition, the mean correlation coefficient over all six sound types was determined. RESULTS. The highest mean correlation coefficient over all sound types was obtained with R_{speech} (-0.74) followed by R_w (-0.73), R_w+C (-0.71), R_{living} (-0.67), R_w+C_{tr} (-0.65) and $R_{traffic}$ (-0.50). CONCLUSIONS. R_{living} (equals with $R_w+C_{50\text{-}5000}$) has been suggested as the primary SNQ for apartments in the new standard proposal ISO 16717-1. Based on this study, there are other well-known SNQs, like R_{speech} and R_w, which should be primarily considered because they predict disturbance significantly better.

Monday 17:40-18:00, Hall Freiburg, Paper 0207 (invited)
Takala Joose
Room acoustics and background noise levels in furnished Finnish dwellings

Takala Joose, Kylliäinen Mikko
Tampere University of Technology, Department of Civil Engineering, Finland

The current standard series ISO 140 defines the measurement methods of airborne and impact sound insulation in buildings. In addition to calculation of apparent sound reduction index R', the standards allow the normalization of measured sound level differences D and impact sound pressure levels L_i to either reference absorption area A_0 (10 m^2) or reference reverberation time T_0 (0,5 s). In Finland, the latest study on the room acoustics of furnished dwellings was carried out in 1965. Then, Finland decided to express the sound insulation requirements as weighted apparent sound reduction index R'_w and weighted normalized impact sound pressure levels $L'_{n,w}$. There is an

ongoing European discussion on the choice between normalization and standardization in setting the sound insulation requirements. The aim of this study is to find out, how the room acoustics of Finnish dwellings correspond with the reference absorption area or reference reverberation time. The subjective ranking of sound insulation is not only based on the sound insulation between dwellings, but also on the masking depending on background noise level from HVAC installations and traffic noise. Another aim of the study is to find out what is the typical background noise level in a furnished Finnish bedroom or living room. The typical reverberation time of a Finnish dwelling corresponds well with the reference reverberation time 0,5 s, but the typical absorption area is closer to 20 m^2 than to 10 m^2. In many Finnish dwellings, the background noise level $L_{A,eq}$ is low, even below 20 dB.

SS27 Long and Short Range Sound Propagation

Chair: Attenborough Keith, Li Kai Ming

Monday 08:20-08:40, Hall Strassburg 1, Paper 0260 (invited)
Attenborough Keith
Exploiting ground effects for noise control

Attenborough Keith, Bashir Imran, Taherzadeh Shahram
Engineering and Innovation, MCT, The Open University, UK

Although ground effect, i.e. the interference between sound reflected from the ground and that traveling directly from a source to a receiver, is known to have significant influences on outdoor sound propagation, little attention has been paid to the potential for exploiting ground effects for noise control. The acoustical properties of hard ground can be altered considerably by adding roughness. Roughness element arrays up to 0.3 m high and 6 m wide are shown to be useful for surface transport noise reduction. Also in view of the wide variety of naturally-occurring acoustically-soft ground types available, it is found that the lower the flow resistivity of the ground surface, the more significant is the soft ground effect. The replacement of acoustically-hard areas between 2 m and 50 m wide by porous ground close to a road can lead to useful reductions in noise levels. Ground effects are most significant for receivers close to the ground but can be increased for higher receivers by elevating the treated areas of ground. Several ways of exploiting ground effect for noise control are illustrated through laboratory and outdoor experiments and numerical predictions.

Monday 08:40-09:00, Hall Strassburg 1, Paper 0372 (contributed)
Jean Philippe
The efficiency of berms against traffic noise – Hosanna project

Jean Philippe, Defrance Jérome, Koussa Faouzi
CSTB, France

Based on BEM calculations, several aspects of berm protections have been analyzed. The size, the overall geometry or local shape variations have been considered. Depending on the type of source (road, railway and tramway) or the position of receivers (man height or first floor), optimal solutions may vary. The addition of a fractal-like surface rugosity was also modeled. Rectangular or triangular, regular or irregular troughs were added on one or 3 sides of the berm. The optimal solution is a two-order roughness leading to several - up to 7

dB(A) - extra noise reduction. Shape optimization was carried out for a berm combined with a supporting wall in order to bring the diffraction point closer to the source while keeping the benefit of long top absorbing surfaces. The notion of small berm has been extended to urban applications and found to be interesting if placed close to tramway sources.

Monday 09:00-09:20, Hall Strassburg 1, Paper 0779 (invited)
Defrance Jérôme
Acoustical performance of innovative vegetated barriers

Defrance Jérôme, Jean Philippe
CSTB (Centre Scientifique et Technique du Bâtiment), France

Abatement of environmental noise by natural means is a growing area of research. In this work carried out in the frame of the HOSANNA European collaborative project we propose to assess the acoustic efficiency of several families of innovative vegetated barriers (with substrate) dedicated to ground transportation noise abatement using a 2D Boundary Element Method. For urban roads and tramways low-height vegetated barriers - no more than 1 m high - are proposed and assessed. The case of a bridge over a pedestrian path is also addressed. For motorways various shapes of vegetated caps at the top of 4 m high barriers are studied. The analysis is carried out for 1.5 m high receivers' areas (pedestrians, cyclists) as well as 4 m high ones (buildings, END strategic maps). Results expressed in terms of insertion losses show that in many studied situations the acoustical gain may be very significant.

Monday 09:20-09:40, Hall Strassburg 1, Paper 1020 (invited)
Van Renterghem Timothy
Loudness evaluation of road traffic noise abatement by tree belts

Van Renterghem Timothy, De Coensel Bert, Botteldooren Dick
Ghent University, Department of Information Technology, Belgium

Detailed full-wave numerical calculations, partly based on measured input data, show that tree belts can be much more efficient than commonly thought. For road traffic noise applications, the trunks and the forest floor are expected to be responsible for the main part of the noise shielding. The choice of planting scheme and tree belt depth are essential parameters at realistic tree densities. The noise attenuation provided by a tree belt is discussed in relation to the one obtained by traditional thin rigid noise walls. The reference ground type between the edge of the road and the receiver showed to be an important parameter in this comparison. In case of rigid soil, a 30-m deep optimized tree belt could give a similar A-weighted sound pressure level as a 4-m high noise wall at receiver distances exceeding 50 m. For grass-covered ground, the equivalent noise screen height is typically lowered with roughly 1 m. Although both types of noise abatement change the frequency balance in a different way, the course of A-weighted sound pressure levels versus Zwicker loudness is rather similar.

Monday 09:40-10:00, Hall Strassburg 1, Paper 1028 (invited)
van der Aa Bart
Shape-optimal design of graded index sonic crystal noise barriers with line defects

van der Aa Bart, Forssén Jens
Division of Applied Acoustics, Chalmers University of Technology, Sweden

A graded index sonic crystal gives rise to upward refraction due to a negative sound speed gradient, which progresses with height. However, in addition to upward refraction, these cylinder formations can simultaneously benefit from band-gap phenomena. This paper presents a method to optimise graded index sonic crystals for broadband traffic noise by: (1) organising cylinders in complex formations using natural cubic splines and (2) introducing line defects. All variables were optimised with a multi-objective genetic algorithm, for structures based on horizontally oriented acoustically hard cylinders, located above a perfectly reflecting ground plane. A four-lane outdoor situation, with a traffic scenario consisting of 95 % light and 5 % heavy vehicles driving at 70 km/h has been studied. For such a configuration we obtained a spatially averaged mean reduction of 3.7, 4.3 and 5.4 dBA, with optimised structures covering an effective cross-sectional area of 0.69, 1.25 and 1.45 m^2, respectively. It is found that the focussing performance of the studied structures is enhanced by increasing the number of scatterers as a function of height, which effectively represents a negative sound speed gradient. In addition, it is found that the effect of line defects is significant, and that the insertion loss among the studied traffic lanes is reasonably constant.

Monday 10:00-10:20, Hall Strassburg 1, Paper 1146 (contributed)
Forssén Jens
Initial results for traffic noise mitigation with Helmholtz resonators in the ground surface beside a road

Forssén Jens, van der Aa Bart
Department of Civil and Environmental Engineering, Division of Applied Acoustics, Chalmers University of Technology, Sweden

For reduction of road traffic noise, measures focussing on the propagation path are needed as complements to measures at source. Here, the effect of Helmholtz resonators, buried in the ground surface alongside the road, is investigated. Possible benefits of buried resonators are that they can function without obstructing the accessibility to the protected area. A modelling approach using equivalent sources is described for a coupled field of resonators in an otherwise acoustically hard ground plane. The model is validated in comparison with laboratory measurements. For selected road traffic cases, the model is used to predict the effect of resonators in a grid pattern within a strip along the road, showing noise reductions of 2–4 dBA.

Monday 11:20-11:40, Hall Strassburg 1, Paper 1111 (invited)
Tao H.
Acoustical characterization of rigid porous materials

Tao H., Liu S., Tong B., Li K. M.
Ray W. Herrick Laboratories, School of Mechanical Engineering, Purdue University, USA

The current study explores an improved method to characterize the acoustical properties of rigid porous materials/ground surfaces. A PC based Maximum-Length Sequence System Analyzer was adopted to obtain the transmission loss (TL) spectra for the sound fields measured either above or below the rigid porous surfaces. Preliminary experiments were conducted with two receivers located above the ground surfaces but separated horizontally. The measured results suggested that there was generally a lack of sensitivity for determining the acoustical properties of the ground surface when both receivers were close to the ground surface. An improved method was proposed where a pair of measured TL spectra was obtained with one receiver located above and the other situated below the ground surface. The downhill simplex method was then applied to derive the

optimal parametric values for the density ratio and the index of refraction of the rigid porous surface.

Monday 11:40-12:00, Hall Strassburg 1, Paper 0826 (invited)
Ortiz Santiago
Sound sources and inverse filtering for the measurement of ground impedance

Ortiz Santiago, Cobo Pedro, Ibarra David, de la Colina Carlos
Centro de Acústica Aplicada y Evaluación No Destructiva (CAEND), Spain

Omnidirectional sound sources are recommended for measuring ground impedance. The ANSI S1.18 standard suggests to use a 1 m large pipe with a driver connected to one end to approximate a point source, provided that its diameter is shorter than quarter of a wavelength. An alternative design proposed by Polack et al. [Acta Acust Acust 2001; 87: 505–512] consisting of a high power loudspeaker feeding a small aperture through a reverse horn is implemented here. Although both designs, the open end of a pipe and the smaller aperture of a reversed horn, have proved to be a solution for omnidirectional sound sources, they have a very irregular frequency response and a resonant time response. The strong resonances can cause significant fluctuations of the excess attenuation curve, which can make difficult its inversion to ground impedance data. To equalize these resonances, inverse filtering is applied. Inverse filters pre-emphasize the electrical signal driving the sound source so that zero-phase (or minimum-phase) cosine-magnitude signals are radiated. Equalization by inverse filtering can also shorten the time response of the sound source, making easier the positioning of a time window to separate ground reflections from reflections coming from nearby objects.

Monday 12:00-12:20, Hall Strassburg 1, Paper 0733 (contributed)
Faure Olivier
Effective impedance models for rough surfaces in time-domain propagation methods

Faure Olivier[1], Gauvreau Benoit[1], Junker Fabrice[2], Lafon Philippe[2]

[1] Ifsttar Nantes – Laboratoire d 'Acoustique Environnementale (LAE), France
[2] EDF R&D – Département Analyses Mécaniques et Acoustique (AMA), France

Ground surface roughness exhibits complex geometry and may be not accurately known. Using an effective impedance model in numerical methods

for sound propagation could avoid meshing the small irregularities and then reduce computation time. The effective impedance model proposed by Attenborough *& al.* considers surface roughness as small scatterers with a constant geometry regularly or randomly spaced on the propagation path. This effective impedance model is transposed in time-domain and tested in two propagation codes (FDTD and Transmission Line Matrix). First results of computations are exposed.

Monday 12:20-12:40, Hall Strassburg 1, Paper 0518 (contributed)
Hohenwarter Dieter
Measured ground effects with meteorological conditions classified according IMAGINE sound propagation guideline

Hohenwarter Dieter
TGM – Institute of Technology, Department for Research and Testing, Austria

During four measurement periods the sound propagation of railway noise was measured in the evening and during the night. The sound exposure level (SEL) was measured up to a distance of 200 m south and north of a railway line and the SEL difference between the distances of 25 and 200 m was calculated. At the same time the meteorological situation was measured at the ground and with a tethered balloon up to a height of 100 m. The meteorological measurements were used to classify the acoustic measurements according the IMAGINE sound propagation guideline. At least 122 frequency dependent measurement results were classified according the IMAGINE sound propagation guideline. The main result is that the IMAGINE sound propagation guideline is also in the case of railway noise very useful at clear downwind or upwind sound propagation. If only a small component of the whole wind speed is into the direction from the nearest source point (of the railway line) to receiver than the IMAGINE classification shows in the case of railway noise not a clear difference between the different meteorological classes.

Monday 12:40-13:00, Hall Strassburg 1, Paper 0635 (contributed)
Oshima Takuya
Finite-difference time-domain outdoor acoustic simulation of a real-life area using land cover acoustic characteristics identified by airborne hyperspectral imagery

Oshima Takuya[1], Hiraguri Yasuhiro[2], Hoshi Kazuma[3]
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On Inter-Noise 2011, one of the authors presented a linearized Euler simulation technique of out-door sound propagation problem in a reconstructed geometry of a real-life urban area using digital geographic information. The technique had to assume the boundary surfaces (the ground and the buildings) to be perfectly reflecting due to the lack of an identification technique of acoustic absorp- tion characteristics of the surfaces from geographic information. In order to solve the identification problem, the authors presented a classification technique of land cover types in a real-life area using airborne hyperspectral imagery on Inter-Noise 2012. The technique classifies the land area corresponding to each pixel of a hyperspectral image to one of five ground types defined by ASJ RTN-Model 2008. In the present study, the identified surface characteristics are given to finite- difference time-domain outdoor acoustic simulations in a real-life area. The simulations employ a porous medium model for the solution of acoustic absorption by the surfaces. Numerical solutions of a flat ground reflection problem obtained by the porous medium model agreed well with exact solutions. The validation is followed by solutions of a real-life problem of a 210 m×290 m area in Nagaoka, Japan. The solutions are compared with those assuming perfectly reflecting surfaces. The maximum difference of 7 dB supports the validity of the present methodology.

Monday 14:00-14:20, Hall Strassburg 1, Paper 1025 (contributed)
Oshima Takuya
Scale-model validation study of finite-difference time-domain simulations over a real-life area reconstructed with digital geographic information

Oshima Takuya[1], Ishizuka Takashi[2], Kamijo Takahide[1]

[1] Faculty of Engineering, Niigata University, Japan
[2] Institute of Technology, Shimizu Corporation, Japan

On Inter-Noise 2011, one of the authors presented a finite-difference time-domain simulation tech- nique of outdoor sound propagation problems over a reconstructed geometry of a real-life urban area using digital geographic information. However, the technique has not been validated against a real-life or a scale model experiment. Of the two, a scale model experiment allows precise controls over problem geometry and experimental conditions. In the present study, a geometry of a real-life urban area in Kanagawa, Japan is reconstructed using three types of digital geographic information: a digital

surface model, a digital elevation model and a building outline dataset. A 1:100 scale model of the geometry is created from the geometry by a combination of numerically controlled machining of the terrain and handicrafts of the buildings. Experiments are carried out to measure shieldings and diffractions by the buildings and the terrain. In parallel with the experiments, large scale finite- difference time-domain simulations are performed over the same geometry and conditions using a supercomputer. Comparisons of the experimental and the simulation results show good agreements at low frequencies. However, notable differences are observed at shadow zones of the buildings in high frequencies and at street canyons where multiple reflections occur.

Monday 14:20-14:40, Hall Strassburg 1, Paper 0678 (contributed)
Iwase Teruo
Binaural simulation of sound propagation from moving sound source using HRTF

Iwase Teruo[1], Kurono Hiroyasu[1], Okada Yasuaki[2], Yoshihisa Koichi[2]
[1] Niigata University, Japan, [2] Meijo University, Japan

Accurate calculation of the predicting sound propagation along ground surface within local area can be performed by basis of both considerations of acoustic impedance of boundary surface for the excess attenuation and Fresnel's Integral for the sound attenuation by barrier. Then, audible simulation signal after propagated for any sound source can be realized by the convolution method based on the frequency characteristics of sound propagation obtained by just described. Audible simulation for moving sound source also becomes possible even though the amount of the calculation becomes huge when this method is applied. Combination of the simulations for each position of right and left ear easily makes stereo phonic sound signal. Authors had already executed the calculation for example as the noise from road vehicles passing on the road paved by normal dense and drainage porous asphalt. For the advanced stage, authors tried binaural simulations by introducing HRTF, Head-Related Transfer Function, into the sound propagation calculation process. Simulated sound signals for many kinds of original sound source as road vehicle, rail train, voice and music instruments made clear feeling on continuous change of distance from moving sound source and feeling of the localization out side of head.

SS28 Sound Propagation in Built-up Areas

Chair: Kang Jian, Van Renterghem Timothy

Monday 15:00-15:20, Hall Strassburg 1, Paper 0423 (contributed)
Vuylsteke Xavier
Fast multipole boundary element method applied to acoustic propagation in urban area

Vuylsteke Xavier[1,3], Leissing Thomas[2], Jean Philippe[3], Semblat Jean François[4]

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For many years, the Boundary Element Method (BEM) has been widely used to solve propagation problems in environmental acoustics. However, the BEM suffers a major drawback due to dense and unsymmetrical matrices. It leads to a prohibitive computation time, for a large number of degrees of freedom, making the BEM unusable at high frequencies or for large scale models. During the 80's, Greengard and Rokhlin introduced the Fast Multipole Method (FMM) to accelerate the matrix-vector product. Employed with the BEM, the FMM can reduce the prohibitive computation time by using the iterative solver Generalized Minimal RESidue (GMRES). We propose here a broadband Fast Multipole Boundary Element Method (FMBEM) algorithm based upon both low and high frequency formulations. First of all, the scattering problem on a spherical body is studied for mixed boundary conditions in order to prove the accuracy of the algorithm. Subsequently, we propose to deal with half-space problem and finally, we focus on a more realistic geometry which could be encountered in urban acoustic problems, proving the efficiency of FMBEM.

Monday 15:20-15:40, Hall Strassburg 1, Paper 0834 (invited)
Guillaume Gwenaël
Recent developments in the transmission line matrix method and implementation - Application in a built-up environment

Guillaume Gwenaël[1], Faure Olivier[2], Fortin Nicolas[1], Junker Fabrice[2], Aumond Pierre[1], Gauvreau Benoit[1]

[1] Ifsttar Nantes - Laboratoire d 'Acoustique Environnementale (LAE), France
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Numerous works aim to develop more and more accurate sound prediction models while keeping reasonable computation burden. Time-domain methods

stand for an interesting field of investigation in order to study acoustic propagation phenomena, but they still remain computationally expensive and often require supercomputing facilities. The transmission line matrix method is a time-domain approach which allows the modeling of sound propagation in realistic built-up areas with complex topography, absorbing ground and meteorological effects. A powerful implementation has been proposed in order to distribute calculations on several graphics processors. Graphics processing units allow performing huge calculations on personal computers since they are especially designed for executing multiple tasks simultaneously within the context of a single process. Thus, the propagation domain is cut out into subdomains in order to carry out subdomains computations on each graphics cards at the same time. The present work presents the accuracy of transmission line matrix method predictions in comparison with finite-difference in the time-domain model and experimental results through an example of application in a built-up environment.

Monday 15:40-16:00, Hall Strassburg 1, Paper 1021 (invited)
Van Renterghem Timothy
Improving the accuracy of engineering models at shielded building facades: experimental analysis of turbulence scattering

Van Renterghem Timothy[1], Wie Weigang[1], Forssén Jens[2], Hornikx Maarten[2,3], Ögren Mikael[4], Botteldooren Dick[1], Salomons Erik[5]

[1] Ghent University, Department of Information Technology, Belgium, [2] Applied Acoustics, Chalmers University of Technology, Sweden, [3] Building Physics and Services, Eindhoven University of Technology, The Netherlands, [4] Department of Environmental and Traffic Analysis, VTI, Sweden
[5] TNO Urban Environment and Health, Delft, The Netherlands

Noise mapping models are able to accurately predict directly exposed facade levels near busy roads on condition that sufficiently detailed traffic data is available. At the non-directly exposed side of the building, however, common practice application of standard methods strongly underpredicts sound pressure levels, potentially leading to an incorrect assessment of noise annoyance and sleep disturbance. The concept of background noise mapping was proposed before, which has the important advantage that it can increase the accuracy of existing noise maps at a limited computational cost. In this study, long-term meteorological and noise data showed that turbulence scattering contributes significantly to the noise level at shielded facades, already at sound frequencies below 1 kHz. Periods with strong atmospheric turbulence are dominant for long-term equivalent noise levels as typically used in strategic noise maps. A comparison between predictions and

measurements show that rather high turbulence strengths should be used when producing noise maps.

Monday 16:00-16:20, Hall Strassburg 1, Paper 1033 (invited)
Jang Hyung Suk
Traffic noise reduction using vegetation in a 1:10 urban scale model

Jang Hyung Suk, Jeon Jin Yong
Department of Architectural Engineering, Hanyang University Seoul, South Korea

Vegetated noise abatements such as vegetated facades, shrubs, trees, and green roofs were evaluated for road-traffic noise in a 1:10 urban scale model of a street canyon with an inner courtyard. The model materials were selected by measuring the absorption coefficients of different layers of boards and fabrics. For the scale-model measurement, a line source was constructed and evaluated to simulate traffic noise with ribbon tweeters. The street canyons are noise-exposed locations in urban areas due to the multiple reflections from parallel facades. The noise from streets into courtyards is determined by the design of building facades and roofs. Among the treatments, the vegetated façade was effective for the street and courtyard and the green roof reduced diffraction noise from the courtyard. Additionally, combinations of vegetation were more effective both in the street and courtyard.

Monday 16:20-16:40, Hall Strassburg 1, Paper 0791 (invited)
Smyrnova Yuliya
Modelling of sound propagation in urban environments with the effect of vegetation

Smyrnova Yuliya, Kang Jian
School of Architecture, University of Sheffield Western Bank, UK

This paper first gives a brief overview of modelling of sound propagation in urban environments. It then introduces the CRR (combined ray-tracing and radiosity) model, which is an energy based model that simulates specular and scattering reflections in an integrated way. Modelling approaches comparing CRR with other energy-based models and also with wave based models are discussed. The paper then focuses on the modelling of urban sound propagation by considering the effects of vegetation. Urban cases of geometries typical for European city centres are studied by applying various types of vegetation on the façades. It was found that green wall results in 1-1.5 dB(A) higher averaged noise reduction compared to configurations with Ivy leaves. The effect of absorption and scattering from vegetation on noise reduction and RT, EDT and D_{50} is also discussed.

Monday 16:40-17:00, Hall Strassburg 1, Paper 0112 (contributed)
Fujimoto Kazutoshi
Prediction method of insertion loss of detached houses against road traffic noise based on a point sound source model

Fujimoto Kazutoshi, Tsuji Kyosuke, Tominaga Toru
Kyushu University, Japan

In the Environmental Quality Standards for Noise in Japan revised in 1998, the problem of environmental noise at areas facing roads is evaluated by obtaining the numbers and the rates of buildings at which noise levels exceed the standard value. The Standards allow for the estimation of noise levels, instead of requiring actual measurements, in cases where taking the actual measurements would be difficult. In order to estimate noise levels, to grasp insertion loss of buildings in an evaluated area is needed. In the previous study, the authors proposed F2006 which can predict insertion loss of detached houses against road traffic noise based on a line sound source model. However, in order to evaluate the Environmental Quality Standards for Noise at residential areas facing curved roads, a prediction method based on a point sound source model is needed. Therefore, a new prediction method of insertion loss of detached houses against road traffic noise is proposed in this paper. The validity of the proposed formula is verified through additional experiments. This new and simple method is applicable to evaluation of the Environmental Quality Standards for Noise.

Monday 17:00-17:20, Hall Strassburg 1, Paper 0394 (contributed)
Tang Lisa
Development of Acoustic Windows for Traffic Noise Mitigation in Hong Kong

Tang Lisa[1], Kwok Grace[2], Fung Victor[1], Lee C.K.[1], Lui Aaron[1], Yeung Maurice[1]

[1] Environmental Assessment Division, Environmental Protection Department, The Government of the Hong Kong Special Administrative Region, Hong Kong
[2] Allied Environmental Consultants Limited, Hong Kong

Hong Kong is a densely populated city. High-rise development built next to major roads and highways has become inevitable to support the large population as well as enormous economic growth. It becomes a constant battle between vying for more fresh air for sustainable development of HK and a noisy living environment versus quieter ambience with closed windows. While noise barriers and enclosures could be an effective option to reduce noise in a high-rise cityscape, the space constraints and the visual impact sometimes make them less attractive. The HKSAR Government has been proactively exploring innovative measures such as acoustic windows and acoustic balcony to improve the noise environment for quality living. This paper will discuss the actual application and in-situ tests conducted for acoustic windows in its application at Lingnan University Hostel. It is noted that, with the use of micro-perforated absorbers, a noise reduction of up to 8 dB(A) can be achieved as compared with normal openable windows. Most importantly, these acoustic windows are designed to have sufficient air ventilation to meet local regulations. With the severe limitations in using noise barriers in built-up areas, acoustic windows seemed to be a promising alternative. Nonetheless, the wider applications would depend on the noise reduction, ventilation and user acceptance - the ease of operation and maintenance as well as visual appearance. Looking forward, design improvements and more practical applications would be needed for wider acceptance.

Monday 17:20-17:40, Hall Strassburg 1, Paper 1313 (invited)
Probst Wolfgang
Sound propagation in street canyons

Probst Wolfgang
DataKustik GmbH, Germany

“Reflected sound in street canyons – diffuse or specular” was the title of a paper presented at Inter Noise 2012 in New York. It treated a question of detail from an investigation covering the prediction of noise levels caused by traffic in built up areas. In June 2013 the final report of this study has been published, and therefore the main findings and conclusions shall be presented.

SS32 Noise Mapping and Action Planning

Chair: Coelho Luis Bento, Popp Christian

Monday 08:20-08:40, Hall Strassburg 2, Paper 1117 (invited)
Blanes Guàrdia Núria
Overview of the current state of the Environmental Noise Directive implementation in Europe and exploitation of results

Blanes Guàrdia Núria[1], Nugent Colin[2]

[1] European Topic Centre on Spatial Information and Analysis, Autonomous University of Barcelona, Spain, [2] European Environment Agency, Denmark

The Environmental Noise Directive has stimulated the implementation of noise mapping assessments and action planning throughout the European Union and European Environment Agency member countries. In December 2012, information concerning people exposed to different noise levels and to different noise sources per L_{den} and L_{night} indicators in European agglomerations with more than 100.000 inhabitants, as well as to all main transport networks should have been reported by member states. This information is being integrated into the existing relational database containing noise data for all of Europe: Noise Observation and Information Service for Europe (http://noise.eionet.europa.eu). With the provision of this information and corresponding action plans, the picture of noise impact at European level is expected to be the most complete to date. This would enable the analysis of trends on noise exposure through two different reporting cycles, as well as providing an overview of the effectiveness of the action plans being implemented. Nevertheless, some critical objectives such as data comparability are yet to be achieved. European institutions and member states worked on measures to obtain data of higher quality, more accurate and comparable among countries, by developing a proposal for common calculation methods and for a common data repository to report the Directive requirements.

Monday 08:40-09:00, Hall Strassburg 2, Paper 1071 (invited)
Coelho J. Luis Bento
Experience on noise mapping and action plans in Portugal

Coelho J. Luis Bento, Alarcão Diogo
CAPS, Instituto Superior Técnico, Technical University of Lisbon, Portugal

The Portuguese Noise Act of 2000 required all local authorities and transport infrastructures to draw noise maps and noise abatement plans, prior to the transposition of the Environmental Noise Directive 2002/49/EC (END), done in 2006, when that document was updated to accommodate the END requirements for agglomerations and large transport infrastructures. Since existing national calculation methods were not suitable for noise mapping purposes, the Portuguese Environmental Agency recommended the use of interim methods except for railway noise, given the difference on the rolling stock, where any method could be used provided some validation procedure was performed. A study was conducted for all types of Portuguese railway stock to check that the RMR database and method could be used. A correspondence of all types of trains in operation was found to train classes in that database, making the method fit for use. The paper describes methodological and data issues related to the experience of the Group of Acoustics and Noise Control at IST, Technical University of Lisbon, on noise mapping and action plans of a number of large cities and of the major railway lines in Portugal.

Monday 09:00-09:20, Hall Strassburg 2, Paper 0204 (invited)
Vogiatzis Konstantinos
Strategic noise mapping in Greece & Cyprus - Some considerations regarding delays and particularities in South European countries from the implementation of the Directive 2002/49/EC

Vogiatzis Konstantinos

Laboratory of Transportation Environmental Acoustics (L.T.E.A.), Faculty of Civil Engineering, University of Thessaly, Greece

The Strategic Mapping of Environmental Noise, (SMEN) as per the European Directive 2002/49/EC, aims at the determination of a common approach for the avoidance, prevention or reduction, on a prioritized basis of the harmful effects, including annoyance, due to exposure to environment noise, in order to create a platform base for noise mitigation measures related to major environmental noise sources. Environmental Noise is an important environmental factor responsible for the degradation of the urban environment and the quality of life especially in countries where climatic conditions favours outdoor activities & the night life. In Greece in the period of 2007 - 2010, Strategic Noise Mapping, was completed for: the New Athens International Airport (A.I.A.), the Attica Tollway (Athens Ring Road) and the Egnatia Motorway. In Cyprus within the same period the Strategic Noise

mapping for all highways & motorways with more than 6 m illion passages/year and the Int. Airports of Larnaka & Pafos was completed. Even though the relevant results are interesting and of a high scientific value, however in Greece and Cyprus and also in several EU member states noise contours and data on noise mapping - due to be submitted by 30 December 2007 – are still incomplete or missing especially regarding the urban agglomerations. Moreover, for roads, airports and railways outside urban agglomerations, in several cases, the data on noise mapping reported to the Commission cannot be linked to the list of major infrastructures, and therefore it is impossible to assess the completeness of the data reported.

Monday 09:20-09:40, Hall Strassburg 2, Paper 0344 (contributed)
Argyropoulos Dimitrios
Residential Exposure to Port Noise and Noise Mapping: A Case Study of Piraeus, Greece

Argyropoulos Dimitrios, Bakogiannis Konstantinos, Cambourakis George

Acoustics Communication and Mass Media Technology, Electrical and Computer Engineering Department, National Technical University of Athens, Greece

Greece's major port, Piraeus, is one of the most significant ports in Eastern Mediterranean Sea. It is the largest passenger port (serving 20 million passengers per year) and among the ten largest commercial ports in Europe. The noise level from the continuous operation of Piraeus port is heavy. The noise levels affecting the nearby urban area become heavier due to the traffic noise being produced by the main road that serves the highly populated area at the outskirts of the port. In this paper, our purpose is to discriminate the noise being produced inside the geographical boundaries of the port from the outside public noise sources, based on real data. For this purpose, real traffic data have been collected, all the different sources of noise have been detected and an extended number of sound level measurements have been held and analyzed. Finally, GIS-based noise mapping, based on our real data, was performed to decorrelate the noise that is due to the port's operation from the noise that is irrelevant to port's activity. As a conclusion, it is defined how the port affects the noise pollution at the nearby urban area.

Monday 09:40-10:00, Hall Strassburg 2, Paper 1082 (contributed)
Zhang Bin
Case study on some new developments of noise mapping in China

Zhang Bin[1], Wu Rui[1], Jiang Congshuang[2], Li Xianhui[2], Ding Yonghua[1], Hu Wencheng[1]

[1] Beijing Municipal Institute of Labor Protection, China
[2] Beijing Key Laboratory of Environmental Noise and Vibration, China

As with a growing requirement of noise control in China, some pilot projects of noise mapping had been conducted in some metropolitan cities. Apart from traditional technology method, some novel methods were proposed and explored in these projects. (1) The implementation of noise mapping in different cities involves not only normalized drawing criteria, but also different noise sources across cities in China. So the integration of normalized drawing methods and localized noise source models are studied. (2) The updating method for the noise mapping using automatic noise monitoring equipments is explored. (3) Noise management system integrating these technologies is developed for authorities to manage the environmental noise. All above exploration lays a solid foundation for future development of noise mapping in China.

Monday 10:00-10:20, Hall Strassburg 2, Paper 0331 (invited)
Braunstein Gert
Suitable tools for the optimization of modeling large noise maps and a discussion about the selection of appropriate input data

Braunstein Gert
Braunstein + Berndt GmbH, Germany

In the second round of noise maps in respect of the END [2], we learned from the experience of the first round. Now we are able to develop acoustic models which can also be used for detailed investigations of a noise action plan - under the condition that input data are in a sufficient quality. Some of these aspects are: Optimization of the use of digital terrain data, road heights and railroad heights on the basis of laser scan data, removal of differences between the terrain heights and road or railroad heights, advantages and disadvantages of the use of laser scan data to form a DTM for the noise calculation, automatic working correction tools for roads and railroads and buildings like detection of bridges, estimating multiple

reflections in street canyons, linking of road axes with traffic models, estimation of exact building heights, and so on. The paper ends with a discussion of the data flow in large projects.

Monday 11:00-11:20, Hall Strassburg 2, Paper 0484 (invited)
Ibbeken Sebastian
Noise mapping of major roads for the state of Baden-Wuerttemberg according to the EU Environmental Noise Directive

Ibbeken Sebastian[1], Krüger Marion[2]
[1] Wölfel Beratende Ingenieure GmbH + Co. KG , Germany, [2] Lärmkontor GmbH, Germany

In the state of Baden-Württemberg, the strategic noise mapping of major roads, major railways and congested urban areas is implemented in separate projects [1]. This paper describes the creation of the calculation model, the procedure of noise mapping for main roads, and the special characteristics of the map representation. The work required for this project was carried out by order and under the technical and scientific guidance of the LUBW ("Regional Office for Environment, Measurements and Nature Conservation of Baden-Württemberg"). The noise mapping of large road networks requires comprehensive geographic and traffic data which must be integrated into a calculation model. Mapping comprises the following steps: • Collecting and providing data; • Merging and adapting the data; • Calculating noise maps; • Evaluating the results for the purpose of reporting to the EU. The calculations and evaluations are made according to the uniform rules of the EU Environmental Noise Directive [2], which are not discussed in detail here. When the input data are acquired and prepared beforehand, however, special data records collected for mapping (e.g., noise barriers, bridges and tunnels) must be combined and compared with general data records (e.g., buildings and terrain) that are, in the most cases, already available. The paper describes the input data used and discusses solutions for potential problems that might arise in connection with their combination. For the process of informing the public, the lecture gives advice on the interpretation of noise maps which reveal unexpected noise levels in the environment of noise barriers, valleys and bridges.

Monday 11:20-11:40, Hall Strassburg 2, Paper 0712 (invited)
Stapelfeldt Hardy
Mapping, monitoring-recalculation, assessment and action planning

Stapelfeldt Hardy[1], Manvell Douglas[2]

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[2] Brüel & Kjær Sound & Vibration Measurement, Denmark

Input data and results from strategic noise mapping, environmental assessment can be reused in action planning and other analysis with advantage once they have been prepared with decent accuracy. Initial GIS or other publicly available data needs to undergo quality assessment and, in most cases, extra data refinement. Automated tools help to avoid human errors and minimize project costs. To ensure sustainable data management with reduced replication of data, decentralized, web-based data management presents a modern alternative to regional data deployment and integration of revised data e.g. generated during action planning. Automated calculation procedures for large projects with integrated grid and façade calculation as well as QA analysis according to DIN 45687[1] for "speed tuned" (i.e. optimized) calculation will reduce costs and risks. The use of measured data, comparable with the calculated data, may help to validate or refine various aspects of the input data. Open, configurable tools may help to present results in a manner which helps to raise the public focus on environmental noise issues. Solutions to the issues mentioned above will be presented in the paper.

Monday 11:40-12:00, Hall Strassburg 2, Paper 0765 (invited)
Stapelfeldt Hardy
EU Noise mapping experiences and action planning for the Grand-Duchy of Luxembourg

Stapelfeldt Hardy[1], Glod David[2], Styra Darius[3], Manvell Douglas[4]

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[4] Brüel&Kjaer Brüel & Kjær Sound & Vibration Measurement, Denmark

For the Grand-Duchy of Luxembourg, EU-conformant noise mapping and noise exposure assessment has been performed for road, rail and aircraft noise. Initial GIS data required extensive refinement and merger with road traffic simulation data as well as rail traffic data provided by the rail authorities based on various sources of less common data formats. The data

integration process, which resulted in a comprehensive state-wide model, utilized LimA macro technology. The major reasons and issues for refinement and the chosen solution will be presented. In support of action planning an automatized strategy for local mitigation schemes will be suggested. For the railway noise propagation a "word by word" interpretation of the standard was applied, which implied a mixed 2D/3D geometry interpretation. Results from this will be compared to a consistent 3D interpretation. For aircraft noise calculation ECAC Doc 29 was applied and data assembling as well as final results will be presented.

Monday 12:00-12:20, Hall Strassburg 2, Paper 1109 (contributed)
Hepworth Peter
Managing the production of the world's largest noise map

Hepworth Peter[1], Shilton Simon[2], Stimac Alan[3], Ausejo Miguel[4]

[1] Hepworth Acoustics, UK, [2] Acustica, Trident One, UK, [3] DARH 2, Croatia, [4] Independent Noise Consultant, Spain

In order to satisfy the requirements for transportation noise mapping for the second round of strategic noise maps under EC Directive 2002/49/EC, the English government let a contract for all road and railway mapping to be carried out by a single project team. This created the world's largest noise mapping project with around 950 million calculation points and up to 7 noise indices to be calculated at each point. The project was awarded using a two stage process. Firstly a pre-qualification questionnaire (PQQ) was circulated to all companies that registered their interest in the project. The PQQ required detailed information from the project team on financial history, project experience, project personnel, experience of joint working, knowledge management, quality control, sustainability, and equality and diversity. Finally, a short list was chosen and tender submissions were made detailing the proposed approach, project team and a fixed price for the project. The Hepworth Acoustics team was awarded the contract, and this paper presents the successful approach to winning the project and managing a project team located in four countries. The importance of the quality of the data provided for the mapping, in meeting the demanding timescales is also highlighted.

Monday 12:20-12:40, Hall Strassburg 2, Paper 1314 (contributed)
Chaves Brito Fco. Aurélio
The creation of the noise map of the city of Fortaleza

Chaves Brito Fco. Aurélio[1], Bento Coelho J. L.[2]
[1]SEUMA, Secretary of Urbanism and Environment, Brazil, [2]IST Technical University of Lisbon, Portugal

Fortaleza is a Brazilian city with approximately 2.8 million people, 900,000 vehicles, in the central region airport, subway having aerial passages and at the surface, recreational establishments with many sound events, cars attached with powerful sound (sound walls) and other aspects of a great city, which generate high levels of noise and discomfort for the population. Based on these aspects, in the year 2000 the population reacted and began requiring authorities effective control of noise pollution in the city and in this fight, a group was created with the task of performing the necessary actions. The fight had initially educational aspects, later a rigorous program to combat what has become known like Zero Tolerance and was finally completed with the production of the first noise map of a large Brazilian city. This paper shows this story and the results obtained.

Monday 12:40-13:00, Hall Strassburg 2, Paper 0215 (contributed)
Berndt Mihály
Action Plans and Hungarian Folktales

Berndt Mihály, Muntag András
EnviroPlus Ltd., Hungary

Strategic noise maps of the Hungarian cities over 100,000 population have been completed. However, the Action plans do not produce the expected results. This is due partly to the shortage of resources caused by the economic crises and also the short time. According to our experience, recalling the elements of the Hungarian folktales, the major obstacle is that the approach to handling the environmental noise regarding the directive is far from how it has worked so far. We will present this topic through examples, experience gained from projects in Hungary and our proposals and efforts to change it will also be introduced.

Monday 14:00-14:20, Hall Strassburg 2, Paper 0809 (contributed)
Estévez Laura
Results of a survey used to evaluate noise annoyance as part of the noise action plan of León (Spain)

Estévez Laura, García Eduardo, Cepeda Jesús, Búrdalo Gabriel, de Barrios Mercedes, de Barrios Miguel

Laboratorio de Acústica, Universidad de León, Spain

The European Directive 2002/49/CE aims to establish a common approach intended to avoid, prevent or reduce the harmful effects, including annoyance due to exposure to environmental noise. Noise not only has negative effects on our health, it modifies our social behavior and causes annoyance. A survey has been designed to analyze the annoyance due to noise pollution in the city of León. (~ 132,000 inhabitants). It was conducted to 509 inhabitants of the whole city and contains a series of questions that can bring some answers in order to meet the requirements set by the Action Plan. The present study shows that more than half of the population of the city is annoyed by both indoor and outdoor noise. In this sense, the exterior sources that causes more annoyance among people are voices and motorcycle traffic. The study reflects that in an area which does not exceed the noise limits, people can perceived as annoying those levels and vice versa. It also shows that the perception of noise as annoying varies depending on age.

Monday 14:20-14:40, Hall Strassburg 2, Paper 1153 (contributed)
Niemeyer Lygia
Sustainable urban planning for Brazilian cities: noise management in the context of urban sprawl

Niemeyer Lygia[1,2], Cortês Marina[1], Ribas Leandro[2]

[1] Proarq, Universidade Federal do Rio de Janeiro, Brazil, [2] FAU, Universidade Federal do Rio de Janeiro, Brazil

Urban centers in Brazil have experienced a great sprawl over the last decades. Currently, about 80% of the population lives in urban areas, being 30% among the major metropolitan regions. However, the rapidly grown has been exceeding the ability of local administration to provide adequate infrastructure and life quality for its inhabitants. The noise pollution in Brazilian cities has often been augmented by the disregard of the environmental issues in the context of urban planning. This paper aims to

discuss the impact over the acoustical environmental of the new urban parameters approved for Vargem Grande, district located in the western area of the city of Rio de Janeiro. By being located in the area of urban expansion and under the influence of investments for the Olympics 2016, the neighborhood suffers severe pressure the real estate market. The evaluation methodology has involved the comparison of noise maps of the present situation/ future scenarios, and the critical analysis the potential impact of the morphological changes in the urban landscape over the sound environment (conflict zones, noise sources, sensitive listening spaces and soundscapes).

Monday 14:40-15:00, Hall Strassburg 2, Paper 1068 (contributed)
Echaniz Lucie
Designing tools to support noise action planning on a large scale: the role of a regional noise observatory

Echaniz Lucie, Mietlicki Fanny, Comment Mathilde
Bruitparif, Noise Observatory, France

The 2002/49/EC European directive and its transposition into French law require agglomerations of more than 250,000 inhabitants to make noise maps and action plans. Since the Paris agglomeration isn't an administrative entity, about 240 local authorities are in charge of its implementation in this area. The multiplicity of the stakeholders involved has required from Bruitparif, the Regional Noise Observatory, a reinforcement of the technical assistance it already provided. In the framework of its local authorities support mission, Bruitparif has elaborated a global methodology by creating new tools to incite noise action plan implementation: • A web-site space dedicated to public authorities with a Geographical Information System tool crossing their noise maps and land use information. • A pre-filled noise action plan framework containing a methodology based on our GIS enabling the local authorities to identify the potential priority areas and their potential quiet areas thanks to their noise mapping. • A workbook summarizing good practices for both administrative staff and representatives in order to give them a better understanding of noise issues and highlighting practical measures falling within their competence. This article aims to present the tools developed to support action planning at a large scale.

Monday 15:00-15:20, Hall Strassburg 2, Paper 0218 (invited)
Zacharias Frank-Christian
Noise mapping and Air pollution mapping Using same Input Data Computation and evaluation by the WFS ODEN

Zacharias Frank-Christian[1], Kunka Rainer[1], Hoar Chris[2]
[1] Thüringer Landesanstalt für Umwelt und Geologie, Germany, [2] NGIS China Ltd., Hongkong, China

Usually road traffic noise mapping is different from air pollution mapping. One additional attribute is to be distinguished for air pollution. The traffic flow situation is needed. This can be derived from a mix of attributes from the noise model. You put together the road category with speed, with statistical distribution of types of cars, lorries and heavy tracks. We get by these parameters emission data PM10, PM2.5 and NOX, if wanted as well for other substances. The 3D city model of terrain, buildings and roads provides WFS ODEN [1], which supplies input interface using MISKAM [2] software for air pollution propagation. MISKAM is a micro scaling prognostic model which is very sophisticated for complex propagation situations. Scaling range for grid resolution has been tested from 1m to 10m. Users can compute one wind field or 12 directions in 30° resolution around compass rose. 2km by 2km area needs hours for the wind field and minutes for concentrations. 12 directions are used for average value weighted with the local wind distribution frequency. There is nothing to do than starting the interface between noise and air which runs automatically. So you can immediately see the results of actions for both mediums.

Monday 15:20-15:40, Hall Strassburg 2, Paper 1015 (invited)
Probst Fabian
Large-Scale Calculation of Possible Locations for Specific Wind Turbines under Consideration of Noise Limits

Probst Fabian, Probst Wolfgang, Huber Bernd
DataKustik GmbH, Germany

The acoustical part of the study “Renewable Energy Potential NRW” [1] was conducted by DataKustik GmbH. One of the major challenges of this project was the pure data size which needed to be processed. The acoustical study comprised an area of 36,540 Km^2, 4.2 million receivers and 136 million high-points. The wind turbines under consideration can be operated in two different modes which differ in energy production and noise emission. The final result of this automatically processed study were the possible areas suitable for wind farms, the areas of exceeding noise levels in respect to specific noise limits and the maximum possible energy production.

Monday 15:40-16:00, Hall Strassburg 2, Paper 0808 (contributed)
Estévez Laura
Acoustic characterization of pedestrian areas

Estévez Laura, García Eduardo, Cepeda Jesús, Búrdalo Gabriel, de Barrios Mercedes, de Barrios Miguel
Laboratorio de Acústica Aplicada, Universidad de León, Spain

Many of the actions that have been proposed to revitalize tourism projects have not taken into account the environmental context and urban heritage in which they have to be developed, threatening the viability of it. One element often overlooked is related to acoustics and how it affects the city and citizens.Our experience allows us to show that these areas with many different noise sources are being subjected to high noise levels. This could lead to social and structural deterioration of these surroundings often characterized as pedestrian areas. Moreover, European Directive 2002/49/EC notes Strategic Noise Maps as a tool for designing action plans against noise pollution, collecting information from road traffic, railway, aircraft and industrial noise. However, pedestrian areas are not taken into account for this study, and, judging by the number of complaints we should consider them as a major source of noise pollution. We propose the development of a project focused on the study of noise impact in an urban pedestrian area like the one in León (Spain). This will let us set out the foundation of sources found in pedestrian areas, which will help to establish a proper methodology for its analysis as part of noise maps.

Monday 16:00-16:20, Hall Strassburg 2, Paper 0863 (invited)
Ascari Elena
Reliable methods for low frequency map to improve action plans

Ascari Elena[1], Licitra Gaetano[2], Cerchiai Mauro[3]
[1] University of Siena, Italy, [2] ARPAT, CNR-IPCF, Italy, [3] ARPAT, Agenti Fisici, Italy

After the first implementing round of Directive 2002/49/EC, different experiences pointed out the need of a reliable method of mapping. To this aim, JRC coordinated CNOSSOS methodology setting-up, which still lacks of implementation. Furthermore, experiences of action plans show that not

all actions really improve noise quality when reducing only noise energy. In fact, the contribution of low frequencies in left shifted road spectrum noise (by barriers, new pavements, etc) can determine a lot people annoyance, which doesn't appear so reduced. Therefore, in this study, a map will be proposed using the most reliable method available (NMPB 2008, Nord2000 and ISO9613 modeling methods will be compared): it will be based upon measurements carried out in order to verify not only the overall A-weighted level but also the spectrum estimation as it is proposed within CNOSSOS methodology. We intend to estimate the $L_{C\text{-}A}$ indicator (used within occupational noise protection laws to evaluate damage to health), which is considered to be suitable to evaluate annoyance due to low frequency content. The aim is to show correlation between $L_{C\text{-}A}$ hot spots and annoyed people. This test has been carried out in Pisa where an accurate evaluation of traffic flows was already available.

Monday 16:40-17:00, Hall Strassburg 2, Paper 0937 (invited)
Bañuelos Alberto
Sustainable mobility and urban biodiversity in the noise action plan

Bañuelos Alberto, Navas Naiara, Mateos Rubén, Tomás Mónica
AAC Acústica + Lumínica, Spain

In urban areas, the main noise source originates from urban traffic, so noise reduction in the city is the main goal of the action plan. Together, the sustainable mobility plan and the noise action plan must work to achieve optimum results for citizens. The mobility plan seeks not only to reduce intensity and speed, but also to recover public space for citizens, offering the city an improvement in sound environment, and more pleasant and quiet urban areas. The previously mentioned objectives are precisely the main aim of the noise action plan in Vitoria-Gasteiz and Donostia-San Sebastián. Furthermore, results and data from this procedure will be presented. In addition, the Vitoria-Gasteiz project also seeks to include new urban green areas and to achieve a new and improved sound environment, which will open new opportunities for the noise action plan, as well as for sustainable mobility. It is also important to note that the new public urban space provides an interesting role to soundscape in general.

Monday 17:00-17:20, Hall Strassburg 2, Paper 0965 (invited)
Faber Nico
The results of the CEDR Project Group Road Noise 2009-2013

Faber Nico[1], Rubio Alférez Jesús[2], Fryd Jakob[3], O'Malley Vincent[4], Milford Ingunn[5]

[1] Oranjewoud Consultancy, The Netherlands, [2] Spanish Roads Department, Spain, [3] Danish Road Directorate, Denmark, [4] Irish National Road Authority, Ireland, [5] Norwegian Public Road Administration, Norway

The Conference of European Directors of Roads (CEDR) is endeavoring to improve cooperation between its members in order to enhance progress in various road transport sector themes. The purpose of this cooperation is to facilitate the exchange of experience and information on road-related issues like infrastructure, traffic and transport, safety, environment and to perform research in all of these areas. Road noise is one of the topics within the environmental domain. In 2009 the CEDR Project Group Road Noise (CEDR RN2) was formed to investigate the status of a range of noise related issues that would contribute to the goals defined in the CEDR Strategic Plan 2009-2013 [1], such as establishing standards in line with the objectives of national road authorities, taking appropriate action on EU directives and develop and share knowledge on road noise. The research areas identified by CEDR RN2 were closely related to the Environmental Noise Directive 2002/49/EC (END) [2] and consist of: • END noise maps; • END noise action plans; • EU directives on vehicle noise; • EU noise calculation model (CNOSSOS-EU). CEDR RN2 completed its tasks in April 2013. The results on the areas identified above will be presented. Also, conclusions and recommendations will be highlighted.

Monday 17:20-17:40, Hall Strassburg 2, Paper 1016 (contributed)
Tracz Marian
Use of noise maps in designing of bypass vertical alignment in relation to housing location

Tracz Marian, Wozniak Krystian
Department of Highway and Traffic Engineering, Krakow University of Technology, Poland

Development of road infrastructure realized in Poland and young member states of the UE, includes among other investments building of several bypasses of towns and villages. In design of such bypasses it is difficult to provide road corridor which can allow for efficient protection of road surroundings from traffic noise. In such cases usually controversial noise

barriers are used to protect a bypass surroundings. In the paper the authors consider use of noise maps in designing of the bypass road vertical alignment using natural cut or false cut or false cut with low noise barriers. The approach allows for limited optimization of vertical alignment resulting in limited visual intrusion caused by noise barriers. The authors conducted also some analyses of an impact of a road cross-section on the noise isolines.

Monday 17:40-18:00, Hall Strassburg 2, Paper 1185 (invited)
Shilton Simon
Improving consistency through quality control with a large strategic noise mapping project

Shilton Simon[1], Jones Nigel[2], Stimac Alan[3], Ausejo Miguel[4]
[1] Acustica Ltd, Trident One, UK, [2] Extrium Ltd, UK, [3] DARH2, Acoustics & Architecture L.l.c.r, Croatia
[4] Noise Consultant, Spain

During 2012 the second round of strategic noise maps under EC Directive 2002/49/EC were delivered across Europe. Lessons learned from the first round of mapping in 2007 indicated that variations in the approach taken both within and between Member States reduced the consistency of strategic noise maps, and therefore reduced the robustness of comparisons between different sets of noise maps. In order to reduce the variation within the Member State, a number of national authorities determined to undertake a single project approach to deliver all the strategic noise maps required within the country. This in turn leads to very large projects which need an extended multi-disciplinary team of experts in order to ensure successful delivery. The implementation of a quality assurance system is then imperative to maintain consistency between technicians and within multi-disciplinary teams. It is also essential to ensure the control of processes and the ability to review inputs, intermediaries and deliverables. A similar approach may also be applied to calculation and post processing of noise levels. This paper presents collective experience of the implementation of quality assurance procedures used in several EU countries during the successful completion of projects within the first and second round of mapping.

SS16 Measurements in Room and Building Acoustics

Chair: Ingelaere Bart, Hopkins Carl

Monday 08:20-08:40, Hall Grenoble, Paper 0828 (contributed)
Huszty Csaba
Performance comparison of monoexponential and multiexponential decay function estimation methods

Huszty Csaba
ENTEL Engineering Research and Consulting Ltd. Inspired Acoustics division, Hungary

Various decay function and decay time estimation methods show different performance properties in terms of accuracy, reliability, convenience in use and ease of implementation. In this paper a systematic way for evaluating and comparing decay function estimation methods is presented. The method is based on decay models. Commonly used monoexponential a multiexponential decay time estimation methods are compared and a new multi-component non-linear method for multiexponential decay function estimation is briefly introduced and compared to the Bayesian method. Model functions are used to evaluate the current and newly introduced methods.

Monday 08:40-09:00, Hall Grenoble, Paper 0718 (contributed)
Simón Francisco
Specifying the acoustic field in rooms in the low frequency range

Simón Francisco, Anthony David K., Fernández de la Heras Maria J.
Centro de Acústica Aplicada y Evaluación no Destructiva, Spain

In both the fields of noise control and sound transmission, determining the sound pressure in a given room continues to be an important issue. This is commonly done using a single value for each frequency band, and relies on the assumption that the sound field is sufficiently diffuse. For most room sizes and frequency ranges used this assumption is normally valid. However, this is not so for the lower frequency bands, especially as consideration now extends to frequencies lower than previously considered. In these lower frequency bands, the acoustic field cannot be considered to be diffuse, and other procedures need to be developed to reliably determine the sound field. This would imply much more complex measurement procedures, however one option is to change the definition of the parameters measured so as to minimize the effects of the lack of the diffusivity of the sound field. In the work presented, the effect of the spatial sampling of the sound pressure field

and the definition of the bandwidths of the frequency ranges are investigated in order to assess new definitions of measurement that reduce the variability. This will lead to measurements that are more robust, repeatable and reproducible.

Monday 09:00-09:20, Hall Grenoble, Paper 0979 (invited)
Monteiro Carolina R. A.
Contribution to uncertainty of in-situ airborne sound insulation measurements

Monteiro Carolina R. A.[1], Machimbarrena María[1], Pedersoli Stefan, Smith Sean[2], Johansson Reine[1]

[1] Valladolid University, Applied Physics Dpt., Architecture School, Spain
[2] Institute for Sustainable Construction, UK

The objective of this paper is to investigate the uncertainty of in situ airborne sound insulation measurements. A large set of field data has been used to perform individual uncertainty calculations curves using a GUM based approach (ISO Guide to the Expression of Uncertainty in Measurement). Based on these results, the uncertainty of various single number ratings including different frequency ranges has also been estimated. It has been observed that extending the evaluation frequency range from 100-3150Hz to 50Hz-5000Hz does affect the uncertainty of single number quantities (SNQs). Some other effects, such as background noise effect and difficulty to measure reverberation time at low frequencies are also discussed.

Monday 09:20-09:40, Hall Grenoble, Paper 0543 (contributed)
Mahn Jeffrey
Review of the uncertainty of the proposed single number ratings for airborne sound insulation

Mahn Jeffrey
Department of Mechanical Engineering, University of Canterbury, New Zealand

A replacement of the ISO 717-1 standard for the calculation of the single number ratings for airborne sound insulation has been proposed. The proposed replacement, ISO 16717-1 introduces new single number ratings for airborne sound insulation which are calculated from the 1/3 octave bands between 50 Hz and 5000 Hz. The uncertainty of the proposed single number ratings has been estimated using the ISO Guide to the Expression of Uncertainty in Measurement (GUM). The uncertainty of the single number ratings of three

hundred and fifty-eight building elements has been evaluated. The building elements included lightweight walls, brick and concrete walls and a window. It was found that the uncertainty of the single number ratings is highly dependent on the shape of the sound reduction index curve. The uncertainty of the new single number rating $R_{\text{living}}$was found to be greater than the uncertainty of the traditional weighted sound reduction index for 96% of the building elements included in the evaluation.

Monday 09:40-10:00, Hall Grenoble, Paper 1302 (invited)
Hopkins Carl
Measurement errors with maximum sound pressure levels used in building acoustics

Hopkins Carl, Robinson Matthew
Acoustics Research Unit, School of Architecture University of Liverpool, UK

In building acoustics measurements, Fast time-weighted maximum sound pressure levels are commonly used to assess noise. For this reason it is useful to identify the signal processing errors due to time-weighting detectors (Fast and Slow) when combined with CPB filters or an A-weighting filter. Four different sound level meters are used to quantify the variation in measured maximum levels using tone bursts, half-sine pulses, ramped noise and recorded transients. Tone bursts indicate that Slow time-weighting is inappropriate for maximum level measurements of short transients due to the large bias error. Greater variation is observed between sound level meters when considering maximum levels in one-third octave bands than with A-weighted levels. To reduce measurement uncertainty it is proposed that limits could be prescribed on the phase response for CPB filters and A-weighting filters.

Monday 10:00-10:20, Hall Grenoble, Paper 0507 (contributed)
Nash Anthony
On the uncertainty of measuring random-incidence sound absorption

Nash Anthony
Charles M. Salter Associates, USA

For over fifty years, the American Society for Testing and Materials (ASTM International) has promulgated a method for the laboratory testing of random-incidence sound absorption coefficients (Test Method C423). This test method falls under the purview of ASTM Committee E33 (Environmental

Acoustics). In 1999, the protocols in this test method became significantly more stringent with the goal of improving *inter*laboratory *reproducibility* (i.e., quantitative differences among laboratories when testing the same specimen). ASTM calls such an *inter*laboratory test a “round robin”; its outcome is an array of computed precision (i.e., uncertainty) values. This paper presents results from several ASTM round robin evaluations and discusses some possible causes for the range of values.

Monday 11:00-11:20, Hall Grenoble, Paper 0530 (contributed)
Keränen Jukka
Improvement of impact sound reduction by floor coverings – measurements using a small floor mock-up and an impact sound laboratory

Keränen Jukka[1], Lietzén Jesse[2], Kylliäinen Mikko[2], Hongisto Valtteri[1]

[1] Finnish Institute of Occupational Health, Indoor Environment Laboratory, Finland
[2]Tampere University of Technology, Department of Civil Engineering, Finland

Traditional impact sound reduction measurements require a test facility of two reverberation rooms above each other separated by a thick concrete slab (ISO 10140). A new standard draft ISO/DIS 16251-1 proposes a measurement method using a small concrete floor mock-up which reduces significantly the investments and the effort for testing improvement of impact sound reduction, *DL*. The aim of this paper is to present our experiences regarding ISO/DIS 16251-1. The *DL* of five different floor coverings (two vinyl carpets, two textile carpets and parquet) was measured using ISO/DIS 16251-1. For comparison, the impact sound reduction was measured using ISO 10140. The weighted reduction in impact sound pressure level, DL_w, was determined according to ISO 717-2 from both measurement results. It seems that the DL_w values based on ISO/DIS 16251-1 and ISO 10140 measurements are comparable, 0…+2 dB.

Monday 11:20-11:40, Hall Grenoble, Paper 0255 (contributed)
Schmidt Jan-Henning
Using a compact setup for the measurement of impact noise reduction

Schmidt Jan-Henning[1], Wittstock Volker[1], Langer Sabine[2]
[1] Physikalisch-Technische Bundesanstalt, Germany, [2] Technische Universität Braunschweig, Germany

To determine the impact noise reduction of floor coverings according to ISO 10140, a test facility consisting of two rooms with a volume of 50 m^3 each is necessary. To minimize the effort for such a measurement, a compact measurement setup has been developed. This setup consists of a 1.2 m x 0.8 m x 0.2 m concrete slab for heavyweight floors or a timber joist construction for lightweight floors. Instead of the sound pressure in a receiving room, the acceleration of the lower face of the slab is measured while the upper face is excited by a tapping machine. Comparisons between measurements performed in the test facility according to ISO 10140 and according to the compact method show good conformity for soft floor coverings. Research shows furthermore that larger differences occur for the determination of the impact sound reduction of plate-like coverings. For a laminate covering it is shown that these differences are the result of a poor coupling between the floor and the laminate plates. Another aim of the current research is to determine the normalized impact sound pressure level for specific ceilings at a compact setup by means of the acceleration and the radiation efficiency.

Monday 11:40-12:00, Hall Grenoble, Paper 0736 (contributed)
Tröbs Hans-Martin
Measurement of the radiation efficiency of suspended ceilings at low frequencies using swept sine excitation and high-frequency resolution

Tröbs Hans-Martin, Schanda Ulrich, Völtl Raphael
University of Applied Sciences, Rosenheim, Germany

It is common for timber floor constructions to include a suspended ceiling made of plasterboard. In order to minimize the radiation from impact excitation, especially in the low frequency range below 100 Hz, an experimental modal analysis was carried out. The radiated sound power from the suspended ceiling was measured using a swept sine excitation by a shaker connected to the top layer of the timber floor construction. Since the experimental modal analysis was conducted using a high frequency resolution and with a non-stationary sound field, it was necessary to check the validity of the intensity measurements by comparing it with 1/3-octave band measurements. By this means the radiation efficiency can be measured simultaneously with an experimental modal analysis of a structure.

Monday 12:00-12:20, Hall Grenoble, Paper 1227 (contributed)
Roozen N.B.
Determination of the sound power radiated into the receiving room of a transmission-loss facility at low frequencies by means of scanning laser Doppler vibrometry

Roozen N.B.[1,2], Labelle L.[1], Pelegrín-García D.[1], Rychtáriková M.[1], Glorieux C.[1], Leclère Q.[3]

[1] Katholieke Universiteit Leuven, Laboratory for Acoustics and Thermal Physics (ATF), Department of Physics and Astronomy, Celestijnenlaan Belgium, [2] Katholieke Universiteit Leuven, Department of Mechanical Engineering, Belgium, [3] Laboratoire Vibrations Acoustique, INSA-Lyon, France

The measurement of the transmission loss of building elements is typically performed according to ISO 140, by measuring the sound pressure level in the sending and receiving room, using standardized loudspeaker-microphone instrumentation. Recent proposals for new building acoustic standards taking into account frequencies down to 50 Hz, provoke new questions. At low frequencies (depending on the dimensions of the rooms), the modal density in the rooms is typically too low, impeding reliable measurements following standard techniques. In this paper the vibration level and distribution of the element is determined by means of advanced laser Doppler vibrometer measurements and the radiated sound power of the element is subsequently determined by means of numerical simulations that use the measured velocity distribution as input boundary condition. This approach to deduce the transmission loss is compared with the classical way of measuring the radiated sound.

Monday 12:20-12:40, Hall Grenoble, Paper 0467 (contributed)
Otsuru Toru
Humidity Effect on Pressure-Velocity Sensor Examined in Sound Absorption Measurement with Ensemble Averaging Technique

Otsuru Toru[1], Asniawaty Kusno[2,3], Tomiku Reiji[3], Okuzono Takeshi[3], Okamoto Noriko[4], Din Nazli Bin Che[5]

[1] Faculty of Engineering, Oita University, Japan, [2] Hasanuddin University, Indonesia. [3] Oita University, Japan,[4] Ariake National College of Technology, Japan, [5] University of Malaya, Malaysia

The authors have proposed an absorption measurement method (EA-method) that utilizes ensemble averaging and pressure-velocity sensor (pu-sensor) for measuring surface normal impedance required for wave-based room acoustics simulations. However, through some amount of

measurements with pu-sensors, the authors have come to have a question about the effect of humidity to the stability of pu-sensor. Then, employing two pu-sensors with the same specifications, the authors conducted a series of experiment, at four periods from 2010 to 2011. One experiment consists both a pu-sensor calibration and an EA-method measurement. In each calibration or EA-method measurement, relative humidity around pu-sensor was systematically controlled from 35% to 60% with 5% step, and both temperature and atmospheric pressure were monitored. By comparing the standard deviations of resulting absorption coefficients, the authors examined the effect of the relative humidity difference between at the calibration and at the EA-method measurement to resulting absorption coefficient. Final results showed that the standard deviation of absorption coefficient increases as the difference of relative humidity increases. If the difference is kept closer to 0%, the standard deviation of measured absorption coefficient stays smaller.

Monday 12:40-13:00, Hall Grenoble, Paper 0453 (contributed)
Ciszewski Radosław
Adapting dynamic stiffness measurement method to predict sound insulation behaviour of heavy walls, built using lost formwork

Ciszewski Radosław
ITB (Building Research Institute), Poland

Heavy walls built using lost formwork technology with prefabricated polystyrene elements have very poor acoustical insulation properties due to mass-spring-mass resonance between heavy core made of concrete and light weight plaster or plasterboard finishing. Searching for solution of the resonance problem may be very time and money consuming because of the time needed to prepare a full-scale sample in laboratory conditions. A research was carried out to check if it is possible to implement small sample measurement technique, described in EN 29052-1:1992 standard, used for dynamic stiffness measurement of resilient materials used in floors, to qualitatively describe resonant behaviour of different lost formwork structures. Results comparison with sound insulation measurements of full scale samples is presented.

SS20 Impact Sound

Chair: Hagberg Klas, Simmons Christian

Monday 14:00-14:20, Hall Grenoble, Paper 0885 (invited)
Zeitler Berndt
Impact Sound Insulation of Hybrid Wood-Concrete Masonry Assemblies

Zeitler Berndt, Schoenwald Stefan, Sabourin Ivan
National Research Council, Canada

As part of a research project to develop design solutions for concrete-masonry buildings for the Canadian market, a study was conducted on the impact and airborne flanking sound insulation performance of hybrid assemblies with concrete masonry walls and wood joist floors. The effect of junction coupling is investigated in an ISO 15712 flanking prediction context. In the paper, predicted flanking path data will be compared to measured data. Recommendations will be made on how appropriate the application of ISO 15712 is on this type of hybrid assembly.

Monday 14:20-14:40, Hall Grenoble, Paper 1103 (contributed)
Medved Juraj
Analysis of floor layers with a respect to impact noise level

Medved Juraj[1], Bobík Mikuláš[2], Puškár Anton[1], Szabó Daniel[1]

[1] Department of Building Structures, Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Slovakia, [2] Applied Precision s.r.o., Slovakia

This paper relates to impact sound insulation of floor and discussed the EN ISO 140-8, 2001 and STN 73 0532. In building practice we often deal with situation in which the ceiling structures complies these standards but nevertheless the building users complain about the disturbing impact noise. In practice, the impact noise loss level is expressed by weighted reduction of impact sound pressure level ΔL_w (dB). Frequently, there is problem with appropriate evaluation of the impact noise in the whole frequency spectrum of noise. This is especially problem of frequency range under 315 Hz. In this article we try to discuss and to clarify the functionality between of floor layers, different materials and their combinations in frequency domain from the point of view of impact noise level.

Monday 14:40-15:00, Hall Grenoble, Paper 1027 (invited)
Kim Jae Ho
Vibration measurements for evaluating walking discomfort of floating floors in residential buildings

Kim Jae Ho, Jeon Jin Yong
Department of Architectural Engineering, Hanyang University, Korea

The walking discomfort of floors was evaluated by measuring the vibrational serviceability of a floating floor system on concrete slabs. Several tests were conducted in test rooms to investigate the effects of the measurement position on the floor vibrations. Uncertainties in the vibration acceleration level according to the measurement position were calculated. Based on the results, the walking discomfort was estimated according to the vibration dose value (VDV_i), and an in-situ measurement method for floor vibration is proposed, including the number and positions of measurement points. The method was validated through subjective experiments performed in an actual residential building.

Monday 15:00-15:20, Hall Grenoble, Paper 1197 (invited)
Koga Takashi
Practical calculation of floor impact sound excited by heavy impact source

Koga Takashi
Kajima Technical Research Institute, Japan

Several standard impact sources are used to inspect the performance of floor impact sound insulation in Japan, including tapping machines and heavy and soft impact sources as defined by the Japanese Industrial Standards. To enhance the effectiveness of the regulations, the insulating performance must be reasonably predictable. In this paper, two calculation methods that compute the sound caused by floor impacts, with a focus on low frequencies, are reviewed. The first is a practical calculation method and the other method combines the practical calculation and finite element methods. The Japanese Industrial Standard A 1418-2 regulates the maximum sound pressure level; we calculated these using several assumptions and the exposure vibration acceleration level. Additionally, two case studies are introduced. The first is the application of the prediction to multi-family dwellings. The authors gathered the sound reduction performances of several floor coverings and ceilings from the same test facility. The measured reduction performances of the floor coverings and the ceilings were compiled

with the computed values for bare floors. The second case study is the prediction for a gymnasium above an experimental laboratory. The results of the calculations agree reasonably well with in situ measurements with a rubber ball.

Monday 15:20-15:40, Hall Grenoble, Paper 0737 (contributed)
Schanda Ulrich
Semi-empirical model of the impact force of a walking person in the time domain and generated impact sound spetcra

Schanda Ulrich[1], Tröbs Hans-Martin[1], Völtl Raphael[1], Becker Philipp[2]
[1] University of Applied Sciences Rosenheim, Germany, [2] Kurz und Fischer, Germany

Lightweight ceiling constructions often do not reveal satisfactory impact sound performance in the low frequency range. In previous publications it has been shown that the impact sound level measured according to ISO 10140 using a standard tapping machine as an excitation source and then rated according to ISO 717 does not always correlate well with the actual excitation caused by a walking person. A more realistic excitation of the floor construction might be favourable, a standardized walking person unfortunately does not exist. Therefore a semi-empirical model for the impact force in the time domain was created, based on a large series of measurements of the vertical force applied to the floor during one footfall. First a comparison of the impact sound spectra of a timber ceiling constructions either induced by a real walker or induced by an excitation of a shaker with a series of steps from the semi-empirical model will be shown. Second the impact spectra generated by the convolution of the transfer function of the floor with the semi-empirical model excitation will be discussed.

Monday 15:40-16:00, Hall Grenoble, Paper 1080 (invited)
Nakamori Shunsuke
Footstep impact noise simulator for evaluation of floor impact sounds

Nakamori Shunsuke, Yoshimura Junichi
Kobayasi Institute of Physical Research, Japan

Thoughtless loud noise such as children jumping and stomping intensely has been hardly occurred in ordinary life owing to growing awareness of residence in multi-dwelling life. In addition, by reforming of sound insulation and

absorption technologies of building elements, sound pressure level in the residence has been lower against noise from outside. As a result, low-level noise, emitted unconsciously such as walking and light footstep (trotting) impact noise from upper floor, has been becoming apparent specifically. These sounds are lower than that by standard heavy/soft impact sources i.e. car tire and rubber ball, and are dependent on individual, and it is difficult to be reproduced even if identical person has done. Therefore, it is necessary to evaluate and develop floor-ceiling structure systems using footstep impact noise simulator. The characteristic of impact force is adjusted to human heel impact force on a rigid surface, which is an initial part in time series wave pattern of footstep impact force. The automatic excitation machine drops two rubber heads on a circumference by turns. In this paper, we introduce specifications of the simulator and adjustment of impact forces between human footstep and simulator, and report measurement results of their impact sounds.

Monday 16:20-16:40, Hall Grenoble, Paper 0146 (contributed)
Crispin Charlotte
Evolution of the dynamic stiffness of typical materials used under floating floor during their lifetime

Crispin Charlotte, Mertens Christian
Belgian Building Research Institute, Belgium

The creep of materials used under floating floor corresponds to a time-dependent deformation process which leads to a modification of the mechanical characteristics of the product, mainly in terms of a progressive stiffening. Information about the evolution of the material's stiffness under long term exposure to structural loads is an important parameter when assessing the acoustical performances of the material in time. This article presents a setup which allows to measure the dynamic stiffness under a long term stress and discusses the measurement results for typical materials used under floating floor.

Monday 16:40-17:00, Hall Grenoble, Paper 0525 (invited)
Jeong JeongHo
Sound field correction of receiving room on heavy/soft impact sound

Jeong JeongHo, Kim JeongUk, Yang WooJin
Fire Insurers Laboratories of Korea, Korea

Floor impact sound in apartment building became one of the major social problems in Korea. Heavy/soft impact sound source such as rubber ball and bang machine is used in Korea, Japan and Canada. Heavy/soft impact sound was being measured in various sound field conditions from a reverberation chamber for a development stage to in-situ condition in apartment buildings. For the measurement of heavy/soft impact sound measurement, maximum sound pressure level in each 1/3 Octave band was measured without any receiving sound field correction. It was known that maximum sound pressure level of intermittent noise was not affected by the receiving sound field condition. However, it was reported that heavy/soft impact sound pressure level was changed by the change of receiving sound field in reverberation chamber and standard test facility, which is similar with the living room of an apartment unit. There are several kinds of measurand considering receiving sound field condition. One is the standardized maximum sound pressure level in ISO 16032, another is normalized maximum sound pressure level, and the other is NRC method. In this study, results of heavy/soft impact sound pressure level measurement using rubber ball in various sound field condition, with the change of sound absorption power was corrected with three kinds of receiving sound field correction method. Standardized and normalized maximum sound pressure level and NRC method were applied in order to select proper correction method. Among the three kinds of correction method, normalized maximum sound pressure level made the level difference larger. From the results of receiving sound field correction method, it was concluded that the NRC method is the proper correction method.

Monday 17:00-17:20, Hall Grenoble, Paper 0738 (invited)
Ljunggren Fredrik
Findings from the AkuLite project: Correlation between measured vibro-acoustic parameters and subjective perception in lightweight buildings

Ljunggren Fredrik[1], Simmons Christian[2], Hagberg Klas[3]

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[3] WSP, Gothenburg, Sweden

Various research aspects on sound and vibrations in lightweight buildings are covered by the Swedish research programme AkuLite. One of the most important topics has been to find out to what extent objective measured parameters correlate with subjective opinions from people living in

multifamily houses. Typical questions to be pointed out are: Do existing ratings like R'_{w} ($+C_{50-1350}$) and $L'_{n,w}$ ($+C_{I,50-2500}$) correlate well enough to the tenants' perception? Can other measureable parameters be found that show better agreement? Are the often used frequency limits of 100Hz or 50Hz low enough? Can any significant differences be seen when comparing lightweight buildings with concrete buildings? Extensive sound and vibration measurements have been performed in numerous buildings of varying construction including lightweight timber or steel based framing, cross laminated timber and concrete. In general frequencies from 20 Hz have been covered. Questionnaires have been distributed to the tenants where they were asked to give their opinion on a number of adequate questions related to sound and/or vibration perception. The results from the measurements and from the questionnaires have then been compiled, followed by a comprehensive statistical analysis in order to see the degree of correlation between them.

Monday 17:20–17:40, Hall Grenoble, Paper 1215 (invited)
Sato Hiroshi
Subjective evaluation of floor impact sound of wood-frame construction dwellings in different living situation

Sato Hiroshi[1], Hirota Tomohito[2], Hiramitsu Atsuo[3], Tanaka Manabu[4]

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The relation between subjective evaluation on impact sound and physical indices with recorded floor impact sound of wood-frame construction in the field and test chamber. Listening test were conducted with two conditions: reading books in a living room and falling in sleep in a bedroom. The results presented that Maximum Zwicker loudness and $L_{A,Fmax}$ were well correlated with subjective evaluation. The relations between them were presented with same curves but they present different threshold of evaluation.

Monday 17:40-18:00, Hall Grenoble, Paper 1077 (contributed)
Wu Xianjun
Transient sound calculation method based on acoustical transfer vector method

Wu Xianjun, Lyu Yadong, Sui Fusheng
Key Laboratory of Noise and Vibration Research, Institute of Acoustics, Chinese Academy of Sciences, China

The Boundary Element Method (BEM) is commonly used for sound radiation problems. As time domain BEM is unsuccessful in theoretical research and applications for its calculation instability, frequency-domain approach and the equivalent convolution method have certain advantages. In this paper a method using convolution and acoustical transfer vector (ATV), which is the most notable method saving calculation time in BEM, is applied for the prediction of transient sound. The procedure is that ATV is used to get the transient sound response of each element by a δ (t) pulse; then convolution and summation are used to get the total transient sound pressure. The calculation examples are given to valid its accuracy and efficiency.

SS58 Psychological effects, cognitive effects and mental health

Chair: Stansfeld Stephen, Clark Charlotte

Monday 08:20-08:40, Hall Igls, Paper 0156 (invited)
Matsui Toshihito
Psychosomatic disorder due to aircraft noise and its causal pathway

Matsui Toshihito
Hokkaido University, Japan

The Okinawa study showed a clear dose-response relationship between the prevalence of psychosomatic disorder (PSD) and L_{dn} of aircraft noise based on a questionnaire (Total Health Index) study conducted around Kadena and Futenma military airfield. In this paper, the causal pathway of the occurrence of PSD was examined statistically on the association with sleep disturbance and speech interference due to aircraft noise. Categorical regression with optimal scaling (CATREG) was applied to find the association between the PSD score and the scores of the disturbances due to aircraft noise with adjustment for age, gender and occupation. The score of annoyance was also analysed in the same way. In the highly noise-exposed area around Kadena airfield, where prevalence of PSD was increased by aircraft noise, the PSD score showed significant association with sleep disturbance, although the annoyance score showed higher association with speech interference than sleep disturbance. In the vicinity of the Kadena airfield, PSD due to aircraft noise would be caused by sleep disturbance. This causality agrees with those obtained from the new Narita study and the Okinawa study on hypertension.

Monday 08:40-09:00, Hall Igls, Paper 1079 (invited)
Selander Jenny
Aircraft noise annoyance at outdoor living spaces

Selander Jenny[1], Alvarsson Jesper[2], Bluhm Gösta[1], Berglund Birgitta[1,2], Nilsson Mats E.[1,2]

[1] Institute of Environmental Medicine, Karolinska Institutet, Swedenm
[2] Department of Psychology, Stockholm University, Sweden

The Swedish guideline value for aircraft noise of 70 dB L_{Amax} (time-weighting Slow) is intended to protect residential outdoor living spaces, such as balconies, patios and terraces. To provide empirical foundation for a revision of this policy, a questionnaire study was conducted among residents living close

to seven Swedish airports. The questionnaire included questions on aircraft noise annoyance as experienced at the dwelling's outdoor living space. About 3100 persons answered the questionnaire (response rate 65 %). Annoyance responses were linked to aircraft noise exposure, L_{Amax} and L_{den}, calculated using the Integrated Noise Model (INM 7.0). A consistent relationship was found between, on the one hand, the number of aircraft events ≥ 70 dB L_{Amax}, and, on the other hand, the proportion of residents annoyed by aircraft noise at their outdoor living space. The proportion of annoyed residents increased rapidly from exposures greater than 3-5 events per day and evening. The same trend was found for activity disturbances at outdoor living spaces, in particular for disturbances related to speech communication, such as conversation or radio listening. In the present study, a large majority of residents exposed to 3-5 aircraft events ≥ 70 dB L_{Amax} were exposed to less than 50 dB L_{den} (outdoor at the facade), which suggest that L_{den}-guideline-values exceeding 50 dB may not protect against noise annoyance at outdoor living spaces.

Monday 09:00–09:20, Hall Igls, Paper 0873 (invited)
Halonen Jaana I.
Traffic noise and psychotropic medication use

Halonen Jaana I.[1], Lanki Timo[2], Yli-Tuomi Tarja[2], Turunen Anu W.[2], Pentti Jaana[1], Vahtera Jussi[1,3], Kivimäki Mika[1,4]

[1] Finnish Institute of Occupational Health, Finland
[2] Department of Environmental Health, National Institute for Health and Welfare, Finland
[3] Department of Public Health, University of Turku and Turku University Hospital, Finland
[4] Department of Epidemiology and Public Health, University College of London, UK

Background: The effects of road traffic noise on mental health have rarely been studied in population level settings. Objectives: To examine whether outdoor levels of road traffic noise are associated with the use of psychotropic medication. Methods: We examined cross-sectional associations between modeled residential road traffic noise levels (L_{den}) and register-based use of psychotropic medication (antidepressants, anxiolytics, and hypnotics) among Finnish public sector employees (3086 men, 12 525 women). The logistic regression models were adjusted for age, sex, marital status, occupational position, education level, residence size, job strain, area-level socioeconomic position, and population density. Results: On average, the participants were 50 years of age (range 21–76), and the average noise level at the participants' home addresses was 52 decibels (dB, standard deviation

8.1). No associations were found for psychotropic medication use in general (odds ratio (OR) 0.93, 95% confidence interval (CI) 0.78–1.11 among those exposed to >60 dB vs. <45 dB), or for more specific medication categories (OR for antidepressants 0.97, 95% CI 0.78–1.20, for anxiolytics 0.92, 0.65–1.28, and for hypnotics 0.83, 0.64–1.08 at noise level >60 dB vs. < 45 dB). Conclusions: Traffic noise was not associated with psychotropic medication use in adults living in well-insulated residential buildings in Finland.

Monday 09:20-09:40, Hall Igls, Paper 784 (invited)
van Kamp Irene
Mental health as context rather than health outcome of noise: competing hyptheses regarding the role of sensitivity, perceived soundscapes and restoration

van Kamp Irene[1], van Kempen Elise[1], Baliatsas Christos[1,2], Houthuijs Danny[1]

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Evidence on the effects of environmental noise on mental health in adults and children over the past 5 year's leans towards the conclusion that there is no immediate relationship between noise and formal psychological disorders. Recent results shed more light on the relationship between noise and mental health, and especially on the role of mediating factors. Increasing attention for the association between environmental sensitivity and mental health can be notified. A few studies position the relationship between noise and mental health in a broader context of soundscapes and environmental quality. Finally, there is growing attention for the restorative function of quiet areas where mental health effects are concerned. People with psychological problems might be more at risk for detrimental effects of noise via noise sensitivity and environmental sensitivity in general and could thus be considered as a susceptible group with respect to environmental noise. This paper explores a set of competing hypotheses and analyses on the role of environmental sensitivity and mental health in reactions to noise and the dynamics of stress, quiet and restoration in view of these.

Monday 09:40-10:00, Hall Igls, Paper 1152 (contributed)
Bodin Theo
Road traffic noise and mental health – Preliminary results from a cross-sectional study in southern Sweden

Bodin Theo, Albin Maria, Bjork Jonas
Dept of Occupational and Environmental Medicine, Sweden

Introduction: Approximately 80 million Europeans are exposed to road traffic noise at their homes exceeding Laeq24h 55dB(A) (at the highest exposed façade) and the problem is growing. The relation between mental illness and air traffic noise has been investigated in earlier studies with inconsistent results, but the relation to road traffic noise is less known. Methods: 52 432 persons aged 18-80 years, were randomized to participate in a public health survey in 2004. Response rate was 54,1%. Mental health was assessed using GHQ-12. We used GIS and a simplified version of the Nordic prediction model to assess average road traffic noise levels at respondents' homes. Results were obtained using logistic regression adjusted for sex, age, BMI, alcohol consumption, country of birth, socio-economy and smoking Results: Adjusted OR were calculated for GHQ ≥3 and were significantly increased at both LAeq24h 55-59 dB(A) and ≥60 dB(A). Unadjusted regressions showed stronger association. Conclusion: We found an association between mental health and road traffic noise in this cross-sectional study. Hopefully longitudinal data can be analysed and eventually presented as well.

Monday 10:00-10:20, Hall Igls, Paper 0870 (contributed)
Masuda Kyoko
Effect of Sound Quality on Fatigue under Long Term Exposure of Noise

Masuda Kyoko[1], Hatano Shigeko[2], Tanaka Toshimitsu[3], Hashimoto Takeo[2]

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In general, quiet environment is preferred for mental working. However, the realization of this atmosphere may be difficult when the machine generated noise under operation. The purpose of this study was to unveil the effect of sound quality on mental fatigue under long term exposure of noise. For this purpose, two kinds of subjective experiments were made. Subject works visual search tasks for 48 minutes with exposing a test sound, and judges about "Fatigue", "Discomfort", "Powerful", and "Booming" sensations with the 7 category scales in every sixth minutes. In the first test, as its test sound condition 4 kinds of machinery noise and "no-sound" were used. As a result, in cases of "no-sound" condition and "sound D" condition, subjective scores about fatigue are significantly lower than other conditions. In the second test, 8 kinds of test processed sounds based on "sound B" were used. They are weighted differently according to frequency and adjusted in the same loudness (15sone, 11sone. As a result, on both loudness levels, in case of using test sound under the low frequency decrement, subjective scores about fatigue are significantly lower than others. These results suggested that a direction of sound quality for restraining fatigue will be determined.

Monday 11:00-11:20, Hall Igls, Paper 0970 (invited)
Hygge Staffan
Acoustical conditions in the classroom I - Speech intelligibility and recall of spoken material heard at different signal-to-noise ratios

Hygge Staffan, Ljung Robert, Israelsson Karl
University of Gävle, Sweden

This study explored speech intelligibility and free recall of word lists heard under different signal-to-noise (S/N) ratios. Pre-experimental measures of working memory capacity (WMC) were taken to explore individual susceptibility to the disruptive effects of noise. The thirty-five participants first completed a WMC-operation span task in quiet and later listened to spoken word lists containing 11 one-syllable phonetically balanced words presented at four different S/N ratios (+12, +9, +6, and +3). Participants repeated (shadowed) each word aloud immediately after its presentation and performed a free recall task of the words after the end of the list. The speech intelligibility function decreased linearly with increasing S/N levels for both the high-WMC and low-WMC groups. Recall and memory of the words decreased with increasing S/N levels only for the low-WMC group. Recall and memory for the high-WMC individuals was not affected by increased S/N levels. Our results suggest that impoverished acoustical conditions impair speech intelligibility and memory, but also that a high WMC may counteract some of the negative effects of speech noise.

Monday 11:20-11:40, Hall Igls, Paper 0814 (contributed)
Alvarsson Jesper
The effect of aircraft noise on speech intelligibility at outdoor living spaces

Alvarsson Jesper, Nordström Henrik, Lundén Peter, Nilsson Mats E.
Department of Psychology, Stockholm University, Sweden

Aircraft noise reduces the potential for outdoor living spaces to provide rest and recreation. One adverse effect is interference with speech communication, including mobile phone conversations and radio listening. Previous research on how noise interferes with speech intelligibility has focused on indoor environments, such as class rooms, and it is unclear how well results from this research generalize to outdoor environments. To explore this, we reproduced first order ambisonic recordings of aircraft noise in a pergola located outdoors in an area with low background level (45-50 dB L_{Aeq}). Lists of phonetically balanced words (average level: 54 dB $L_{Amax,slow}$) were reproduced simultaneously with noise from aircraft over flights, ranging from 72 to 84 dB $L_{Amax,slow}$. Twenty young adult listeners, with normal hearing, were tested individually. They were seated in the pergola and were asked to write down each presented word. The results suggested that aircraft noise, at outdoor living spaces, impairs speech intelligibility at signal-to-noise ratios of 0 dB or less. Calculations of the speech signal's partial loudness, showed impaired intelligibility for loudness levels below 40 dB phon. These results apply to listeners with normal hearing and for speech intelligibility of single words in noise.

Monday 11:40-12:00, Hall Igls, Paper 0891 (contributed)
Rossi Laura
IPER index: quantification of influence of noise on human performance through physiological, operational and psychological parameters

Rossi Laura[1], Schiavi Alessandro[2]

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[2] INRiM, Department of Mechanics, Italy

The effect on human performance due to different kinds of noise (one stochastic noise and another carrying an informative content) is evaluated and compared to silent reference condition. The experiment involved 25 subjects (divided into two groups: age between 20 and 35 years and over 50). The influence of noise on the execution of a cognitive task (using the

Stroop effect) is quantified through the measurement of three parameters: • physiological (heart rate), • operational (response time) • and psychological (questionnaires). A specific index is modelled and here described: the IPER index (index of influence on performance), permitting a direct comparison between the results of subjects in a weighted combination of all the parameters taken into account. Differences between diverse kinds of noises are highlighted and the validity of IPER experimented.

Monday 12:00-12:20, Hall Igls, Paper 0972 (contributed)
Iwaya Yukio
Alert sound design considering musical-chord and frequency-sweep effects

Iwaya Yukio[1], Anbe Takuya[1], Cui Zhenglie[2], Suzuki Yôiti[2]
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Because of the huge tsunami created by the gigantic earthquake of March 11, 2011, Japan's Tohoku District sustained widespread and severe damage. Reportedly, alert speech sounds from open-air loudspeakers of governmental emergency radio communications systems were often not sufficiently intelligible because of the superposition of long-path echoes. A similarly huge tsunami is expected to occur about once every 1,000 years in this area, necessitating preparation for future tsunamis. Alert sounds are useful to convey specific alert signals using non-verbal sounds. Therefore, conditions to produce an alert sound that is tolerant to long-path echoes were investigated in this study, which examined musical chords for the design of alert sounds. To increase the saliency, we also applied an octave-up sweep from stationary chords. Subsequently, we investigated the influences of harmonic structure and sweeping characteristics so that an alert sound can have optimal alert impressions. The alert impression of the sounds, which consist of five tones and the fifth harmonic, was higher than those of single and second harmonic chords. That result indicates that open-air loudspeaker systems to convey alert information must have a sufficiently broad frequency range.

SS59 Effects on sleep - adults & children

Chair: Brink Mark

Monday 12:40-13:00, Hall Igls, Paper 1230 (invited)
Ristovska Gordana
Methodological approach in research on noise induced sleep disturbance in Central and Eastern Europe, South-East Europe and Newly Independent States

Ristovska Gordana[1], Lekaviciute Jurgita[2,3]

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[3] LG2I: Geovision Laboratory in Information and Intelligence, Switzerland

Background: environmental noise was recognized as a public health problem in many countries from Central and Eastern Europe (CEE), South-East Europe (SEE) and Newly Independent States (NIS). Aim of this paper is to analyze methodological approach used for assessment of noise induced sleep disturbance in population of CEE, SEE and NIS countries. Methods: we made a systematic search through accessible electronic databases, conference proceedings, PhD thesis, national reports and scientific journals in English and non-English language. We included six papers and one PhD thesis in this review. Results: sleep disturbance was assessed with questionnaire based surveys in five studies and in one study was assumed from dose–effect relationship between night-time noise indicator (L_{night}) for road traffic noise and sleep disturbance. The following confounding factors were considered: gender, age, socioeconomic status, noise sensitivity, neuroticism and time of residence. Findings comprised such sleep disorders as high or moderate level of sleep disturbance, difficulty falling asleep, time needed to fall asleep, night awakenings, sleeping with open windows, tiredness after sleep, use of sleeping pills and self evaluation of sleep quality. Conclusion: research work on noise induced sleep disturbance in these countries made significant contribution to the assessment of adverse effects of noise.

Monday 14:00-14:20, Hall Igls, Paper 0930 (invited)
Lercher Peter
The relation between disturbed sleep in children and traffic noise exposure in alpine valleys

Lercher Peter[1], Eisenmann Alex[1], Dekoninck Luc[2], Botteldooren Dick[2]
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Background: Epidemiological studies in children indicate that noise exposure can affect children's cognition, motivation and annoyance and may have small effects on blood pressure. Limited knowledge is available about effects on sleep and the prevalence in a typical community setting. Methods: Noise and survey information (N=1251) from schoolchildren (aged 8-11 years) was collected in alpine valleys of the Tyrol region. Sleep disturbance was obtained by three questions from children and equivalent questions from their mothers. A sleep score was used with multiple linear and logistic regression to provide exposure response curves and to assess the importance of contributing and modifying factors. Results: Prevalence of sleep disturbance is distinctly different when obtained from children and their mothers. Noise exposure indices were not significantly related to the sleep disturbance score. A strong relation was, however, observed between a noise disturbance/interference index and children reported sleep impairments but not with mother reported sleep assessments. Conclusion: In complex acoustic situations the accumulation of disturbing factors from traffic sources lying close together may lead to effects on sleep in children not sufficiently reflected by calculated or measured noise levels. Since children reported interference scores showed a strong relation with reported sleep problems, a soundscape and environmental health perspective can improve the assessment in children.

Monday 14:20-14:40, Hall Igls, Paper 1236 (invited)
Brink Mark
Sleep Disturbances from Transportation And Non-Transport Related Ambient Noise Events – A Comparison Of Exposure-Effect Relationships

Brink Mark, Omlin Sarah
D-MTEC Public and Organizational Health, Ergonomics & Environment, Switzerland

The last decade has seen a handful of laboratory and field studies that investigated sleep disturbances from transportation noise sources. Only very few studies looked at other than transportation-related sources and their potential to elicit reactions of the sleeper, as measured by self-reported sleep quality, signaled awak- enings, actigraphy or ambulatory polysomnography (PSG). In this paper, we will briefly review the avail- able evidence for effects of non-transportation noise related noise exposures on sleep on one hand, and on the other, present preliminary results from a polysomnographic pilot study about awakening effects of am- bient noises from the immediate neighborhood, like people talking, impulsive noise, noise from animals, or noises from weather events. The pilot study used acoustic and polysomnographic data that were collected in a study on awakening probability of nightly church bell noise. Noise events of different types were de- tected by an automatic algorithm and later identified by human listeners. The resulting exposure-effect relationships are compared with those obtained with transportation noise sources.

Monday 14:40-15:00, Hall Igls, Paper 1237 (contributed)
Smith Michael G.
Noise sensitivity impacts the evaluation of sleep due to vibration and noise from freight trains

Smith Michael G.[1,2], Croy Ilona[1], Hammar Oscar[1], Persson Waye Kerstin[1]

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Freight trains are expected to increase on the European railway network. Freight trains are particularly problematic with regards to generation of low frequency vibration and noise which has the potential to propagate to nearby homes and influence residents. Sleep is expected to be of critical importance from a health perspective. As part of the EU project Cargovibes, we have carried out three laboratory trials with a total of 59 young healthy persons (28 men and 31 women) over 350 person-nights to ascertain physiological and psychological reactions to nocturnal vibration and noise from freight traffic, and to examine differences between gender and noise sensitivity. Nights with low (0.0058 m/s^2) moderate (0.0102 m/s^2) and high (0.0204 m/s^2) maximum weighted vibration amplitudes and low (20), moderate (36) and high (52) number of train passages were simulated keeping the noise levels of the same order. Sleep was assessed using polysomnography and questionnaires. This paper focusses on the impacts of individual's noise sensitivity on the assessed sleep. Noise sensitive persons reported overall less sleep quality and had a lower amount of slow wave sleep, making them potentially vulnerable to nocturnal disturbances.

Monday 15:00-15:20, Hall Igls, Paper 0216 (contributed)
Evrard Anne-Sophie
Sleep effects of aircraft noise near Paris-Charles de Gaulle airport: results from the pilot study of the DEBATS research program

Evrard Anne-Sophie[1,2,3,7], Ribeiro Carlos[4], Khati Inès[1,2,3,7] Champelovier Patricia[5], Elbaz Maxime[6], Lambert Jacques[5], Léger Damien[6], Mietlicki Fanny[4], Sineau Matthieu[4], Laumon Bernard[7]

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DEBATS is an on-going research program aiming to characterize the relations between the aircraft noise exposure and the health status of French residents around three airports. In particular, this program includes a sleep study whose goal is to characterize specifically acute effects of aircraft noise on sleep quality using accurate noise exposure measurements. A pilot study was performed in 2011 in order to test and validate the protocol. Twelve individuals wore a wrist actiwatch for seven nights and completed a sleep diary in order to evaluate their sleep quality. An actiwatch allows detection of wrist movements and is useful for discriminating sleep from wake activity. It has been validated in the assessment of sleep indicators. Simultaneously, a sonometer located in the participants' bedroom recorded their noise exposure during these nights. A second sonometer set up outside (at the bedroom façade) allowed us to identify the aircraft noise and to evaluate the impact of this noise in the participants' bedroom. Thus, energetic as well as noise event indicators have been estimated and a link between these indicators and sleep quality has been investigated. The results of this pilot study are presented and discussed.

SS60 Cardiovascular and other somatic effects: adults & children

Chair: Matsui Toshihito, de Kluizenaar Yvonne

Monday 15:20-15:40, Hall Igls, Paper 0360 (invited)
Babisch Wolfgang
Road traffic noise, air pollution and (isolated systolic) hypertension.Cross-sectional results from the KORA study

Babisch Wolfgang[1], Wolf Kathrin[2], Petz Markus[3], Heinrich Joachim[4], Cyrys Josef[5], Peters Annette[2]

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Introduction: Cardiovascular studies on environmental noise exposure rarely considered air pollution as a covariate. Isolated systolic hypertension has not yet been in the focus of epidemiological noise studies. Methods: The association between road traffic noise and the prevalence of hypertension was assessed in 1,933 subjects aged 25-74 years living in Augsburg, Germany. Road traffic noise (weighted day-night average noise level L_{DN}) at the facade of the dwellings was derived from noise maps. Annual averages of $PM_{2.5}$ mass concentration at residential address was estimated by land-use regression method. Hypertension was assessed by blood pressure readings, self-reported doctor-diagnosed hypertension and antihypertensive drug intake. The results were adjusted for established confounders and in addition for $PM_{2.5}$. Results: The adjusted odds ratio (95% confidence interval) for hypertension was 1.16 (1.01-1.35) per increase of the noise level by 10 dB(A). After additional adjustment for $PM_{2.5}$ the effect estimate attenuated to 1.11 (0.95-1.30). For isolated systolic hypertension the effect estimates for noise were 1.48 (1.16-1.89) and 1.43 (1.10-1.86) after additional adjustment for $PM_{2.5}$. Conclusion: Road traffic noise was associated with a higher prevalence of hypertension, particularly, systolic hypertension. The noise effect was only marginally affected by $PM_{2.5}$, which may be due to different biological mechanisms.

Monday 15:40-16:00, Hall Igls, Paper 0526 (invited)
Foraster Maria
Disentangling the effects of traffic-related noise and air pollution on blood pressure: indoor noise levels and protections

Foraster Maria[1,2,3], Basagaña Xavier[1,2], Aguilera Inmaculada[1,2], Rivera Marcela[4], Agis David[1,2], Bouso Laura[1,2], Deltell Alexandre[5,6], Elosua Roberto[2,7], Künzli Nino[8,9]

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[4] University of Montreal Hospital Research Center (CRCHUM), Canada
[5] GREFEMA (Grup de Recerca en Enginyeria de Fluids, Energia i Medi Ambient), Spain
[6] University of Girona (UdG), Spain
[7] IMIM (Hospital del Mar Medical Research Institute), Spain
[8] Swiss Tropical and Public Health Institute, Switzerland
[9] University of Basel, Switzerland

Outdoor road traffic noise levels are associated with hypertension (HT). Studies on blood pressure (BP) are inconsistent and the true indoor traffic noise exposure may differ due to protections against noise. We analysed the effects of long-term exposure to outdoor and indoor traffic noise levels on HT, systolic (SBP) and diastolic BP (DBP, mmHg), adjusting for outdoor annual average concentrations of near-road traffic-related air pollution (nitrogen dioxide, NO_2) among 1926 participants (aged 36-82) from the Catalan REGICOR study. Long-term outdoor residential levels of traffic noise at night (L_{night}, in A-weighted dB) and annual averages of NO_2 (in $\mu g/m^3$) were estimated at the postal addresses' façades with a city-specific noise model and a land-use regression model, respectively. Indoor traffic noise was calculated from outdoor noise levels subtracting the attenuations in dB according to reported noise protections. Median noise levels were 56.7 dB outdoors and 27.1 dB indoors. Spearman correlations between outdoor and indoor noise with NO_2 were 0.75 and 0.23, respectively. Outdoor noise was only associated with HT (OR=1.19, 95%CI: 1.02, 1.40), whereas there was a suggestive association of indoor noise with both HT (OR=1.06, 95%CI: 0.99, 1.13) and SBP (ß=0.38, 95%CI: -0.08, 0.83) per 5 dB increase in outdoor noise levels. NO_2 was also associated with both outcomes after adjustment for indoor noise. Findings for indoor traffic noise levels are more plausible than those for outdoor traffic noise. The use of indoor traffic noise estimates help to disentangle the effects from those of traffic-related air pollution.

Monday 16:00-16:20, Hall Igls, Paper 0781 (invited)
Floud Sarah
Heart disease and stroke in relation to aircraft noise and road traffic noise – the HYENA study

Floud Sarah[1,2], Blangiardo Marta[1], Clark Charlotte[3], de Hoogh Kees[1], Babisch Wolfgang[4], Houthuijs Danny[5], Swart Wim[5], Pershagen Goran[6], Katsouyanni Klea[7], Velonakis Manolis[8], Vigna-Taglianti Federica[9], Cadum Ennio[10], Hansell Anna[1,11]

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Relatively few studies have examined relationships between noise and cardiovascular disease other than hypertension. Methods: Cross-sectional associations between self-reported ‘heart disease and stroke’ and road traffic and aircraft noise were examined using data from 4712 participants (276 cases) who lived near airports in six European countries collected as part of the Hypertension and Environmental Noise near Airports (HYENA) study. Data were available to assess potential confounding by NO_2 air pollution in three countries. Results: ‘Heart disease and stroke’ were associated with 24 hour average road traffic noise exposure (adjusted OR: 1.19 (95% CI 1.00, 1.41) per 10dB) in the six country analysis, but adjustment for NO_2 in the subsample suggested this may have been due to confounding by air pollution. An association with night-time average aircraft noise was found for participants who had lived in the same place for ≥ 20 years (OR: 1.25 (1.03, 1.51)); this did not appear to be confounded by air pollution. Statistical assessment (correlations and variance inflation factor) suggested a modest collinearity between noise and NO_2 exposures. Conclusions: Findings were consistent with the hypothesis that exposure to transport noise increases risks of heart disease and stroke. Future studies should consider confounding by air pollution.

Monday 16:20-16:40, Hall Igls, Paper 0953 (invited)
Argalášová-Sobotová Ľubica
Environmental noise annoyance and cardiovascular risk score in the Bratislava agglomeration at different time intervals

Argalášová-Sobotová Ľubica, Jurkovičová Jana, Ševčíková Ľudmila, Štefániková Zuzana
Institute of Hygiene, Faculty of Medicine, Comenius University, Bratislava, Slovakia

Background: The intensity of noise pollution is growing in Slovakia. The aim of the study is to follow the time trends of noise annoyance and cardiovascular risk in Bratislava agglomeration at time intervals of 10, 15, 20, 25 years. Methods: We used the validated methodology for the subjective assessment of annoyance and the objectification of noise levels. Ten year cardiovascular risk was quantified by the Relative risk SCORE chart according European Society of Cardiology in the year 2007 and 2012. Respondents were university students, representing a homogenous sample. Results: The continuous increase in traffic noise burden in the exposed area beyond the health risk zone was found. Subjectively, we observed a sharp increase of road traffic noise annoyance over 10 years (OR_{MH}=2.56 (95 % CI=1.93–3.42) in 1989 and 6.01 (95 % CI=4.97–7.95) in 1999) with slightly decreasing trend (OR_{MH}=3.31 (95 % CI=2.68–4.08) in 2013. Cardiovascular risk score according to the Relative risk SCORE chart was significantly higher in the exposed group (OR = 2.37, 95 % CI = 1.43–3.92) in 2009; in 2013 the risk was not significant (OR = 1.22, 95 % CI = 0.86–1.74). Conclusion: Our results showed decreasing trend of road traffic noise annoyance and cardiovascular risk explained by adjustment to road traffic noise, the other noise sources, or by the other confounding factors.

Monday 16:40-17:00, Hall Igls, Paper 0220 (invited)
Evrard Anne-Sophie
Cardiovascular effects of aircraft noise near Paris-Charles de Gaulle airport: results from the pilot study of the DEBATS research program

Evrard Anne-Sophie[1,2,3,5], Khati Inès[1,2,3,5], Champelovier Patricia[4], Lambert Jacques[4], Laumon Bernard[5]

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DEBATS is an on-going research program (2011-2018) involving adult residents around three French airports: Paris-Charles de Gaulle, Toulouse-Blagnac, and

Lyon Saint-Exupéry. It aims to characterize the relations between the aircraft noise exposure and the health status of the population living in the vicinity of these three airports, both physically and mentally but also regarding annoyance. In particular, it includes a longitudinal field study whose objective is to follow-up approximately 1,200 of the above-mentioned airports residents during four years. At inclusion phase and two and four years later, annoyance and health status (in terms of sleep disturbances, cardiovascular diseases, anxiety and depressive disorders) are assessed by a questionnaire carried out by an interviewer at the place of residence of the participants. Physiological variables like blood-pressure, heart rate or salivary cortisol are also considered within the frame of this study. A pilot study was performed in 2011 in order to test and validate the protocol on 100 residents around Paris-Charles de Gaulle airport. The results of this pilot study are presented and discussed. They concern self-reported doctor-diagnosed hypertension and measured blood-pressure.

Monday 17:00-17:20, Hall Igls, Paper 1149 (invited)
Vienneau Danielle
The relationship between traffic noise exposure and ischemic heart disease: a meta-analysis

Vienneau Danielle, Perez Laura, Schindler Christian, Probst-Hensch Nicole, Röösli Martin
Swiss Tropical and Public Health Institute, University of Basel, Switzerland

Since publication of the World Health Organization's report Burden of disease for environmental noise in 2011, several new studies on traffic noise and ischemic heart disease (IHD) have been published. There is thus a need for a meta-analytic update of risk estimates for these outcomes. We conducted a systematic review and retained published cohort and case-control studies using road, rail or aircraft noise as exposure. Study-specific results were transformed into risk estimates per 10dB using generalised least squares for trend estimation of summarised dose–response data. Subsequently a random effects meta-analysis was conducted. We identified 7 studies for IHD incidence and 4 for mortality. Per 10dB increase in noise, the risk estimate was 1.08 (95%CI: 1.03-1.14) for IHD incidence (total of 6,000 new cases). The risk estimate for IHD or myocardial infarction mortality accounting for a total of 22,000 deaths was 1.04 (0.98-1.09). Combined incidence and mortality risk for IHD was 1.05 (1.02-1.09). Preliminary results confirm an increase risk in IHD incidence with traffic noise exposure, and subgroup analyses suggest higher risk for MI compared to all IHD combined, for males compared to females,

for road traffic noise compared to aircraft noise and for studies without air pollution adjustment compared to those with adjustment. Future analysis will address the form of the exposure-response curve before the risk estimates will be used in an assessment of the external health costs of traffic in the Swiss population.

Monday 17:20-17:40, Hall Igls, Paper 0159 (invited)
Heinonen-Guzejev Marja
Noise sensitivity and multiple chemical sensitivity – similarities and differences

Heinonen-Guzejev Marja[1], Koskenvuo Markku[1], Mussalo-Rauhamaa Helena[1], Vuorinen Heikki S.[1], Heikkilä Kauko[1], Kaprio Jaakko[1,2,3]

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Noise sensitivity increases the degree of reactivity to noise. It may be a part of a more generic sensitivity to environmental stimuli. Multiple chemical sensitivity (MCS) encompasses a wide range of subjective symptoms provoked by exposure to low levels of chemicals. It has to some extent been accompanied by noise sensitivity indicating a moderate correspondence between them. This narrative review will evaluate the similarities and differences in the characteristics, mechanisms and genetic predisposition of noise sensitivity and MCS. Noise sensitivity is a more common trait than MCS. Most patients with MCS have been women while noise sensitivity has been equally present in men and women. Weinstein's Noise Sensitivity Scale and QEESI's Chemical Intolerance Subscale differentiate noise sensitivity and MCS as different entities. Overlaps have been found in the characteristics of persons reporting chemical and noise sensitivities. For MCS a large number of mechanisms have been presented, while there are only a few studies on the mechanism of noise sensitivity. To evaluate the similarities and differences in their mechanisms more studies are needed. The genetic predisposition for MCS and noise sensitivity should be studied further to see whether there is a shared genetic predisposition. Further studies are needed to investigate whether noise sensitivity and MCS are a part of the general environmental sensitivity.

Monday 17:40-18:00, Hall Igls, Paper 0707 (contributed)
Paunović Katarina
Hemodynamic and blood pressure changes provoked by recorded traffic noise in normotensive men

Paunović Katarina[1], Stojanov Vesna[2], Jakovljević Branko[1], Belojević Goran[1]

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Background: The aim of this experimental study was to assess changes in blood pressure and hemodynamic parameters provoked by recorded traffic noise in normotensive men. Methods: The study included 38 men, aged 24.8±2.6 years. Blood pressure and hemodynamic parameters were monitored with thoracic electrical bioimpedance device. Participants were exposed to recorded road-traffic noise (Leq=89 dBA) for 10 minutes and rested in quiet conditions (Leq=40 dBA) before and after noise. The differences between settings were tested with Wilcoxon signed ranks test. Results: Noise exposure provoked significant changes in the following hemodynamic parameters: decrease of pumped blood volume [Systolic Index (ml/m^2), SI_quiet_start =54.22±11.76, SI_noise =53.19±10.95; $p<0.05$], decrease of global heart flow [Cardiac Index (l/(min*m^2), CI_quiet_start =3.65±0.75, CI_noise =3.56±0.74; $p<0.01$], and increase of vascular resistance [total peripheral resistance index (dyne*s*m^2/cm^5), TPRI_quiet_start =1963.85±494.15, TPRI_noise =2063.00±505.84; $p<0.001$]. These hemodynamic changes lead to the increase of systolic blood pressure [(mmHg), SBP_quiet_start =118.91±12.04, SBP_noise =122.55±10.20; $p<0.001$] and diastolic blood pressure [(mmHg), DBP_quiet_start =73.24±9.42, DBP_noise =75.62±8.41; $p<0.001$]. A significant decrease of systolic and diastolic pressure was observed after noise exposure. Conclusion: Experimental exposure to recorded traffic noise provoked significant hemodynamic changes in normotensive men that might have lead to the increase of blood pressure during noise exposure.

SS44 Vibroacoustics and Vibrations

Chair: Conlon Stephen C., Buchschmid Martin, Kolbe Frank

Monday 08:20-08:40, Hall Maximilian, Paper 0386 (invited)
Hambric Stephen A.
Vibro-acoustic measurements and simulations of a rib-framed honeycomb core sandwich panel

Hambric Stephen A.[1], Shepherd Micah[1], May Carl[2], Snider Royce[2]
[1] ARL/Penn State, USA, [2] Bell Helicopter, Textron Inc., USA

Modes of resonance, mobilities, radiated sound, and sound power transmission loss have been measured and simulated for a rib-framed honeycomb core sandwich panel with carbon-fiber face sheets. The measured modal wavenumbers and resonance frequencies are used to confirm analytic estimates of the effective flexural sound speeds in the panel. The flexural wavespeeds are strongly affected by the honeycomb core shear properties, and become supersonic at about 700 Hz. The mode shapes of the panel section between the frames resemble those of simply supported plates. Numerical simulations of resonance frequencies made with a Finite Element (FE) model match measurements within 10%. The numerically extracted modes are used to compute point and surface averaged mobilities, which compare very well with those measured on the physical structure, and to infinite panel analytic calculations. The FE mobilities are then combined with an acoustic boundary element (BE) model to calculate radiated sound transfer functions which are further used to compute a virtual sound power transmission loss for acoustic diffuse field loading. The virtual transmission loss (VTL) calculations are within 3 dB of measurements made of the physical panel in NASA's Structural Acoustic Loads and Transmission (SALT) facility.

Monday 08:40-09:00, Hall Maximilian, Paper 0710 (contributed)
Kohrmann Mathias
Numerical models for the prediction of vibro-acoustical characteristics of light-weighted ceilings

Kohrmann Mathias[1], Buchschmid Martin[1], Müller Gerhard[1], Völtl Raphael[2], Schanda Ulrich[2]
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In order to set up guidelines for the design of light-weighted ceilings for timber constructions to be used by engineers in practice, investigations based

on both measurements and numerical models have been carried out within the cooperative research project “VibWood”. In this contribution the setup and the calibration of the numerical model of the structure as well as the prediction of radiated sound are discussed, where a special focus is set on a dimensionless description in order to deduce information for a wide range of system’s specifications. The structure, consisting of a timber slab, a floating floor and a suspended ceiling, is built up in a Finite Element model, where the material properties of wood and the characteristics of the system (e.g. support conditions, contact phenomena dynamic properties of individual parts) are considered. The model is parameterized in order to enable computations with varying geometry and material parameters. After calibrating the FE-model with the help of measurements using model updating techniques dimensionless parameters are defined based on the Buckingham-π-Theorem and computations are carried out in order to specify guidelines for various systems. The radiation of sound is computed in a post processing using Integral Transform Methods.

Monday 09:00-09:20, Hall Maximilian, Paper 0061 (contributed)
Bai Mingsian R.
Modeling, identification, and parameter optimization of a curved PVDF loudspeaker

Bai Mingsian R., Lo Yi-Yang, Chang Yu-Ming
Department of Power Mechanical Engineering, National Tsing Hua University, Taiwan

In this work, a polyvinylidene fluoride (PVDF) loudspeaker is developed for mobile devices, where thickness and efficiency is of chief concern. The membrane is slightly curved to convert in-plane strains to transverse motions. To facilitate the design optimization, a simulation platform is established by using a hybrid analogous circuit. While the circuit is primarily lumped-parameter in nature, the mechanical impedance is derived from finite-element analysis. This enables the prediction of the high order modes of the loudspeaker. Simulation result indicates that a reduced radius of curvature leads to increased sound pressure level and a higher resonance frequency. To identify the lumped parameters, a special procedure is developed. Based on the measurement of electrical impedance, the electrical capacitance is estimated. Mechanical parameters and coupling factor are identified from the measurement of diaphragm velocity with a laser vibrometer inside a vacuum chamber. To optimize the design parameters of the loudspeaker, the simulated annealing (SA) algorithm is used under practical constraints. The results have shown that, with the optimal configuration, the sound pressure

level is increased by 15 dB and the resonance frequency is increased by 700 Hz, as compared with a non-optimal design.

Monday 09:20-09:40, Hall Maximilian, Paper 0827 (contributed)
Scherrer Roch
Analysis of the sound radiated by a heavy fluid loaded structure excited by an impulsive force

Scherrer Roch[1,2], Maxit Laurent[1], Guyader Jean-Louis[1], Audoly Christian[2], Bertinier Michel[3]
[1] LVA, INSA de Lyon, France, [2] DCNS Research, France, [3] DGA TN, France

The aim of this work consists in evaluating and analyzing vibrations and radiated pressure from a fluid loaded structure excited by a transient mechanical source. The time signature can be estimated from a discrete inverse Fourier transform of the Frequency Response Functions (FRF) of the considered system. In order to validate the numerical process, a simple structure composed of an infinite flat plate excited by an impulse point force is considered. Results are compared with an analytic result for the in-vacuo plate. When the plate is immerged on one side, the vibrations and radiated pressure from the plate are evaluated with the developed numerical process. Then, one studies the effect of the fluid loading and the dispersive nature of the flexural waves on the vibrations, and radiated pressure time signature in the far field of the plate. A comparison between Khirchoff-Love and Mindlin Timoshenko plate is also made.

Monday 09:40-10:00, Hall Maximilian, Paper 0847 (contributed)
Werner Kauê
Acoustic radiation by means of an acoustic dynamic stiffness matrix in spherical coordinates

Werner Kauê, Cordioli Júlio A.
Department of Mechanical Engineering, Federal University of Santa Catarina, Brazil

In general, numerical methods used to obtain the acoustic radiation of vibrating structures through a fully coupled analysis display large computational costs, especially when the frequency range of interest involves several wavelengths. The Boundary Element Method (BEM) and the Finite Element Method (FEM) are examples of such methods and are therefore limited to the analysis at low frequencies. An alternative approach is given by the Rayleigh Integral and the calculation of an

acoustic dynamic stiffness matrix (ASDM). However, in its classical form such approach is restricted to planar structures. The purpose of this work is to extend the approach based on the acoustic dynamic stiffness matrix to include spherical geometries, so that complex structures that are "sphere-like" can be analyzed. The surface displacement of the sphere is expressed in terms of pistons, centered at nodes of a uniform mesh. Two validation cases are presented in the work, including the radiated power of a breathing sphere (monopole) compared with its analytical solution; and the radiated power of a dipole, compared with a FEM-BEM coupled model and the analytical solution. An average simulation time comparison between the FEM-BEM and the matrix method is also presented.

Monday 10:00-10:20, Hall Maximilian, Paper 0890 (invited)
Conlon Stephen C.
Vibroacoustic response of complex equipment loaded panels

Conlon Stephen C.
Penn State Applied Research Laboratory, USA

Aerospace system structures are by necessity stiffness to weight optimized, which often results in efficient coupling to their intense external acoustic environments. For many aerospace, as well as other vehicle structures, a lightweight primary or master structure is loaded with equipment or substructures. The effects of these attachments on the master structure's structural-acoustic coupling (radiation and response) are critical for assessing the system's acoustically induced responses. However, these attachment effects are often poorly understood and also are difficult to deterministically model and predict. In this work the radiation coupling and efficiency of a class of lightweight aerospace panel (aluminum sandwich honeycomb core panel) with and without complex (electronic equipment) attachments are investigated using Power Injection (PI) experimental techniques. The panel's radiation efficiencies are explored and trended for various mechanical boundary conditions, acoustical boundary conditions, and complex equipment loading configurations. The results for the unloaded panels correlate well with theory for the edges free vs. supported and acoustically baffled vs. un-baffled. A range of complex attachment configurations, for attachment to panel mass ratios up to seven-to-one, are also evaluated and general predictive design assessment procedures developed for use by designers and noise/vibration control engineers.

Monday 11:00-11:20, Hall Maximilian, Paper 0957 (contributed)
Hufenbach Werner A.
Experimental study on the vibro-acoustic properties of fibre-reinforced composites with integrated viscoelastic Ethylene-Propylene-Dien-Monomer (EPDM) rubber

Hufenbach Werner A.[1], Dannemann Martin[1], Friebe Stefan[1], Kolbe Frank[1], Täger Olaf[2]

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[2] Volkswagen AG, Konzernforschung K-EFW/K, Germany

Composite materials offer for automotive applications the specific advantage of low constructive weight in combination with a high stiffness. For vibro-acoustic applications, especially the low structural weight leads to higher vibration amplitudes due to low forces of inertia and causes undesired sound radiation. A useful approach to eliminate these drawbacks and increase the structural damping without adding too much additional weight to the construction is the integration of viscoelastic damping layers in the composite materials during the manufacturing process. In the presented experimental study, different types of viscoelastic Ethylene-Propylene-Dien-Monomer (EPDM) rubber sheets are integrated in the mid-plane of a reference laminate made from carbon textile-reinforced epoxy. The vibro-acoustic properties of the fibre-reinforced multilayered composites – absorption coefficient, sound reduction index, dynamic stiffness and material damping – were measured and compared. As expected, the integration of EPDM sheets in the composite leads to higher material loss factors. To identify the vibro-acoustically optimal position of the EPDM layer within the composite lay-up special simulation methods suitable for composite materials have to be used.

Monday 11:20-11:40, Hall Maximilian, Paper 0711 (contributed)
Barsotti Riccardo
A model for the stick-slip motion of slender structures subjected to axial loads and coulombian frictional constraints

Barsotti Riccardo, Bennati Stefano, Quattrone Flavio
Department of Civil and Industrial Engineering, University of Pisa, Italy

A number of slender beam-like structures subjected to axial load and frictional constraints (for example, undercarriage legs, digging buckets, blades of turbines, brushes and wiper systems) exhibits a complex dynamic behavior. The main components of these systems are often constrained to slide on a surface with friction. Here we present a

dynamical model where a flexible beam is spring-hinged at one end, while the opposite end can slide with coulombian friction on a rigid surface moving with prescribed velocity. The beam is subjected to a concentrated compressive load at the top end. The equations of motion are solved analytically as a combination of free-modes shapes and elastically deformed axis' line shapes. Once refined, the proposed model could constitute a design tool useful in many of the above-described applicative contexts. One of the first results is that the frequency of the alternation between the stick and the slip phase may be sensibly different from the natural frequencies of the system.

Monday 11:40-12:00, Hall Maximilian, Paper 0241 (invited)
Ma Guancong
Doubly negative acoustic metamaterial with coupled membrane resonator

Ma Guancong[1], Yang Min[1], Yang Zhiyu[1], Sheng Ping[1,2]

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We demonstrate that a single resonating unit can exhibit simultaneously negative effective mass density and effective bulk modulus. The metamaterial has a symmetric design: it comprises two decorated elastic membranes mounted on two ends of a hollow cylindrical tube. The two membranes are then connected by a rigid ring, forming a single resonating cell. Impedance measurements show that this system's transport property is governed by three eigenmodes in the sub-kilo hertz regime. Displacements profiles obtained with a laser vibrometer reveal that these eigenmodes are dipolar and monopolar in their symmetry, respectively. Homogenization is performed to extract the effective parameters. Double negativity is confirmed. The results also shed light on the special transport behavior of the metamaterial. Excellent agreement between experiment and theory is achieved.

Monday 12:00-12:20, Hall Maximilian, Paper 0013 (contributed)
Yang Cheng
A note on the coupling mechanism of Micro-perforated Panel Absorber

Yang Cheng, Cheng Li
Department of Mechanical Engineering, The Hong Kong Polytechnic University, China

Extensive research was found in the literature regarding to the topic of Micro-perforated Panel Absorber (MPA). However, these works mainly focused on examining the performance of this device. As a result, the coupling mechanism of the MPA system is less highlighted. Conventionally, MPA was recognized as a local reactive sound absorption material, that its property is spatially independent over the panel surface. But in fact, a Micro-perforated Panel (MPP) with the backing cavity forms a coupling system and its absorption capability is determined by the coupling between the MPP and the backing cavity modes. Depending on the type of the cavity modes that dominate in the coupling, the MPA may be either local reactive or not. For the latter case, the horizontal modes dominate in the coupling and the non-local reactive property of the MPA varies with respect to the dimension of the MPP. This usually results local absorption performance variation, leading to global performance degradation. As a solution, it is suggested to use partitioned backing cavities so that the original non-local reactive absorption material becomes local reactive. If the partitioned backing cavities with different depths are used, it is possible to further enhance absorption performance of MPA.

Monday 12:20-12:40, Hall Maximilian, Paper 0418 (contributed)
Kawamura Tomohiro
Improvement of bicycle ride comfort using dynamic vibration absorber

Kawamura Tomohiro, Yoshida Junji
Osaka Institute of Technology, Japan

Bicycle is a popular vehicle by the low price and the easy maintenance in comparison with car and motorcycle. In order to expand the popularity of the bicycle, improvement of the ride comfort is essential. Specifying which part and frequency band affects the ride comfort and reduction of the vibration of the part are important to improve it. In this study, we investigated them through subjective evaluation test and vibration analysis, and we tried to reduce the vibration. Through the subjective evaluation test, the seat vibration less than 40 Hz was found to have large influence on the ride comfort. Subsequently, we considered applying a dynamic vibration absorber to reduce the low frequency vibration using existing parts not to increase total weight and cost. Then, we chose rear carrier and used it as dynamic vibration absorber, and modified the structure to meet the resonance frequency with a frequency where the seat vibration was large at running condition. As a result, the seat vibration was reduced, and the ride comfort was improved.

Monday 12:40-13:00, Hall Maximilian, Paper 0003 (contributed)
Vinokur Roman
Correct sign for imaginary part in the complex modulus of elasticity

Vinokur Roman
ResMed Motor Technologies, USA

The complex modulus of elasticity can be defined as E* = E (1 + i η) or E* = E (1 - i η) where E is the actual modulus of elasticity and η is the loss factor. The first form (with the positive imaginary part) is utilized in ANSI S2.9-1976 standard “Nomenclature for Specifying Damping Properties of Materials”. To many practical specialists, the complex modulus of elasticity represents just a symbolic relationship. But the engineering theorists use it to simulate the stiffness, speed of sound, and wavenumber in the equations where sound and vibration energy dissipation is introduced via the loss factor. As demonstrated here, (1) the complex modulus with the positive imaginary part is applicable only with the time-oscillating factor exp (i ω t), (2) if the time-oscillating factor is expressed in the form exp (- i ω t), the complex modulus of elasticity must be defined as E* = E (1 - i η), that is, with the negative imaginary part. This important conclusion may not have been clearly explained in the existing literature. Two simple examples are considered for illustration: (1) vibration of 1-DOF mechanical model, (2) sound propagation in a semi-infinite thin rod.

Monday 14:00-14:20, Hall Maximilian, Paper 0417 (contributed)
Kawakami Yasuhiro
Vibration reduction of drum type washing machine using dynamic damper

Kawakami Yasuhiro, Yoshida Junji
Osaka Institute of Technology, Japan

Drum type washing machine is high performance washing machine by the higher detergency and less water comparing with the other type. However, drum type washing machine occasionally generates large vibration at spin drying. In this study, we investigated the vibration characteristic to reduce it. Through vibration measurement of the drum at spin drying, the vibration displacements were found to be large along horizontal axis at 150 rpm and along vertical axis at 300 rpm. Subsequently, applying dynamic damper was considered to reduce the vibration efficiently in each axis at each rotational speed. For applying the damper, we calculated a vibration displacement in each rotational speed at both axes using basic vibration theory. Suitable characteristics of the dynamic damper such as spring rate were obtained using

the calculated model to reduce the large vibration at spin drying. Then, a dynamic damper was made according to these characteristics and the damper was attached to the machine. As a result, the drum vibration displacement along horizontal axis at 150 rpm and the displacement along vertical axis at 300 rpm could be reduced by the dynamic damper.

Monday 14:20-14:40, Hall Maximilian, Paper 1221 (contributed)
Sharma Gyanishankar
Improved barrier design through lumped mass addition

Sharma Gyanishankar, Sarkar Abhijit, Ganesan N.
Machine Design Section, Dep. of Mechanical Engineering, Indian Institute of Technology, India

The objective of present work is to improve the transmission loss of a barrier separating two acoustic spaces and subjected to low frequency harmonic excitation. A novel concept of achieving this is proposed through addition of point mass at the optimal location over the barrier surface. This allows for a local control of the radiated noise at the target location through the directivity pattern. Analytical expressions to find the structural response to the normally incident acoustic excitation on the planar barrier is derived and validated by a finite element simulation. Rayleigh integral is then used to calculate the sound pressure. The complete procedure is non-dimensionalized for generalization. The optimal location of mass to minimize sound radiation at a receiver location is obtained using numerical optimization. Point mass attachment at the optimal location results in major sound pressure reduction at the target location which is much more than those obtained by uniform distribution of mass over the plate. The total energy radiated over the entire transmission region is also reduced. However, the reduction in total transmitted energy is smaller than the reduction achieved at the specific target location. Passive techniques to improve the transmission loss of a barrier in global sense works well for high frequency whereas, active techniques spans the low frequency range. But active control methods are costly and difficult to implement and hence local control in the transmitted sound using passive techniques could be an alternative.

Monday 14:40-15:00, Hall Maximilian, Paper 0843 (invited)
Zhang Hua
Effectiveness Comparison of Damping and Dynamic Vibration Absorber Treatments in Lightweight Structures

Zhang Hua, Du Yu
School of Automotive Engineering, Dalian University of Technology, China

Viscoelastic damping materials and dynamic vibration absorbers (DVAs) have been extensively used for structural vibration and noise control. It is inevitable for either approach to add additional masses to the original structure. Although it has been a common practice to minimize the added mass through optimization processes, there are few studies directly comparing the performance of viscoelastic and DVA treatments in terms of their mass addition effects. In this paper, analytical models are developed to calculate the vibration levels of beam structures with the inclusion of viscoelastic materials or multiple DVAs. The vibration reduction performance of viscoelastic materials depends highly on the material properties as well as the actual implementation methods, which makes it difficult to be optimized by common approaches in practice. On the other hand, DVA parameters are well defined and usually more straightforward to be designed. Both theoretical model predictions and experimental data show that, with the same vibration and noise reduction performance, the DVA approach typically leads to less mass addition in comparison to the viscoelastic treatment, especially at low-mid frequencies. The findings of the current study are informative for noise and vibration control of weight-sensitive structures such as vehicle bodies of lightweight design.

Monday 15:00-15:20, Hall Maximilian, Paper 0429 (contributed)
Robin Xavier
Vibro-acoustic simulation of automotive turbochargers using a finite and infinite element technique

Robin Xavier[1], Driot Nicolas[2], Jacqmot Jonathan[1]
[1] Free Field Technologies, Belgium, [2] BorgWarner Turbo Systems, Germany

Noise generation in turbochargers becomes an important source of inconvenience in modern vehicle. Noise sources are now well known but they are complex because of their multiplicity and the physics involved. This noise is mostly studied experimentally but this paper presents an innovative simulation strategy to study one of the major components of the turbocharger

noise: the structure borne noise. First of all, the methodology based on a multi-disciplinary approach is presented. The dynamic behavior is assessed using a modal analysis technique. The turbocharger is excited through the supports of the rotor bearings. In a second step, an acoustic finite element model considers the vibration of the structure as a boundary condition to radiate acoustic energy in the surrounding air. The paper focuses on the results of the acoustic radiation all around the turbocharger. A first analysis shows that the acoustic radiation is led by the modes of the structure. Nevertheless, not only the level of vibration is important but also the shape of the modes must be taken into account. This is an important conclusion in the frame of the understanding of the acoustic behavior. The effect of the excitation itself on the acoustic radiation is also considered.

Monday 15:40-16:00, Hall Maximilian, Paper 1086 (contributed)
Matsumoto Yasunao
Evaluation of human perception thresholds of transient vibrations by standardised methods

Matsumoto Yasunao[1], Kunimatsu Sunao[2]

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In the assessment of vibration in residential environments, human perception of vibration is an important factor, as stated in, for example, ISO 2631-2. For the evaluation of the effect of vibration on people in residential environments, there have been different standardised evaluation methods defined in the current international and national standards. This paper describes an investigation of the applicability of those current standardised evaluation methods to the determination of vibration perception thresholds measured in a laboratory experiment involving human subjects. The characteristics of input vibration used in the experiment were determined based on field vibration records obtained in Japanese single-family houses with vibration sources outside of them. Some principal current standardised evaluation methods were applied to determine the perception thresholds of those input vibrations with different time and frequency characteristics. An evaluation method developed from the results of previous investigation was applied also to determine the thresholds. The effects of frequency weighting and integration methods for running averaging were discussed.

Monday 16:00-16:20, Hall Maximilian, Paper 0142 (contributed)
Shi Xianjie
Three-Dimensional Vibration Analysis of Annular Sector Plates with Arbitrary Thicknesses and Boundary Conditions

Shi Xianjie[1], Kong Lingcheng[1], Shi Dongyan[1], Li Wen L.[2]

[1] College of Mechanical and Electrical Engineering, Harbin Engineering University, China
[2] Department of Mechanical Engineering, Wayne State University, USA

Vibration analysis of annular sector plates is of importance to many engineering applications. However, three-dimensional vibration analysis of annular sector plates with arbitrary boundary conditions is rarely attempted in the literature. In this investigation, an analytical Fourier series solution method is developed for the three-dimensional vibration analysis of annular sector plates with arbitrary boundary conditions. Under this solution framework, all the classical homogeneous boundary conditions can be universally considered as the special cases when the stiffness for each of restraining springs is set equal to either zero or infinity. The displacement fields are invariably expressed as an improved trigonometric series which converges uniformly and polynomially over the entire solution domain. All the unknown expansion coefficients are treated as the generalized coordinates and solved using the Rayleigh-Ritz technique. The present solution method can be generally applied to a broad range of annular sector plates, regardless of their thicknesses and sector angles. Numerical examples are presented to verify the accuracy and reliability of the current method.

Monday 16:20-16:40, Hall Maximilian, Paper 0330 (contributed)
Zhou Pan
Multi-input identification using adaptive delayed inverse model in time domain

Zhou Pan, Li Wan-you, Zhang Quan, Shuai Zhi-jun
College of Power and Energy Engineering, Harbin Engineering University Harbin, China

In this paper, a new method is presented for estimation of real time forces acting on non-collocated system. This identification method is based on inverse model of mechanical structure which is established adaptively based on white noise forces applied to the system and resulting acceleration responses. The inverse system represented by adaptive filter (finite impulse response filter) is adopted to model the vibrational inverse characteristics of mechanical structure and is obtained through adaptive

algorithm rather than matrix inversion for avoiding the ill-conditioned problem. Hence, opposite to traditional numerical structural model, this model treat operational dynamic acceleration as the input while the force estimation as the output. In addition, time delay is introduced in the process of inverse modeling in order to obtain the stable inverse model of non-collocated system. This method is applied to reconstruct the time histories of multiple input forces simultaneously acting on a multi-mounts suspension system. The effectiveness of the present method is verified both for reconstruction of stationary forces and transient forces.

Monday 16:40-17:00, Hall Maximilian, Paper 0202 (invited)
Žíaran Stanislav
Low frequency vibration and noise generated by seismic sources and their effects on surroundings

Žíaran Stanislav
Faculty of Mechanical Engineering, Slovak University of Technology in Bratislava, Slovakia

This paper presents some sources of induced seismicity which generate low frequency mechanical and acoustic vibration transmitted through the soil in the ground and through the air on to buildings, industrial structures, machinery and their surroundings, which include human beings. Some sources, as a result of human activity, for strong low frequency vibration and their subsequent seismic waves were investigated and analyzed. These types of vibrations and noise are responsible for the damage of structures, machinery and are an annoyance during relaxation, sleep and mental work, which may reflect negatively on the comfort and health of the population, and the mental state of people. Measurements were made for different deterministic sources and their operating conditions: for example, high power sawmills and an unbalanced rotating component of a dust separators. For detection of the low frequency vibration, the acceleration vibration was measured and the fast Fourier transform (FFT) analysis was used. From the FFT analysis the reasons of the strong low frequency vibration were detected and corresponding measures were designed to reduce this vibration. Low frequency vibration and noise sources are specified, and the direct effects on the structure and surrounding (include people) are investigated as well. The results of the frequency analysis, and the consequent measures shows the most effective way to reduce very strong energy of low frequency loading.

Monday 17:00-17:20, Hall Maximilian, Paper 0248 (contributed)
Wang Gang
Vibration analysis of conical shells by using a new form of differential quadrature method

Wang Gang[1], Li Wen L.[2], Li Wan-You[1], Du Jingtao[1]

[1] College of Power and Energy Engineering, Harbin Engineering University, China
[2] Department of Mechanical Engineering, Wayne State University, Detroit, USA

Conical shell structures are widely encountered in various engineering fields, and their dynamic behaviors are of interest to design and application engineers. Differential Quadrature (DQ) method is a promising tool for solving various structural vibration problems. In this paper, a new DQ algorithm is proposed based on an improved Fourier series with accelerated convergence. The proposed DQ method is subsequently used to study the vibrations of conical shells. The present DQ method is validated by the conventional DQ solutions.

Monday 17:20-17:40, Hall Maximilian, Paper 0326 (contributed)
Lv Binglin
Free Lateral Vibration Analysis of Shafting Considering Gyroscopic Effect using Fourier Spectral method

Lv Binglin[1], Li Wan-You[1], Ouyang Huajiang[2]

[1] College of Power and Energy Engineering, Harbin Engineering University, China
[2] Department of Engineering, University of Liverpool, UK

In this paper, the Fourier Spectral Method (FSM) is employed for vibration analysis of shafting considering the gyroscopic effect. The FSM is an analytical approach with excellent convergence and accuracy. Compared with conventional Fourier series applied to structural dynamic problems, several supplemental terms are added to remove the discontinuities due to the particular form of the series used at the elastic boundary in the FSM. The shaft is modeled as a Rayleigh beam considering rotatory inertia and gyroscopic effects. Based on the Fourier Spectral Element method and an energy method, the numerical model of a shaft system with flexible bearings represented as simple linear springs is established. The mass, stiffness and gyroscopic matrices are derived for a single shaft firstly. Lumped masses can also be included. Then a system of connected shafts is studied. Several numerical examples are given in the end to show the validity of the present method by comparing with results from the literature.

Monday 17:40-18:00, Hall Maximilian, Paper 0297 (contributed)
Park Jewoo
Floor vibration evaluation of lightweight steel frame floor for different design factors and measuring methods

Park Jewoo[1], Kim Hongjin[1], Hwang Jaeseung[3], Choi Sunyoung[2], Park Seongcheol[3], Choi Junseong[3]
[1] Kyungpook National University, Korea, [2] Posco E&C, Korea, [3] Chonnam National University, Korea

Since the natural frequency and damping ratio of the light weight steel floor are lower than those of the reinforced concrete floor, the floor vibration due to a dynamic load is significant and the serviceability issue becomes more critical. In this paper, the floor vibration performance of the light weight steel floor is evaluated for different design factors. The impact loading test and walking test were performed on the floor specimen built with different design factors. The acceleration data obtained from tests were analyzed to obtain the natural frequency and damping ratio of the specimen, and the effect of design factors on the floor stiffness and vibration are evaluated. Further, the effect of variables of walking test method on the floor vibration performance is also evaluated. The floor vibration performance is evaluated using AISC design guide and AIJ design guide. The results indicate that the connection between the upper and lower beams due to wall construction increases the stiffness and the natural frequency of the entire floor and thereby improves the floor vibration performance. However, the installation of floor heating system and furniture do not effect on the floor vibration performance considerably.

SS69 Soundscape and Human Resources

Chair: Schulte-Fortkamp Brigitte, Kang Jian

Monday 08:20-08:40, Hall New Orleans, Paper 1170 (invited)
Botteldooren Dick
How appraisal and meaning may affect the soundscape approach

Botteldooren Dick
Acoustics group, Department of Information Technology, Ghent University, Belgium

The soundscape approach focuses at least as strongly on the person as on the sonic environment while addressing assessment and design. It is thus worthwhile to unravel the relationship between the place and the soundscape by studying the processes that occur in the human mind. In previous work, the role of auditory scene analysis and attention focusing has been explored. In this contribution we focus on how the attended auditory streams together with a variety of context and personal factors affect the appraisal of the sonic environment. In this paper we analyze the available knowledge in various different disciplines ranging from the early work on appraisal and coping in psychology to recent neurological evidence and interpret it in the context of environmental sound experiences. This allows us to understand more clearly to what extend the meaning given to sound events and sound sources dominates the expected holistic appraisal. The importance of prior experience and familiarity with the sound and its source becomes clear. Several observations commonly made by soundscape researchers such as the role of expectations can be explained in terms of the many feedback loops that occur in the appraisal process.

Monday 08:40-09:00, Hall New Orleans, Paper 1192 (invited)
Steele Daniel
How do urban planners conceptualize and contextualize soundscape in their everyday work?

Steele Daniel[1,2], Guastavino Catherine[1]

[1] McGill School of Information Studies (SIS) and Centre for Interdisciplinary Studies in Music Media and Technology (CIRMMT), Canada, [2] INCAS3, The Netherlands

Previous studies have established that soundscape concerns constitute a low but significant priority for urban designers and planners, and that the way they conceive of acoustical concepts is different from soundscape

researchers. The gap in discourse between planners and researchers has prevented the achievement of the best possible outcomes for soundscape. In May 2013, 3 public-sector urban planners were interviewed to investigate how planners consider soundscape in their decisions and evaluate the success of an intervention. Open-ended questions addressed abstract soundscape conceptualizations and contextualized them with 2 specific interventions, from past and future work, to ground the responses in concrete settings and expectations. Using the constant comparison method of grounded theory, we identified planners': conceptualization(s) of soundscape, perceived agency for change, agency to obtain expertise, and evaluation practices. Our findings will inform the production of educational materials for urban planners to help them identify and achieve better soundscape outcomes in their native discourse.

Monday 09:00-09:20, Hall New Orleans, Paper 1233 (invited)
Yang Ming
Automatic identification of environmental sounds in soundscape

Yang Ming[1], Kang Jian[1,2]

[1] School of Architecture, University of Sheffield, Western Bank, UK
[2] School of Architecture, Harbin Institute of Technology, China

Since perception and evaluation of soundscape are greatly influenced by the type of sound, automatic identification/classification of environmental sounds in soundscape is explored in this paper, by analysing sound with a number of objective measures, including statistic indices of psychoacoustic parameters, such as loudness, pitch, timbre and rhythm. The sound recordings of single sound source, labelled in four categories of water, wind, bird, and urban sounds including street music, mechanical sounds and traffic noise, are automatically identified with artificial neural networks and discriminant functions based on the results of objective measures. The accuracies of the identification are high, generally reaching about 90% for all the four categories.

Monday 09:20-09:40, Hall New Orleans, Paper 0123 (contributed)
Deng Zhiyong
Semantic Assessment for the Soundscape of Chinese Ethnic Historical Areas

Deng Zhiyong[1], Wang Daiwei[1], Liu Aili[2], Chen Haokui[1], Zhang Jian[3]

[1] College of Music, Capital Normal University, China
[2] College of Resource Environment and Tourism, Capital Normal University, China
[3] Harbin Institute of Technology, Shenzhen Graduate School, China

Soundscape of the ethnic historical areas is one of the core components of its unique culture and the perception of its formation of community for the local residents. The subjective assessment of geographical soundscape is very important for the soundscape design or promotion. Based on six soundscape case studies in different Chinese ethnic historical areas, including South Putuo Temple of Xiamen in 2006, the downtown of Kashkar in 2006, NiangniangTemple of South Gaoluo in 2007, the Nanxiangkou local music performing area in Hebei University in 2010 and 2011, Qianjuntai and Zhuanghu village of Beijing in 2012, by means of semantic method, a certain relationship analysis between the acoustical parameters and the subjective assessment is introduced in this paper. According to the features of the soundscape samples, nine semantic pairs were chosen for the subjective evaluation experiments, including “noise to quiet”, “boring to lively”, “common to divine”, “modern to traditional”, “rough to smooth”, “directional to omni-directional”, “far to close”, “strong to weak”, and “dislike to preferred”. Meanwhile, from a view of the common people, a rough concept to preserve the original soundscape for the ethnic historical areas is also put forward in the paper.

Monday 09:40-10:00, Hall New Orleans, Paper 0585 (contributed)
Cheng Stone
Analytic research on the time-varying ingredients of emotion evoked by the sound of music

Cheng Stone[1,2], Wu Wei-ting[2]

[1] Department of Mechanical Engineering, National Chiao Tung University, Taiwan
[2] Master Programme of Sound and Music Innovative Technologies (SMIT), National Chiao Tung University, Taiwan

The researches of music emotion recognition usually provide a general emotion classification on the entire scope of music signal and conclude the

music-aroused human emotion. This study presents an approach for analyzing the ingredient of emotions aroused by the music signals. The proposed system integrated variety of emotion models, including two-dimensional emotion space and category type. The model is consisted of four quadrants: Contentment, Depression, Anxious, and Exuberance. Training process for emotion recognition is preceded in a variety of features by 192 music clips to build emotional classification model between each other in order to construct two dimensional analyses of the emotive states. Eleven features are extracted into music and audio categories. Each feature used different length of frame for analysis. The study demarcates the boundaries of four emotions in the emotion plane by support vector machine (SVM) as classification algorithm, and draws the variation of emotion ingredients evoked by musical signals. Furthermore, a questionnaire survey is conducted to compare the results from proposed system analysis the actual listener experience. Preliminary evaluations indicate that the proposed algorithms produce results agreed approximately.

Monday 11:00-11:20, Hall New Orleans, Paper 0502 (contributed)
Andringa Tjeerd C.
Core affect and soundscape assessment: fore- and background soundscape design for quality of life

Andringa Tjeerd C.[1], van den Bosch Kirsten A.[2]

[1] Artificial Intelligence and Cognitive Engineering (ALICE), University of Groningen Nijenborgh, The Netherlands, [2] Special Needs Education and Youth Care, University of Groningen, The Netherlands

The first and foremost evolutionary role of audition is to estimate safety. One typical safety indicator is normalness and subcortical auditory processes are always estimating normalness. If the situation is normal and safe, our higher cortical functions are free to attend their own matters. But if subcortical and subconscious auditory processing are unable to estimate safety, they task cortical processes with vigilance tasks that arouse and make it more difficult to relax and to concentrate on self-selected activities. This is apparent from the way we appraise (sonic) environments and from the way these influence our moods (core affect). The words that we use to describe sonic environments reflect the difficulty to decide on appropriate behavior (easy in quiet environments and difficult in chaotic environments) and the affordance content (very low or inappropriate in boring environment and very high and highly appreciated in lively environments). The way arousal and attention is controlled is described in a recent model of sensory cognition that we

summarize here. We conclude that it is not the physical attributes of sound, but the simplest – safety relevant – meaning attributable to the sonic environment that is the key to understanding soundscape quality. And this realization allows one to engage in soundscape design for quality of life. We end with a few suggestions to explicitly design for quality of life as alternative to design for compliance with noise regulations.

Monday 11:20-11:40, Hall New Orleans, Paper 0872 (contributed)
Kaiser Fabio
Orlando theme park acoustics – A soundscape analysis

Kaiser Fabio, Rohde Thorsten
Rohde-BeSB Noise + Vibration GmbH, Austria

Theme parks are self-contained environments creating a fantasy world with a very special purpose - entertaining. It is self-evident that sound plays a crucial role in the design of a visitor's experience. In order to identify the relationship between a park's architecture, the prevalent activities and the acoustics the soundscape approach is applied. It not only comprises quantitative measures but also perceptual and context-based measures and therefore seems to be most promising for the task. For this research four different theme parks in Orlando, USA, were evaluated during one day each. Soundwalks using binaural microphones as well as standard sound level measurements of single points-of-interest and the daily sound exposure were carried out. Further the sound quality and the context were captured by filling out evaluation forms. These methods helped in identifying characteristics, e.g., of noise sources of a contextual positive quality as well as sources having a rather negative effect. Examples of destructive acoustic design were identified and sound levels of attractions and of the daily exposure were measured that reach critical values. This work also discusses the use of the soundscape analysis for the consulting on the acoustic design of new theme parks.

Monday 11:40-12:00, Hall New Orleans, Paper 1042 (contributed)
Colon Paul-Louis
Participative monitoring for soundscape assessment

Colon Paul-Louis
LASC, University of Liege, Belgium

This study was aimed at developing a new assessment technique for soundscapes, inspired by recent experiences in citizen monitoring in environmental field, which prove citizens to be a reliable source of information on some facets of their environment. In two Belgian localities, people were asked to note every sound they heard around home during 5 minutes, at different times of the day and week. They were also asked to qualify these sounds regarding to the feelings they evoke, their temporal frequency, their perceived emergence and the visibility of the source. Those repeated notations were then combined to identify trends in local soundscape. They permitted to point out a criterion of sonic diversity of soundscapes, which appears to be linked to the potentiality of noise annoyance. The notations further helped to define qualitative features of noise that are involved in annoyance and not taken into account in quantitative assessment of noise. The technique has also potential in developing people's awareness towards their sonic environment and could provide an objective basis of discussion amongst stakeholders. The test stage of this monitoring technique provided encouraging results. It is currently being developed to a broader scale.

Monday 12:00-12:20, Hall New Orleans, Paper 1141 (contributed)
Zhang Jiping
An objective evaluation method for the road traffic noise impact on soundscape – West Lake as a case

Zhang Jiping[1], Schomer Paul[2], Yan Hao[3], Zhou Xilu[3], Zhu Shenghui[3], Ye Xuhong[4], Yang Le[4], Ge Jian[5], Sun Lu[1], Cai Juan[1], Min Hui[1], Tang Tingmei[1]

[1] Zhejiang Research & Design Institute of Environmental Protection, China, [2] Schomer and Associates, Inc., USA. [3] Hangzhou Traffic Police Detachment of Public Security Bureau, China, [4] Hangzhou municipal environmental monitoring center, China, [5] College of Civil Engineering and Architecture, Zhejiang University, China

A positively judged soundscape generally includes both natural and social/cultural sounds in the sonic environment such as birds singing, water flowing, bell ringing, music playing, etc. Road traffic noise is a major source that may interrupt and even impact the natural and social/cultural soundscape. Many of the studies consider a soundscape, which includes road traffic noise, natural and social/cultural contexts were based on an objective, social scientific assessment, mainly using an on-site questionnaire, to develop an understanding of the situation. This paper tries to develop the correlation between road traffic background noise and environmental or community sound, proposing an objective evaluation method for protecting the

soundscape from road traffic noise. It is hoped this method would not only overcome the shortcomings of subjective investigation, but also would provide a warning of impending damage and could be applied to early alert the interrupt, impact, and destruction to soundscape by road traffic noise.

Monday 12:20-12:40, Hall New Orleans, Paper 0958 (invited)
Schulte-Fortkamp Brigitte
Soundscape – a matter of human resources

Schulte-Fortkamp Brigitte
Technische Universität Berlin, Germany

Soundscape research represents a paradigm shift in the field of noise evaluation as it is interdisciplinary with regard to social sciences and to physics. Moreover, it firstly improves human perception and then turns to physical measurements. Therefore it refers to the use of different investigation techniques – taxonomy and measurement methods (soundwalks, questionnaires, interviews, recordings) - will be basics to approach a subject or phenomenon to improve the validity of the research outcome and avoid systematic errors by relying only on one approach. The soundscape approach relies by definition on this strategy and in the strict sense it can be said: any study which does not use triangulation cannot be considered a complete soundscape study. In practice there is still a significant gap between soundscape indicators which are used in some standardized way in measurement by persons" and those applied in measurement by instruments". Hitherto, most studies conducted are at small scales such as parks, gardens, places and triangulation is not yet fully exploited. To establish the Soundscape concept and the Soundscape approach there is the need to advise the respective local actors and stakeholders in communities, parks and wilderness- meaning to use the resources given with respect to also future generations and its with respect to socio cultural, aesthetic and economic effects.

Monday 12:40-13:00, Hall New Orleans, Paper 1154 (contributed)
Niemeyer Lygia
Methodology for field procedures and data record in open spaces (Parque do Flamengo, Rio de Janeiro)

Niemeyer Lygia[1,2], Rego Andrea[1,2], Vasconcelos Virginia[1,3]

[1] Proarq, Universidade Federal do Rio de Janeiro, Brazil, [2] FAU, Universidade Federal do Rio de Janeiro, Brazil, [3] EBA, Universidade Federal do Rio de Janeiro, Brazil

The research aims to discuss the importance of sounds in the qualification of urban spaces and their relation with the form of the city and the urban climate. Differently from the temperate zones where buildings should preferably remain “sealed” throughout almost the whole year to avoid heat loss (which conveniently work on preserving users from urban noises), in tropical hot-humid zones, the low-cost design strategies to reach thermal comfort (i.e. maximizing the use of natural ventilation) may constitute an important challenge to deal with high levels of urban noise exposure. Several methodologies (soundwalks, recordings, measurements, noise maps) are developed to evaluate qualitatively and quantitatively the current noise environment in order to contribute to the formulation of urban planning policies focused on management of environmental noise in the context of the landscapes studied. This paper presents a case study conducted in a course in Flamengo Park and as a result, allowed to reassess and modify the procedures proposed in order to optimize the fieldwork and analysis.

SS70 Soundscape Design and Interventions

Chair: Maffei Luigi, Coelho Luis Bento

Monday 14:00-14:20, Hall New Orleans, Paper 0015 (contributed)
Santiago Gabriela
Cognitive Neuroscience of Hearing applied to Audiovisual Sound Design

Santiago Gabriela
University of The Andes, Venezuela

In the constant pursuit of knowledge and practices that strengthen the artistic flair in audiovisual creations, it is time to expand the horizons and give way to the findings of neuroscience. If a hierarchy were to be set up for brain activities, the regulation of basic bodily functions would come first, secondly all that is related to movement, and thirdly the transduction of external stimuli into electrochemical signals that results in higher cognitive processes. Such processes are the starting point of this research that pretends to offer a thorough study of the cognitive process of hearing that might be associated in a verifiable way to sound design in audiovisual productions.

Monday 14:20-14:40, Hall New Orleans, Paper 0381 (contributed)
Calarco Francesca M.A.
Audio-visual interaction and perception of waterscapes used in outdoor environments

Calarco Francesca M.A., Galbrun Laurent
School of the Built Environment, Heriot-Watt University Edinburgh, UK

This paper examines the audio-visual interaction and perception of a wide range of waterscapes where road traffic noise is audible. The waterscapes examined include small to medium sized water features that can be installed in outdoor settings (e.g. gardens and parks), in view of improving soundscape perception in terms of peacefulness and relaxation. The visual impact of the water features' displays has been examined using images of the displays placed over a single natural background, whilst auditory perception was based on the corresponding water sounds recorded in the laboratory. Audio only, visual only and audio-visual preference tests have been carried out under controlled conditions, in view of identifying the interaction between audio-visual factors. Qualitative analysis has also been performed using a semantic differential scale, in view of investigating how evocation and meaning might affect preferences.

Monday 14:40-15:00, Hall New Orleans, Paper 0485 (contributed)
Nagahata Koji
A pilot study on environmental quality standards for noise in scenic areas

Nagahata Koji[1,2], Akanuma Hayato[3], Handa Akina[4], Shoji Yukako[1]

[1] Fukushima University, Japan, [2] Kanayagawa, Japan, [3] Fukushima University (Currently, TOA, INC), Japan, [4] Fukushima University (Currently, Kyushu University), Japan

In Japan, the environmental quality standards for noise had been established for residential areas only. As a result, difficult problems exist in preserving soundscapes at quiet scenic areas from noise caused by large-scale developments (such as highway expansions and tunnels). Indeed, a court decision explicitly stated that there is no legal standing covering the preservation of soundscapes in scenic areas, even though such soundscapes might be valuable. Therefore, environmental quality standards for noise in scenic areas should be considered. To discuss these standards, we investigated acceptable sound levels of road traffic noise at four different types of scenic areas by psycho-acoustic experiments involving a group of participants. The results show that the acceptable levels cannot be explained by a simple S/N ratio although these depend on the environmental noise levels at each area. In addition, individual differences in the acceptable levels are high, but level differences between places are quite similar among participants. Those results means that a wide citizenry participation in establishing standards is required to make those standards appropriate.

Monday 15:00-15:20, Hall New Orleans, Paper 1164 (invited)
Maffei Luigi
Soundscape approach to evaluate the effectiveness of a Limited Traffic Zone as environmental strategy

Maffei Luigi, Di Gabriele Maria, Masullo Massimiliano, Aletta Francesco
Dep. of Architecture and Industrial Design “Luigi Vanvitelli”, Second University of Naples, Italy

Limited traffic zones LTZ are strategies that municipalities adopt to improve environmental quality. In recent years a wide increase of LTZ has been registered in Europe. Although the main aim is to tackle air pollution, they impact also on noise pollution which is a big problem in many cities, despite legislation limits are imposed and/or suggested at national and international level. Recently the municipality of Naples is implementing the LTZ in different areas, within a wider program of interventions aimed at urban

renewal and conservation of cultural heritage. In a study dated years ago the authors were involved in a field survey performed before and after the implementation of LTZ in Naples. The survey was based on the acquisition of environmental parameters influencing the human perception and on in situ interviews. The survey confirmed the multidimensional nature of the environmental perception according to a Soundscape approach. Despite a not really significant decrease of sound levels, the variation of the “quality of sound” after LTZ implementation was evaluated globally positive by a significant percentage of subjects. In this paper further measurements, interviews and analysis are presented in order to confirm the above tendency and/or identify possible modifications of judgements.

Monday 15:20-15:40, Hall New Orleans, Paper 0223 (invited)
Axelsson Östen
Sound Cities: Computational modelling of urban soundscape quality

Axelsson Östen[1], Lundén Peter[2], Nilsson Mats E.[2]

[1] School of Architecture, University of Sheffield, UK, [2] Department of Psychology, Stockholm University, Sweden

Whether to improve existing acoustic environments, as they are perceived or experienced and/or understood by people, in context (i.e., soundscapes), or to design future soundscapes it is central to have a prediction model that relates predictors (i.e., acoustic indicators) to outcomes (i.e., psychological variables). In the Sound Cities project it is proposed to use as outcome what Axelsson previously has termed Information Load. The purpose of the Sound Cities project is to identify what acoustic indicators may predict the information load of soundscapes. The method will be psychoacoustic experiments in which a large sample of naïve listeners will assess recordings of authentic acoustic environments with regards to information load. Acoustic signals and information-load data will be submitted to machine learning, based on music information retrieval technology. It is expected that the Sound Cities project will contribute to the underpinnings of future tools for soundscape planning and design, like soundscape maps that provide information on how people perceive the acoustic environment. This is in contrast to present noise maps, which only provide calculated sound-pressure levels from transportation and industry.

Monday 15:40-16:00, Hall New Orleans, Paper 0623 (contributed)
Mossberg Frans
Holistic Sound Environment Research

Mossberg Frans
Sound Environment Center at Lund University, Sweden

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. The board is a mix of disciplines that in different ways are dealing with soundscape and sound environment incorporating humanities, medicine and natural sciences. Going from research to practice and change, in joint collaboration with acoustics, logopedics and cognitive science the center is initiating research on health and noise, the impact of acoustics on voice production, how memory, cognition and reception are affected by light and acoustics in a multi sensory input, in communication of heavy intellectual material in academic education, with the aim of providing an empirical foundation and incentives for development of the university campus and its indoor soundscape.

Monday 16:00-16:20, Hall New Orleans, Paper 1254 (contributed)
Yu Lei
Soundscape design in the Shenzhen Dongmen Culture Square

Yu Lei[1], Kang Jian[2], Huan Liu
[1] HIT Shenzhen Graduate School, China, [2] Architecture School, Sheffield University, UK

Attention on visual effects is insufficient in urban open spaces, while soundscape design is important. In this paper, a soundscape study on the Shenzhen Dongmen Open Space have been made in order to provide aural pleasant for the users. The study shows that existing sounds on the Space are not delightful to satisfy the users. Based on the study results, a soundscape design is made in order to prove the Space sonic environment. Eventually, effects of the soundscape design have been examined in the laboratory

experiment and also by using the Artificial Neural Network (ANN) models. Furthermore, the subjective evaluations of soundscape design made in the experiment and made by ANN models have been compared.

SS71 Noise-Control Education Delivery and Technology Transfer Methods

Chair: Davis Patricia, Borroughs Courtney

Monday 16:20-16:40, Hall New Orleans, Paper 0893 (invited)
Hodgson Murray
Acoustics and Noise Control Education at the University of British Columbia (UBC)

Hodgson Murray
Acoustics & Noise Research Group, Canada

This paper discusses how the author – the only acoustical-engineering prof at UBC – provides students with an education in acoustics and noise control. His joint appointment in a health unit and in MECH define the students to be educated. His mandate is to teach several three main types of student with different objectives: 1. undergraduate and graduate engineers (who may seek employment as acoustical professionals in industry, consulting or government) or go on to grad school; 2. graduate hygienists/health scientists from a variety of mainly non-engineering backgrounds; 3. graduate students in engineering and physics. Starting from scratch, except for inheriting a fully anechoic chamber and some test equipment from a former acoustics prof, he developed and now teaches every year three full-term courses: 1. Acoustics and Noise Control (an undergrad MECH technical elective); 2. Occupational and Environmental Acoustics and Vibration (for graduate students in occupational and environmental health/hygiene); and, C. Advanced Topics in Theoretical Acoustics (for graduate students interested in acoustics). The first two courses involve lectures and labs; the last involves lectures and a term project. The author also provides a number of acoustical service lectures (to undergrad mining engineers, grad students in the Sustainable Building Science Program) and supervises undergrad and grad projects in acoustics to students in various disciplines. Notably, though UBC has a prominent architecture school, and the author's research focus is architectural acoustics, he (and no-one else) teaches acoustics to architecture students.

Monday 16:40-17:00, Hall New Orleans, Paper 1012 (invited)
Belek H.
Sound and Vibration Teaching Environment at Istanbul Technical University

Belek H. Temel, Erol Haluk
Department of Mechanical Engineering, Istanbul Technical University Gumussuyu, Turkey

Over the last three decades, Turkish society witnessed the benefits of economic growth as well as the impacts of economic recessions. The experience gained during this period have lead Turkey to raise the science and technology platform to a higher level, as well as to be engaged in a significant science, technology and innovation impetus. In parallel to these developments; comfort, life standards and the expectations of society increased, hence sound and vibration related problems gained more popularity. As the universities main goals in society are; education, research and industrial applications; Istanbul Technical University responded to these developments by introducing undergraduate courses and a graduate degree program in sound and vibration. Additionally strong links with local and global industrial partners are established. In this paper, sound and vibration teaching environment at Istanbul Technical University will briefly be summarized, information on the physical and human resources in sound and vibration teaching as well as research activities will be given. Our approach to education in acoustics and noise control will be explained and the topics covered in the courses will be introduced. Some examples of research activities as well as thesis topics will also be discussed.

Monday 17:00-17:20, Hall New Orleans, Paper 0579 (invited)
Burgess Marion
Fully distance education program for those entering acoustic consulting

Burgess Marion[1], Stead Matthew[2]

[1] School of Engineering and Information Technology University of New South Wales, Australia
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Comprehensive formal education programs in sound and vibration ensure the graduates are well placed to commence a career in acoustical consulting. Where such courses are not available companies face the need to employ staff but find that, while there may be very good applicants with general engineering and science backgrounds, there are few that have any real knowledge in acoustics and noise control. Any courses available for postgraduate study via the formal University system may not be available when or where needed. To meet these needs a flexible distance learning program of study, based on the UK Institute of Acoustics Diploma, has been developed in Australia. This is managed via a University short course program, and is not part of the formal academic program thus allowing for full flexibility for the registrants. The support and involvement of the professional organization for acoustic consultancies ensures that the syllabus for each

module covers the areas that they need to develop the expertise of their staff and the continued interest and support from the senior, experienced acoustical consultants This program has been operating for five years and in this paper we will discuss the structure and experiences from the implementation.

Monday 17:20-17:40, Hall New Orleans, Paper 1309 (invited)
Russell Daniel A.
Engaging distance education students in online graduate level courses in acoustics, noise and vibration

Russell Daniel A., Sparrow Victor W., Hambric Stephen A.
Graduate Program in Acoustics, The Pennsylvania State University, USA

For more than 25 years, the Graduate Program in Acoustics at Penn State has been offering courses leading to the M.Eng. degree in Acoustics to students at a distance. While methods of course delivery have changed during that time span, the intent and purpose has remained constant: to provide a rigorous and comprehensive acoustics curriculum available to a wide variety of students from different backgrounds and locations. In this paper we provide a brief overview of the M.Eng. in Acoustics Distance Education program along with our current delivery methods. We also summarize the topical content and professor-student interactions for three specific courses: Noise Control Engineering, Computational Acoustics, and Research and Writing for Acousticians. The focus of the paper will be the challenges of engaging distance education students in an online graduate level course in acoustics.

Monday 17:40-18:00, Hall New Orleans, Paper 0500 (contributed)
Meric Isin
Acoustics education for architects: Developing a base of knowledge for professional experience

Meric Isin[1], Caliskan Mehmet[2]

[1] Department of Architecture, Middle East Technical University, Turkey
[2] Department of Mechanical Engineering, Middle East Technical University, Turkey

There is a dispersion of professional expertise in building industry since demand for rapid, detailed and correct information has been increased with the developing technology. According to their expertise, the actors in a project may share technical, organizational, financial information about their specific discipline or even guide other actors for the benefit of the project. Architects who combine all the information gathered from various actors should at least own basic knowledge about other disciplines to communicate with these actors. Moreover, this knowledge is also essential to take befitting decisions in every design step. Acoustics is one of the major knowledge areas in the architectural projects. University education is important to build up this knowledge. This paper will discuss the role of acoustics courses in architectural education, question a pair of teaching methods and present the outcomes of acoustics education in the professional life of architects through the case of architectural acoustics graduate courses given in Middle East Technical University Department of Architecture.

SS40 Signal Processing and Analysis

Chair: Xiang Ning, Shimizu Yasushi, Bai Mingxian

Monday 08:20-08:40, Hall Lugger, Paper 0514 (contributed)
Ličanin Marko
Analysis of spherical microphone array using simulations

Ličanin Marko, Djordjević Ana, Ćirić Dejan
University of Niš, Faculty of Electronic Engineering, Serbia

Analysis of spatial properties of the sound field, using spherical harmonic decomposition, has recently become a focus point in a number of researches related to spatial audio recordings or room acoustic. As a base of spherical harmonic decomposition, concept of spherical microphonearray has been introduced. In this paper, simulationsof such array in the sound field are presented. Influence of various configurations of sensors (microphones) on accuracy of the sound field presentation is investigated. Also, impact of the size of sphere where the microphones are placed is analyzed. The simulations are performed using hardand open sphere model for plane wave sound field. Special attention is paid to the simulation model of the spherical microphone array that is going to be realized asa practical technical solution, and further used for real spatial sound field environment study. Coordinate system of the simulated spherical microphone array corresponds to the real model. Therefore, presented results can be compared to the real-case scenario. All simulation models, signals processingand graphical presentationsofresults havebeen realized using Matlab.

Monday 08:40-09:00, Hall Lugger, Paper 1198 (contributed)
Koutný Adam
Holographic reconstruction of an incident field assuming the spherical waves scattered by a rigid sphere

Koutný Adam[1], Jiříček Ondřej[1], Thomas Jean-Hugh[2]

[1] Czech Technical University in Prague, Czech Republic, [2] Laboratoire d'Acoustique de l'Université du Maine (LAUM-UMR CNRS 6613) and Ecole Nationale Supérieure d'Ingénieurs du Mans, France

This paper deals with the reconstruction of an acoustic field in the near-field around a rigid sphere using Near-field Acoustical Holography (NAH) based on an expansion in terms of the spherical harmonics. By employing the rigid sphere providing stable inversion of the propagation function one

has to take into account the scattering effect that could significantly affect the total field around the sphere. This effect is commonly accounted for the separation of the incident and scattered field from the total measured field. In applications performing sound field reconstruction by NAH, the presence of source in the near-field of the sphere is to be expected. In this study, such a source in the near-field is considered and a method for determination of the source distance is examined. We consider the spherical waves scattered by a rigid spherical surface for the separation and subsequent reconstruction of the only incident field in this paper. The results are presented in a model simulation.

Monday 09:00-09:20, Hall Lugger, Paper 0364 (contributed)
Fernández Comesaña Daniel
A novel deconvolution beamforming algorithm for virtual phased arrays

Fernandez Comesaña Daniel[1,2], Fernandez-Grande Efren[3], Tiana-Roig Elisabet[3], Holland Keith R.[2]

[1] Microflown Technologies, The Netherlands, [2] Institute of Sound and Vibration Research, UK
[3] Acoustic Technology, Dep. Electrical Engineering, Technical University of Denmark, Denmark

Beamforming techniques using phased microphone arrays are one of the most common tools for localiz- ing and quantifying noise sources. However, the use of such devices can result in a series of well-known disadvantages regarding, for instance, their very high cost or transducer mismatch. Virtual Phased Arrays (VPAs) have been proposed as an alternative solution to prevent these difficulties provided the sound field is time stationary. Several frequency domain beamforming techniques can be adapted to only use the relative phase between a fixed and a moving transducer. Therefore the results traditionally obtained using large arrays can be emulated by applying beamforming algorithms to data acquired from only two sensors. This paper presents a novel beamforming algorithm which uses a deconvolution approach to strongly reduce the pres- ence of side lobes. A series of synthetic noise sources with negative source strength are introduced in order to maximize the dynamic range of the beamforming deconvolved map. This iterative sidelobe cleaner algorithm (ISCA) does not require the of use of the covariance matrix of the array, hence it can also be applied to a VPA. The performance of ISCA is compared throughout several simulations with conventional deconvolu- tion algorithms such as DAMAS and NNLS. The results support the robustness and accuracy of the proposed approach, providing clear localization maps in all the conditions evaluated.

Monday 09:20-09:40, Hall Lugger, Paper 0899 (invited)
Kim Yang-Hann
Analysis method of sound visualization by using beamforming

Kim Yang-Hann, Seo Dae-Hoon, Choi Jung-Woo

Center for Noise and Vibration Control(NOVIC), Department of Mechanical Engineering, Advanced Institute of Science and Technology (KAIST), Korea

There are many ways to implement what we obtain by using a beamforming. Depending on the size of array and its configuration as well as the scan vector and source distribution, the beamforming power indicates different information. Therefore, our objective is to find out the way to show source distribution from the beamforming power, in such a way to relate beamforming information and source distribution. To start with, we analyze beamforming power coming from several monopole sources and line sources and we establish an analysis method to determine the source distribution form the beamforming power results.

Monday 09:40-10:00, Hall Lugger, Paper 0732 (contributed)
Kim Kihyun
A study on implementation of active localization system using a microphone array and a loudspeaker in a small room

Kim Kihyun[1], Ryu Homin[1], Wang Semyung[1], Lee Sung Q.[2], Park Kang-Ho[2]

[1] School of Mechatronics, Gwangju Institute of Science and Technology, Korea, [2] IT Convergence & Components Laboratory, Nano Convergence Sensor Team, Electronics Telecommunication, Research Institute, Korea

Active localization system using a microphone array and a loudspeaker is developed to detecting the position of a silent intruder in building security system. Proposed system has a similar concept with ultrasound system in terms of active system. Ultrasound imaging is obtained by transmittance and reception of excitation signals, and acoustic imaging produced by the active localization system is obtained as a transmitter, a loudspeaker, and a receiver, a microphone array. If proposed approach is considered about getting the spatial information in the control domain, active localization system estimates the position information using only a line microphone array. However, this proposed system is assessed in an anechoic chamber. In this paper, the active localization system is dealt with in reverberant environment. If this system is applied in a relative large room, the results of

acoustic imaging are reasonable, but acoustic imaging in a small room possibly becomes bad results because room effects in a small room make complex distributed pressure of sound field. Therefore, inverse filtering with regularization is employed to suppress the room effects. To design the inverse filter, simplified configuration is established using medium density fibreboard (MDF) in an anechoic chamber. The measured signals from this setup are applied to inverse filtering, and room effects are reduced, while the effects of a PVC pipe are increased.

Monday 10:00-10:20, Hall Lugger, Paper 0287 (invited)
Bai Mingsian R
Adaptive array-based acoustic echo jammer

Bai Mingsian R., Chen Yung-Chiang
Department of Power Mechanical Engineering, National Tsing Hua University, Taiwan

Acoustic echo that can substantially undermine speech quality is one of the key issues one must address in practical telecommunication systems. Distinct from conventional mono-channel acoustic echo cancellation (AEC) techniques, this paper proposes an acoustic echo jammer (AEJ) that takes advantage of beamforming to nullify the echo path. Highly directional microphone array is designed to focus on the near-end speaker and suppress the echo from the far-end as well as noise and interference from the back ground. With the beamformer, the cancellation performance can be significantly enhanced, as compared to conventional AEC. However, various forms of system deviations can arise due to channel mismatch, sensor location error, and pointing error. To cope with these deviations, a robust AEJ is developed on the basis of an adaptive generalized sidelobe canceller (GSC). The robust AEJ comprises a fixed beamformer (FBF), a blocking matrix (BM) and a multiple-input canceller (MC) by which a null is adaptively placed at the direction of the incident interference. In addition, subband (SB) implementation is employed to enhance the processing efficiency. Objective and subjective tests are conducted to compare several implementation approaches of the proposed systems. The cancellation performance metric ERLE (Echo Return Loss Enhancement) have attained 26 dB and 30 dB with the AEJ-SB-AEC and the SB-GSC, respectively, in comparison with 15 dB with the conventional AEC.

Monday 11:00-11:20, Hall Lugger, Paper 0234 (contributed)
Li Xinhui
Blind sources separation of harmonic signals for output only modal analysis

Li Xinhui[1], Brennan Michael J.[2], Yang Tiejun[1], Lu Zeqi[1], Dong Jianchao[1]

[1] College of Power and Energy Engineering, Harbin Engineering University, China
[2] Departamento de Engenharia Mecânica UNESP, Brazil

Blind source separation (BSS) is an emerging technique in array processing and data analysis, aimed at recovering unobserved sources from observed signals which are a filtered mix of the sources. The only assumption in the technique is the mutual independence or uncorrelation of the source signals. This technique has gained recent interest in modal analysis. As one of the widely used techniques for blind source separation, independent component analysis (ICA) fails when the frequency ratio of two harmonic sources is close to three. This is a disadvantage of ICA when it is used to do modal analysis. In the present study, an analytical method is employed to find out why the technique fails. An alternative technique, namely secondary-order blind identification (SOBI) is shown to avoid such a problem. Both of the two techniques are compared by way of numerical simulations and experiments.

Monday 11:20-11:40, Hall Lugger, Paper 0309 (invited)
Ikuta Akira
Stochastic Signal Processing for Cancellation of Additive and Multiplicative Noises in Sound Environment Systems

Ikuta Akira, Orimoto Hisako
Prefectural University of Hiroshima, Japan

In the actual situation of sound environment systems, the observed data often contain several fluctuating noises. Therefore, it is necessary to estimate the specific signal based on the observed data by introducing some noise cancellation methods. In this study, a sound environment system considering both noises of the external noise based on the additive property of energy variable and the internal noise dependent on the specific signal expressing in a multiplicative form is first paid our attention. Next, a noise cancellation method to estimate recursively the specific signal is derived on the basis of Bayes' theorem in an expansion series form suitable to a signal processing with lower and higher order statistics for the observation data. More specifically, an expansion expression of the conditional probability distribution reflecting the information on linear and nonlinear correlation among the time series of the specific signal and observation is adopted to express the statistical relationship between the specific signal and the signal dependent noise. Finally, the validity of the proposed method is experimentally confirmed by applying it to the actual data observed in real sound environment.

Monday 11:40-12:00, Hall Lugger, Paper 0072 (contributed)
Cang Yan
An efficient gating size estimation algorithm in multiple hypotheses tracking algorithm

Cang Yan, Zhang Rubo, Sun Weijin
Harbin Engineering University, China

Gating is an important component of most multi-target tracking system. It is a technique for eliminating unlikely observation-to-track pairings, which determines which observations are valid candidates to update existing tracks. Joint probability data association can associate probabilities are now computed using all observation and all tracks, the paper derives an efficient gating size calculation algorithm which joint probability data association filter estimates the gate size at each scan. Moreover, by introducing a balance factor, the new gate size will not depend on parameter of target manoeuvre which always a constant between 0 and 1. The paper discussed the relationship between the balance factor and gate size. The simulation shows when the factor is bigger, the gate size will be a constant. The proposed algorithm has the smaller gate size than maximum likelihood gate. Finally, it doesn't need to calculate the likelihood of any branch of the multiple hypotheses tree.

Monday 12:00-12:20, Hall Lugger, Paper 3648 (invited)
Xiang Ning
Bayesian analysis for evaluation of interdependence between parameters of multilayer microperforated panel absorbers

Xiang Ning, Schmitt Andrew, Fackler Cameron
Graduate Program in Architectural Acoustics, Rensselaer Polytechnic Institute, USA

The Bayesian inference framework has recently been applied to a wide range of acoustics engineering problems. This paper demonstrates how two levels of inference – Bayesian model selection and parameter estimation – can be applied to the design of multilayer microperforated panel (MPP) absorbers. MPP absorbers are capable of producing high acoustic absorption coefficients without the use of fibrous porous materials, extending their potential use to many critical situations where traditional materials do not suffice. Combining several MPP layers can drastically increase the absorption bandwidth of an MPP absorber. When designing such multilayer MPP absorbers with the Bayesian inference framework, understanding the interdependence among the multi-layered MPP parameters is crucial. Occam's razor is embodied by the Bayesian framework, intrinsically producing a multilayer design which meets user-specified absorption requirements while minimizing the number of MPP layers used. In addition to the necessary number of MPP layers and corresponding parameter values, the Bayesian framework also provides quantitative measures of the interdependence between the MPP parameters across multilayer configurations. Focusing on the practical design of multilayer MPP absorbers, this paper discusses quantifying the interrelationship among the MPP parameters, obtaining estimates of their values, and minimizing the number of MPP layers required.

Monday 12:20-12:40, Hall Lugger, Paper 0547 (contributed)
Jelenković Marko
Machine learning based system for control and synthesis of sound source radiation directivity

Jelenković Marko, Ćirić Dejan, Zdravković Jelena
Faculty of Electronic Engineering, University of Niš, Serbia

Sound source directivity represents one of the most important features of a real sound source. Recently, significant research efforts have been directed towards control and synthesis of the radiation directivity. In this way, the radiation of real sound sources can be simulated more realistically, but also some specific radiation patterns can be generated. For this purpose, special sound sources consisting of independent element loudspeaker arrays have been applied. In this paper, the system developed for control and synthesis of sound source directivity based on machine learning is presented. Among other elements, the system includes two sound cards, a twelve-channel audio amplifier and spherical sound source in the form of dodecahedron with independent elements (loudspeakers). The system has basic signal control options implemented in every channel, such as amplitude regulation and phase shifting (inversion). The main feature of this system is

the ability to synthesize the specific radiation directivity pattern. This is done by machine learning using the input set of parameters (radiation directivity patterns obtained for different excitation settings). The system predicts which elements of dodecahedron needs to be activated and in which way to obtain a desired directivity.

Monday 12:40-13:00, Hall Lugger, Paper 0404 (contributed)
Tiwari Nachiketa
Transmission of Visual Data in Pipes Using Sonic Methods

Tiwari Nachiketa, Oorath Rahul
Department of Mechanical Engineering, Indian Institute of Technology, India

This paper explores the feasibility of transfer of visual data in pipes using sonic transmission methods. The importance of such a method of data transfer exists in scenarios where transmission of electromagnetic signal in long pipe is difficult. In scenarios where the medium for transmission is denser than air, electromagnetic waves fail to perform as they get easily absorbed by the medium. In such scenarios we propose to use sonic signals for transmission of visual images for conveying the health of pipelines. The authors have explored such an approach of image transfer using sound signals using six different techniques. Experiments have been conducted in which images with varying resolutions where converted to sound signal using a loudspeaker subsequently transmitted, and finally recorded using a microphone. These recorded signals were subsequently processed using appropriate algorithms to re-construct the original image. Using such an approach, gray scale and color images of different resolutions have been successfully transferred and re-constructed and the method of sonic transmission of visual data has been found to be feasible.

Monday 14:00-14:20, Hall Lugger, Paper 0333 (contributed)
Xiangyang Zen
Integrating visualized and auditory features for speaker recognition in reverberant fields

Xiangyang Zeng, Qiang Wang, Lixiang Ma
School of Marine, Northwestern Polytechnical University, China

Many applications of the technique of speaker recognition are limited in enclosed spaces such as meeting rooms, subway stations and so on, where the influence of reverberation on speech signals must be suppressed. In this paper,

the auditory features such as loudness, Mel frequency cepstrum coefficient are extracted at first, and then the reverberant speech signals are transformed into images, from which the visualized features such as gray-scale gradient co-occurrence matrix are extracted and then are processed by the principle component analysis (PCA) method. Finally, both modes of features are combined by GMM algorithm to classify speaker signals. The experimental results show that the combined method performs well and achieve a higher recognition rate than traditional single mode features in reverberant fields.

Monday 14:20-14:40, Hall Lugger, Paper 0777 (invited)
Shimizu Yasushi
Influence of Apparent Source Width on Speech Intelligibility of a Reproduced Sound in a Public Space

Shimizu Yasushi, Okuma Ryohei
Built environment, Tokyo Institute of Technology, Japan

Speech intelligibility of a reproduced sound has been investigated and acoustical target such as Speech Transmission Index has been utilized to evaluate its intelligibility so far. Speech intelligibility has been known to correlate with a signal to noise ratio (SN ratio), and therefore target sounds louder than background noises are necessary to produce high speech intelligibility. The acoustical environment, however including multiple reproduced sound sources become loud based on this idea if individual sound is played louder comparing to the other sound sources. On the contrary, high speech intelligibility will be achieved if two sounds are separated in frequency domain, frequency separation, and two speakers are located at the different position and are perceived as a different spatial impression, spatial separation. This study discusses an influence of auditory source width on speech intelligibility for a reproduced sound by directional speaker and unidirectional speaker. Subjective Speech Intelligibility for speech announcement is measured with various degree of apparent source width in a simulated acoustical environment in signal to noise ratios.

Monday 14:40-15:00, Hall Lugger, Paper 0122 (invited)
Xie Bosun
Analysis on the Transformation between Free-field And Binaural Pressure Levels for Near-field Sound Source

Xie Bosun[1,2], Yu Guangzheng[1]

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[2] State Key Laboratory of Subtropical Building Science, South China University of Technology, China

In the analyses of noise exposure, directional loudness and spatial unmasking, it is often required to transfer the free-field pressure level to binaural pressure levels or vice versa. This transformation is accomplished by adding an appropriate HRTF (head-related transfer function) logarithmic-magnitude to the free-field pressure level. In the case of free-field-far and frontal incidence, the HRTF logarithmic-magnitude for such a transformation has been derived from the statistical analysis on the measurements from certain population, and the result at each 1/3 octave has been specified in some standards such as ISO 11904-2, ANSI 3.4, 2007. However, HRTFs vary with source position, especially, depend on source distance for a near-field distance less than 1.0 m. Due to the scarcity of near-field HRTF data, the standardized HRTF logarithmic- magnitudes for the transformation of binaural pressure levels in near-field are still unavailable. In present work, based on the measured HRTFs from KAMAR manikin and boundary-element-based calculated HRTFs from 56 human subjects, the HRTF logarithmic-magnitudes for several near-field distances and directions are derived at each 1/3 octave and ERB (equivalent- rectangular-bandwidth). The results are proved to be distinguished from those of far-field, and also exhibit considerable inter-individual variation at high frequencies above 6 kHz.

Monday 15:00-15:20, Hall Lugger, Paper 0419 (contributed)
Yamashita Daisuke
Target setting method for operational TPA using principal component

Yamashita Daisuke, Yoshida Junji
Osaka Institute of Technology, Japan

Transfer path analysis (TPA) technique was developed to obtain contributions, and many TPA methods were proposed until now. Operational TPA enables us to obtain the contributions with small man-hour, because this method needs only sound pressure or vibration acceleration signals at the operational condition. In this study, target level setting method for reference signals of operational TPA was considered using principal component regression method. In the method, the target level was calculated by reducing principal component having high contribution to the response signal. To verify the efficiency of the proposed method, we tried to reduce floor vibration of a small model vehicle. As a result, the vibration of the response point could be reduced to the target level with less weight by applying the new method. Through these consideration and experiment, operational TPA could have more function in which the method could set the target of reference signals.

Monday 15:20-15:40, Hall Lugger, Paper 0929 (contributed)
Wang Longqi
Damage detection using local polynomial regression fitting on operating deflection shape extracted from a passing vehicle

Wang Longqi[1], Zhang Yao[2], Li Xianhui[1], Lie Seng Tjhen[2]

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[2] School of CEE, Nanyang Technological University, Singapore

This paper proposes a novel damage detection method based on operating deflection shape (ODS) which can be extracted from dynamic response of a passing vehicle easily. The ODS will show outliers if there exists any damage while it will be smooth when the structure is intact; therefore the outliers on the ODS can be used to detect and locate damages. However, previous studies usually use the information of undamaged structure as baseline which is difficult to obtain in practice. Considering that the outliers related to the damages will change the global shape of ODS very little and ODS of intact structure is smooth, the Local Polynomial Regression Method (LocPRM) is proposed to estimate the ODS of undamaged structure by using the information of damaged structure only and then detect the outliers accordingly. The new method has been verified by numerical studies and experimental examples. Moreover, if there is any prior information, it can be used for optimizing the LocPRM parameters, which is helpful for obtaining better results.

Monday 15:40-16:00, Hall Lugger, Paper 0058 (contributed)
Zhang Bingrui
Feature Extraction of Impact Sounds and Its Applications to Recognition of Sound Source Materials

Zhang Bingrui, Chen Kean, Ma Xiyue

Department of Environmental Engineering, School of Marine Engineering, Northwestern Polytechnical University, China

Feature extraction of impact sounds and its applications to recognition of the material of struck plates was investigated. Firstly, impact sounds of different materials plates are synthesized. Secondly, a set of features involving in temporal, spectral and auditory perception are extracted from signals and a three layers BP neural network is exploited as the classifier. Then, the results of pattern recognition using each feature are compared. Finally, in order to test the stability of features in the present of noise, we added white noise to synthesized sounds and obtained the results of material recognition under different signal to noise rates. The results show that damping-related signal features which perform well under different signal to noise rates can be used for identification of the source material.

Monday 16:00-16:20, Hall Lugger, Paper 0095 (invited)
Nava Baro Enrique
A signal processing method for extracting vibration signals due to ants' activities

Nava Baro Enrique[1,2], Oberst Sebastian[2], Lai Joseph C.S.[2], Evans Theodore A.[3]

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[3] Department of Biological Sciences, National University of Singapore, Singapore

Many software algorithms have been developed to track ants by analysing recorded videos. On the other hand, the feasibility of using vibrations measured at the substrate to classify ants' behaviour has not been examined before. A method is developed to separate vibrations owing to ants' activities from the substrate's response through a filtering/de–convolution procedure. This involves estimating the frequency response of the substrate and applying wavelet analysis to the measured vibrations. A number of responses due to ants' behaviours have been observed: ants shaking, falling, carrying stones, walking, scratching / biting, tapping hind legs, grooming, and antennation /

feeding. Vibrations produced by ants falling, carrying stones, walking and scratching / biting are measurable (i.e, above background noise levels). The proposed method is shown to be successful in classifying activities due to ants falling, ants carrying stones and to a lesser extent ants' scratching/biting. With further refinement, it seems feasible to use vibrations and the proposed algorithm to measure ants' behaviours in bioassays.

Monday 16:20-16:40, Hall Lugger, Paper 0276 (contributed)
Berkhoff Arthur
Directional sound sources using real-time beamforming control

Berkhoff Arthur[1], van der Rots Raymond[2]

[1] TNO Technical Sciences, Acoustics and Sonar, University of Twente, Faculty EEMCS, The Netherlands, [2] University of Twente, Faculty EEMCS, The Netherlands

Quiet vehicles may be noticed relatively late and therefore constitute a potential risk for vulnerable road users such as pedestrians and bicyclists. The ideal acoustic warning signal generator notifies vulnerable road users while minimizing noise pollution. 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. The warning 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 actuators, using least-squares beamforming methods. The particular least-squares methods are based on measured transfer functions between the actuators and the acoustic sensors. Different actuator technologies were evaluated. Changes of the relative positions of the vehicle and the vulnerable road user require continuous adjustments of the sound beam. The latency of the beamforming method with respect to an adjusted beaming direction is an important factor for the present application. Different methods to generate the sound beam are described and advantages of the different beamforming methods in experimental results are shown. Rapid real-time adjustment of the beaming direction is demonstrated.

SS42 Measurement of Surface Properties

Chair: Hübelt Jörn

Monday 16:40-17:00, Hall Lugger, Paper 1148 (contributed)
Huebelt Joern
Young's Modulus and Mechanical Impedance of Road Pavements

Huebelt Joern[1], Lindemann Jutta[3], Zander Ulf[2], Wellner Frohmut[3]

[1] Hochschule Mittweida, Germany, [2] Universität Siegen, Institut für Straßenwesen, Germany
[3] TU Dresden, Institut für Stadtbauwesen und Straßenbau, Germany

The long term durability of road pavements plays an important role when calculating the expenses of road construction. Among others, this durability is influenced by the conditions during the laying process of the pavement. Here, as important factors, the environmental temperature and the time duration between the laying process and the opening for traffic has to be mentioned. In Germany, for constructing a double layer, the required duration time is about 36 hours. During this time, the road has to be remaining closed. This can lead to big traffic jams, not only in urban areas. To shorten this time gap accurate information about the properties of the asphalt during and after the laying process are required. An indicator for the durability of the pavement could be the mechanical input impedance. Therefore, in the paper, the convenience of the use of the measurement of the mechanical input impedance for predicting the durability of the pavement will be discussed.

Monday 17:00-17:20, Hall Lugger, Paper 0229 (invited)
Horoshenkov Kirill
Acoustic properties of low growing plants

Horoshenkov Kirill [1], Khan Amir[1], Benkreira Hadj[1], Smyrnova Yuliya[2], Rehioui Kevin[2], Kang Jian[2]

[1] School of Engineering, University of Bradford, UK
[2] School of Architecture, University of Sheffield, UK

The plane wave normal incidence acoustic absorption coefficient of low growing plants is measured in the laboratory in the presence and absence of soil. These plants are generally used in green living walls and flower beds. Three 3-parameter equivalent fluid models for sound propagation in rigid frame porous media are used to predict the experimentally observed behaviour

of the absorption coefficient spectra of soils, plants and their combinations. It is shown that the leaf area density and dominant angle of leaf orientation are two key morphological characteristics which can be used to predict accurately the effective flow resistivity and tortuosity of plants. The random incidence absorption coefficient of soil and plants is studied using the model proposed by London [A. London, J. Acoust. Soc. Am., Vol. 22(2), 263-269 (1950)]. It is shown that clay-based soil cannot be always represented as a uniform porous layer and its acoustical properties need to be predicted using a transmission matrix approach which accounts for the pore structure change.

Monday 17:20-17:40, Hall Lugger, Paper 1202 (invited)
Bécot François-Xavier
Linking in-situ measured surface properties to material micro-structure

Bécot François-Xavier[1], Jaouen Luc[1], Benoit Gaëlle[2], Chevillotte Fabien[1]
[1] MATELYS, France, [2] CETE, France

This work aims at linking the in-situ measured surface properties of a given single-layer or multi-layer system to its intrinsic characteristics. The methods for measuring in-situ the surface properties, which are numerous and were proved to be robust, provide however only limited information about the material dissipation mechanisms. For some materials indeed, the final in-use performance is inherently connected to the transforming or mounting process and cannot be measured in laboratory or prior to the material assembling. Thus, this paper will discuss the applicability of a method using ambient noise for measuring in-situ the surface properties of sound absorbing surfaces and to deduce some information related the material micro-structure. Methods for deducing major importance material parameters like air flow resistivity, open porosity or tortuosity will also be reviewed. Results will assessed for various materials (granular, fibrous, cellular foam) from comparisons with directly measured characteristics, inverse characterization method using impedance tube, in-situ method using sensitivity analysis. Bottom approaches will also be described to tailored some macroscopic indicator like single rating DLα. Results obtained for porous concrete and a draining asphalt are compared to typical values obtained for this type of surfaces.

Monday 17:40-18:00, Hall Lugger, Paper 0412 (contributed)
Alarcão D.
Assessing the scattering uniformity of three full scale diffusers

Alarcão D., Fafaiol C., Coelho J. L. Bento
CAPS, Instituto Superior Técnico, Universidade Técnica de Lisboa, Portugal

The scattering uniformity of three full scale 1-D diffusers was assessed in the IST anechoic chamber. Two of the diffusers were of the Schröder type, while the third one consisted of an arrangement of various semi-cylinders placed at different depths from the surface. The dimensions of the anechoic chamber posed some constrains in the measurement setup, firstly due to the linear dimensions of the diffusers, typically circa 1 m, and secondly because of the minimum acceptable distance between microphone and sample, so as not to measure in the near field. The microphone was fixed to a rotating turntable which was controlled by a time gating system. The angular resolution used for the polar measurements of the scattering field from the diffusers was equal to 10°. An MLS based measuring technique was used for the acquisition of the impulse responses, which were then post-processed in order to isolate the diffusers scattered reflections from the direct sound. Polar diagrams for different frequency bands were drawn for the comparison of the scattering uniformity of the three diffusers.

SS36 3D Sound Reproduction

Chair: de Vries Diemer, Brix Sandra

Monday 08:20-08:40, Hall Aalborg, Paper 0564 (contributed)
Nishimura Kiminobu
Study on 3-dimentional localization under standard stereophonic representation by vibration control with audio insulators

Nishimura Kiminobu[1], Ina Ryuhkei[2]
[1] Kinki University, Japan, [2] KRYNA Co. Ltd., Japan

Three-dimensional distribution of reproduced acoustic phantoms recognized by summing localization under a standard stereophonic representation and detail circumstances of recording scene suffer from effects of signal and power cables, a jitter of digital audio system, vibration on equipments and etc. These high order acoustic and sensational information seems to be preserved and recorded together with major acoustic signal, but an additive noise and harmonic distortion of stereophonic equipment cover its spatial information and make them blurred one. On the other hand, many kinds of audio insulators are used to better the sound quality of stereophonic equipments, but their effects seem not always better in improvement of sound quality. In this study, to clarify how the insulators effects on stereophonic equipment, first we consider how works the insulator to the loaded equipment from view point of mechanical vibration induced on stereophonic equipments related with a AC power transformer, CD drive mechanism and radiated sound from loud speakers etc. Next, we evaluate experimentally its effects on noise suppression of stereophonic equipments and finally we carried out a listening test of represented sound. Consequently, the insulator is effective to reduce inevitable vibration and electrical noise on stereophonic equipments and to improve the sound quality and summing localization of reproduced stereophonic sound.

Monday 08:40-09:00, Hall Aalborg, Paper 0821 (contributed)
Nykänen Arne
Effects on localization performance from moving the sources in binaural reproductions

Nykänen Arne[1], Zedigh Axel[2], Mohlin Peter[2]
[1] Luleå University of Technology, Sweden, [2] SEMCON, Sweden

A well-known problem for reproductions of binaural recordings and simulations using HRTFs other than those of the actual listener is decreased localization performance and increased front-back confusion. Previous studies have indicated that moving the sound source can reduce these problems. The objective of this study was to measure how a unidirectional sound source movement along an orbit in the horizontal plane (achieved by reproducing sounds with a loudspeaker and turning a recording artificial head with a velocity of 5°/s) affects front-back confusion and localization errors. Two factors were studied: 1. Movement (static or rotation). 2. Acoustic environment (anechoic or reverberant). Male speech and recurring 840 Hz sinusoidal tones with a Gaussian envelope were used as stimuli. Listening tests showed that the front-back confusion rate and the rate of incorrectly perceiving that the sound is coming straight from the side were significantly lower (95% confidence level) in the reverberant condition compared to the anechoic condition. The front-back confusion rate was lower for the moving auditory scene compared to the static auditory scene, both in anechoic and reverberant conditions, but these differences were not significant. To conclude, there is reason to add room reflections to 3D sound synthesis in order to enhance localization performance in auditory displays. The effect of adding movements is small in comparison to the effect of adding reflections.

Monday 09:00-09:20, Hall Aalborg, Paper 0682 (contributed)
Firtha Gergely
Sound field reproduction with stochastic secondary sources

Firtha Gergely, Fiala Péter
Budapest University of Technology and Economics, Laboratory of Acoustics, Hungary

Sound field reproduction (including wavefield synthesis and spectral division method) is a state-of-the-art technique, aiming to physically reproduce an arbitrary sound field, usually generated by a virtual sound source. To achieve this, densely spaced loudspeaker array, termed as secondary source distribution is driven by a driving function derived either in spatial or spectral domain. The synthesis is usually modelled as reproduction, applying continuous point source distribution. However, practial realization applies extended vibrating surfaces (e.g dynamic loudspeaker), exhibiting stochastic properties. In this contribution we give a treatise on the synthesis applying extended secondary sources. Stochastic behaviour is modelled as additive noise on source extension function and on the driving function. The proposed model can incorporate the effect of stochastic speaker sensitivity, surface rugosity, mechanical anisotropy and stochastic modal behaviour. It is

investigated, how the different stochastic properties contribute to the radiated sound field. Based on the sensitivity of human auditory system it is examined, how the stochastic behaviour of the sec- ondary sources influences the localization of the synthesized virtual sound source. Besides analytical examination the results of Monte Carlo simulations are presented.

Monday 09:20-09:40, Hall Aalborg, Paper 1014 (contributed)
Zhykhar Albert
Spatial Sound Reproduction for the Prediction of Machine Acoustics - A Case Study

Zhykhar Albert, Sladeczek Christoph, Wolf Maximilian, Brix Sandra
Fraunhofer Institute for Digital Media Technology IDMT, Germany

In the recent decades the requirements for sounds created by machines have been significantly increased, such as controlling noise radiation or producing brand sounds. Thus, techniques to predict and assess the sound emission of machines, including the spatial properties of the sound field, become more and more important. Different physical/mathematical models exist to estimate the radiated sound of machines. Combining these models with a spatially correct sound reproduction system can lead to improvements in acoustical prototyping. Wave field synthesis (WFS) is a spatial sound reproduction technique which uses an array of loudspeakers for the physical creation of a virtual source sound field. Besides the support of multiple users over an extended listening area, recent approaches allow the synthesis of complex sound fields such as those radiated by directional sources. This paper presents a case study on the re-synthesis of a sound field emitted by a machine using WFS. For this purpose, the directional sound field of a specific mechanical device, called pick-and-place unit, has been measured, analyzed, and is then reproduced using a loudspeaker array. Starting from the derivation of a loudspeaker driving function, we describe a workflow for capturing, processing, and reproduction of the measured sound field.

SS37 Numerical Techniques

Chair: Atalla Noureddine, Hamdi Mohamed-Ali

Monday 09:40-10:00, Hall Aalborg, Paper 0694 (invited)
Tautz Matthias
A coupling method for hybrid CFD-CAA simulations using a dual mesh approach

Tautz Matthias, Altenhein Kerstin, Willmitzer Sebastian, Becker Stefan
Institute for Process Technology and Machinery, Germany

Noise prediction, reduction and design inside cars passenger compartments gains increasing interest. In this context numerical methods get more important in order to predict the noise of HVAC systems. In this work a hybrid method is presented for the simulation of aeroacoustic noise, based on Lighthills analogy. Therefore in the first step a transient fluid dynamics simulation using the LES turbulence model and finite volume discretization approach is carried out. The aeroacoustic sources appearing are calculated on an especially created finite element grid, which is dual to the CFD grid. This approach avoids interpolation during the acoustic source calculation. In the last step the sources are interpolated onto an acoustic simulation grid and the noise propagation is calculated by solving the wave equation in a finite element scheme. The model simulated was a simplified HVAC outlet consisting just of a plate inside a channel. This way a significant Parker type mode appears, which can be compared to experiments as well as analytics and shows good agreement.

Monday 10:00-10:20, Hall Aalborg, Paper 0062 (contributed)
Xuan Ling-kuan
A finite volume method applied to the structural-acoustic problem in anisotropic structure

Xuan Ling-kuan, Zhang Wen-ping, Ming Ping-jian, Gong Jing-feng
College of Power and Energy Engineering, Harbin Engineering University, China

This work presents a unified finite volume approach for evaluating the structural-acoustic problem in anisotropic structures. A partitioned bidirectional coupling algorithm is adopted to solve this multi-physics problem. The global model is divided into solid and fluid subdomains and each subdomain is solved independently. The interaction between the different subdomains is implemented by interface boundary conditions of force balance and normal velocity continuity. A time marching method of

explicit scheme is applied and different time steps are adopted in different subdomains to improve the computational efficiency. The dynamic and modal analysis of the structural-acoustic system is studied. The predicted results show good agreement with exact solutions and those from finite element method.

Monday 11:00-11:20, Hall Aalborg, Paper 0056 (contributed)
Chu S. H. K.
Three-dimensional numerical modelling of sound propagation in a long partial enclosure

Chu S. H. K., Tang S. K.
Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong

The acoustical properties along a long rectangular partial enclosure with a circular sound source on the top wall of the duct centre are studied numerically using three-dimensional stimulations. The computational domain of interest is set to be a uniform cross section with a gap along the duct and the gap is connected to a free field environment. An absorptive portion is added to each end of the domain as non-reflecting termination. Sound propagating modes inside the rigid partial enclosure are identified. The gap radiates sound into the free space and distortion of mode shape is recognized at cross sections for various gap sizes. In-duct modal decomposition is adopted to analyze the computational data of sound pressure over the concerned internal cross sections. Contributions of discrete propagating modes are examined. Results show that the decaying rate of the amplitude of acoustic pressure along the duct axial direction correlates closely with the modal frequency and gap size.

Monday 11:20-11:40, Hall Aalborg, Paper 0832 (invited)
Alimonti Luca
Assessment of the accuracy of a hybrid Finite Element-Transfer Matrix based model for vibroacoustic systems including poroealstic materials

Alimonti Luca[1], Atalla Noureddine[1], Berry Alain[1], Sgard Franck[2]
[1] Groupe d'Acoustique de l'Universite de Sherbrooke, Canada, [2] IRSST, Canada

Modeling complex vibroacoustic systems including poroelastic materials using Finite Element (FE) based methods can be computationally expensive. For this reason, fast analytical approaches, such as the Tranfer Matrix Method (TMM), are often preferred to such sophisticated numerical techniques. However,

analytical methodologies suffer from a lack of accuracy in the description of the geometry of the system. To alleviate this drawback, attempts have been made to couple a FE model of the elastic and acoustic domains with a TM model of the sound package. The authors recently proposed a hybrid methodology based on a Green's function formulation to account for sound packages in FE models. Although this hybrid methodology seems capable of capturing the physics better than classical approaches, the simplifications introduced by the analytical model can, in some cases, lead to an erroneous estimation of the vibroacoustic performance. In this work, the limitations of the methodology are assessed. A benchmark of typical vibroacoustic systems is presented to show the misbehavior of the hybrid model by a comparison with the FE solution. This lack of accuracy is due to the assumption of an infinite extent sound package inherent within the TMM.

Monday 11:40-12:00, Hall Aalborg, Paper 0813 (contributed)
Guerich Mohamed
Design vibro-acoustic Optimization of Sandwich panels

Guerich Mohamed[1], Assaf Samir[2]

[1] Département de Mécanique des Systèmes, Ecole Supérieure d'Ingénieurs Léonard de Vinci (ESILV), France, [2] Equipe Acoustique et Vibration, Ecole Supérieure des Techniques Aéronautiques et de Construction, Automobile (ESTACA), France

In this paper, an optimization methodology to enhance the acoustic performance and lightweight characteristics of damped sandwich structures is proposed. The studied damped structure is made up of a thin, soft viscoelastic core sandwiched between two relatively stiff layers. The vibro-acoustic indicator used to evaluate the acoustic performance is the noise transmission loss (TL). The prediction of the TL uses a numerical tool based on a finite element formulation for the sandwich plate coupled to a boundary element method for the acoustic medium. This tool can be used for arbitrarily shaped three-layer sandwich plates with various boundary conditions and it is well adapted to parametric and optimization studies. First, a parametric study was conducted to choose the objective function, the constraints and the pertinent design variables to use in the optimization problem which consist in reducing the sound power transmitted by a viscoelastically damped sandwich plate. Next, by constraining the acoustical behavior of the sandwich panel, the surface mass of the sandwich structure was minimized. It is shown that a significant reduction in the transmitted sound power can be achieved by

selecting the appropriate geometric configuration and damping layer material.

Monday 12:00-12:20, Hall Aalborg, Paper 1188 (contributed)
Bajer Andrzej
Modal coupled acoustic-structural frequency-response analysis based on coupled modes

Bajer Andrzej, Belyi Mikhail, Belsky Vladimir
Dassault Systèmes Simulia Corporation, USA

For most NVH engineers, the frequency-response analysis is a commonly accepted tool for noise simulation of coupled acoustic-structural problems. For weakly coupled problems (e.g. air and steel), usually modal methods are used, because they are computationally inexpensive and mod al subspace determined by solving two separate eigenproblems on acoustic and structural domain provides approximation that is sufficiently accurate to model the coupled problem. But for strongly coupled problems (e.g. water and steel), a much more expensive direct-solution frequency-response is usually used. A modal method that uses coupled acoustic-structural modes is available, but it becomes quite expensive if the higher number of modes is utilized what limits applications of such an algorithm only to a rather low frequency range. We propose a new implementation of the frequency-response algorithm based on coupled acoustic-structural modes which drastically reduces analysis time. In addition, parallel implementation is available and demonstrates very go od scaling on shared-memory machines. These improvements allow utilizing many more eigenmodes and thus, extending the area of applications of this method to much higher frequency range. The effectiveness of the proposed algorithm is supported a by a couple of industrial applications where superior performance (comparing to direct-solution method) and very good accuracy are achieved.

Monday 12:20-12:40, Hall Aalborg, Paper 0426 (contributed)
Cutanda-Henríquez Vicente
Implementation of an Acoustic 3D BEM with Visco-Thermal Losses

Cutanda-Henríquez Vicente, Juhl Peter M.
Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Denmark

There is an increasing need in industry for numerical acoustic models including viscous and thermal losses of sound in air. Small devices such as couplers,

microphones, mobile phones and hearing aids contain small cavities and passages where wave propagation cannot be assumed to be lossless. Viscous and thermal losses are relevant within the so-called viscous and thermal boundary layers, filling a significant part of the internal volume of these small devices. The fact that the loss mechanism is related to a boundary makes the Boundary Element Method a natural choice for this implementation. In the present work, a three-dimensional BEM implementation based on the Kirchhoff decomposition of the Navier-Stokes equations into viscous, thermal and acoustic wave modes is described. The implementation details include: i) development of a vector velocity boundary condition and the coordinate changes involved, ii) tangential derivatives on the boundary using irregular meshes and iii) derivation of the acoustic variables in the domain.

Monday 12:40-13:00, Hall Aalborg, Paper 0424 (contributed)
Juhl Peter M.
Verification of an Acoustic 3D BEM with Visco-Thermal Losses

Juhl Peter M., Cutanda-Henríquez Vicente, Álvarez Jesús Gómez
Maersk Mc-Kinney Moller Institute, University of Southern Denmark, Denmark

Sound waves propagating in the interior of devices such as acoustic transducers, hearing aids and mobile phones undergo a significant amount of losses due to viscous and thermal effects. In some cases like microphones, the performance of the device even relies on controlling these loss mechanisms. A newly implemented three-dimensional Boundary Element Method with visco-thermal losses will be tested in this work using a number of cases, including idealized setups with analytical solutions and actual measurements on existing devices. In particular, measurement microphones will be used as test cases. These devices are challenging due to the high degree of coupling between diaphragm, internal gap, back cavity and external medium. In this work they are modeled using a coupled FEM-BEM model, where the Finite Element Method is used on the diaphragm.

Monday 14:00-14:20, Hall Aalborg, Paper 0684 (contributed)
Fiala Péter
NiHu: A BEM-FMBEM Matlab toolbox

Fiala Péter, Rucz Péter
Budapest University of Technology and Economics, Laboratory of Acoustics, Hungary

We introduce an open source BEM Matlab/C++ toolbox, called NiHu. The toolbox is a general frame- work implementation for Boundary Element Methods. NiHu is meant to serve mainly educational and research purposes, but it is also capable of dealing with large-scale industrial problems. The toolbox consists of a core and a shell layer. The core is implemented in C++, and is responsible for the evaluation of weighted residual integrals. Conventional collocational and Galerkin BEM is implemented therein. C++ template metaprogramming is extensively exploited in order to achieve good core performance and flexibility at the same time. The implementation incorporates recently published techniques, such as efficient evaluation of (hyper)singular integrals and economic treatment of symmetric problems. The Matlab shell provides an easy-to-use user iterface with basic meshing capabilities, mesh import/export, compatibility with other modeling software and result visualisation. The Fast Multipole BEM module of the toolbox is implemented in the Matlab shell. NiHu is released with tutorials containing benchmark test cases and introducing applications in sev- eral acoustic areas, such as noise propagation, musical acoustics, electroacoustics and sound field reproduction. The toolbox is available at http://last.hit.bme.hu/devel/nihu-toolbox.

Monday 14:20-14:40, Hall Aalborg, Paper 0812 (contributed)
Rondeau Jean-François
Equivalent curvatures broadband Insertion Loss simulation technique coupling Virtual SEA and BEM/FEM approaches

Rondeau Jean-François, Duval Arnaud, Monet-Descombey Julien, Dejaeger Ludovic
Faurecia AST Acoustic TechCenter, France

Reliable broadband trims simulation is a key issue in the automotive industry, in order to reach CO2 emission reduction targets, meaning reducing weight while maintaining the passenger's acoustic comfort. Recent developments have shown the feasibility to use BEM/FEM approaches in the low-middle frequency range for both trims considered alone (dash-inner or complete floor for example) or in combination such as the so-called cockpit (dash-inner and instrument panel) for example. Nevertheless, such kind of modeling approaches remain time-consuming especially regarding multilayers trims meshing tasks. Using a frequency dependent SEA substructuration based on a virtual Power Injection Method and a peripheral attraction algorithm (Virtual-SEA analysis) for the bare structure, the aim here is to introduce trims as FEM Insertion Losses recomposed from a database of pre-

computed equivalent curvature cases (depending on radius of curvature, thicknesses and nature of the trim) in order to drastically decrease the model building time and thus automate computation tasks. This paper presents direct measurement of a dash-inner in coupled reverberant rooms and the correlation with the full direct BEM/FEM simulation and the correlation with this new equivalent curvature approach depending on the way the trim Insertion Losses are simulated: FTMM on plane models and/or BEM/FEM techniques on plane and curved models.

Monday 14:40-15:00, Hall Aalborg, Paper 0462 (contributed)
Waubke Holger
Boundary element method for the calculation of correction factors of insertion loss for arbitrarily shaped noise barriers

Waubke Holger[1], Kasess Christian[1], Hoislbauer Heinz[2], Strohmayer Gerhard[2]
[1] Acoustics Research Institute, Austria, [2] TAS SV-GmbH, Austria

Noise mapping software uses in general geometric methods to calculate the insertion loss of a noise barrier which is not appropriate for complex shapes with e.g. multiple edges. The aim of the current project is to derive simple formulas that can be used in noise mapping software. In this way new shapes of noise barriers can be brought into praxis. The boundary element method in 2D is used to calculate the insertion loss. The ground surface is modelled with a two parameter grassland model from Attenborough for a more realistic representation of ground reflections. Deriving the correction factors for different geometries requires a large number of different geometries to be calculated. Thus, for reduced computational effort a 2D model with a coherent line source is assumed. This assumption leads to considerable interference effects behind the barrier. Spectral and spatial averaging can reduce these effects only to a certain degree. In order to estimate the contribution of this effect, a few selected geometries will be assessed using 3D models and partially incoherent summation over a number of evaluation points along the z-axis. 3D modelling employs the fast multipole method and thus no grassland model will be used in 3D.

Monday 15:00-15:20, Hall Aalborg, Paper 0647 (contributed)
Ogawa Satoshi
Numerical sound field analysis considering atmospheric conditions

Ogawa Satoshi, Oikawa Yasuhiro
Department of Intermedia Art and Science, Waseda University, Japan

Some systems such as an outdoor public address system and radio acoustic sounding system create loud sounds. The sounds need to be propagated to the desired location for efficient public address. However, sound is greatly affected by atmospheric conditions particularly for long-distance propagation, and it is important to comprehend atmospheric effects. Numerical methods based on geometric acoustics or linear wave acoustics are widely used today for sound field analysis. However, these methods cannot easily consider atmospheric conditions. In addition, we cannot analyze nonlinear sound fields by these methods. In the present paper, we propose a method for analyzing sound fields considering atmospheric conditions and nonlinearity. Equations for numerical sound field analysis, with which we can consider various atmospheric conditions and nonlinearity, are derived from the equations of continuity in fluid dynamics, the Navier–Stokes equations and the law of the conservation of energy. We present numerical calculations of acoustic radiation characteristics and sound fields based on the equations we have obtained, and we use the finite-difference time-domain method to solve them. The effects of atmospheric conditions such as wind, viscosity and nonlinearity can be seen in the results, and thus, the sound generation and sound wave propagation can be comprehended in detail.

Monday 15:20-15:40, Hall Aalborg, Paper 0955 (contributed)
Iwabuki Hiroshi
Numerical simulation for low frequency sound emitted from viaduct of the road by the vehicle load

Iwabuki Hiroshi[1], Osafune Toshikazu[1], Shimura Masayuki[2], Kamiakito Noboru[2], Aoki Atsushi[2], Kobayashi Masato[2], Niwa Hisashi[2]

[1] Nippon Expressway Research Institute Co. Ltd., Japan
[2] Civil Engineering and Eco-Technology Consultants Co. Ltd., Japan

The road complaints regarding noise, vibration and low frequency sounds have been delivered to the road and highway manager by residents living along the road. The countermeasure of road’s noise and vibration depend on the generating source which define the construction work. Since, it may be

difficult to determine the cause of low frequency sound, then, the generation mechanism should be considered. Therefore we tried the numerical simulation of low frequency sound field to estimate the response of a viaduct when vehicles run along track using three dimensional finite element method with unsteady analysis and non-stationary boundary condition. This method can be used to consider which part of the viaduct that largely generates low frequency sound. This paper introduces several cases that simulated by large-scale numerical model.

Monday 15:40-16:00, Hall Aalborg, Paper 1116 (contributed)
Ishikawa Satoshi
Two-dimensional Acoustic Analysis by Concentrated Mass Model

Ishikawa Satoshi[1], Kijimoto Shinya[1], Koba Yosuke[1], Owaki Ryoma[2], Mori Yuuki[1]

[1] Department of mechanical engineering, Kyushu University, Japan
[2] Mitsubishi Electric Corporation, Japan

FDTD method and CIP method are used for an acoustic analysis in time domain. However, these methods do not take into account a sound attenuation from viscosity. In our study, we propose a concentrated mass model which consists of spring-mass-damper system to perform a two-dimensional acoustic analysis. The dampers of this model consider viscosity of air. In this paper, we derive mass, connecting springs, connecting dampers, and base support dampers. The characteristic of the connecting spring is derived from the condition of adiabatic change of air, and the connecting damper is derived from the normal stress. To confirm the validity of the proposed model, the numerical results obtained by the concentrated mass model are compared with the theoretical value of the traveling wave, and with the theoretical value of the natural frequency. All numerical computational results agree very well with the theoretical values. Therefore, it is concluded that the proposed model is valid for the two-dimensional acoustic analysis.

Monday 16:00-16:20, Hall Aalborg, Paper 1122 (contributed)
Sugiki Shohei
Simulation of Speech Production by Concentrated Mass Model

Sugiki Shohei, Ishikawa Satoshi, Kijimoto Shinya, Koba Yosuke
Department of Mechanical Engineering, Kyushu University, Japan

Larynx cancer or pulmonary problems cause the initial symptoms such as hoarse voice. There is a possibility of diagnoses of the affected area by analyzing these changes of voice. In this study, our purpose is to enable diagnoses of larynx cancer or pulmonary problems by an acoustic analysis model inside of the vocal tract. As a first step, we aimed to establish an acoustic analysis method in the vocal tract, and identification method of vocal tract shapes and vocal sound source waveforms. In this paper, we modeled the air in the vocal tract as a concentrated mass model that consists of masses, connecting linear springs, connecting dampers, and base support dampers. And we make an acoustic analysis model in the vocal tract. Then we identified the vocal tract shapes by using the Levenberg-Marquardt method, and analyzed vocal sound source waveforms by using the transfer matrix method from the measured voice wave. And we simulated a speech production by the analyzed sound source. The identified vocal tract shapes are valid and the analyzed vocal sound source waveforms are similar to the Rosenberg wave. The speech production results are clear voices. Then, we conclude our proposed methods are valid.

Monday 16:20-16:40, Hall Aalborg, Paper 0644 (contributed)
Soga Akihisa
Measurementof high frequency engine noise using converted nearfield acoustic holography method

Soga Akihisa[1], Nagamatsu Masao[2], Iwahara Mitsuo[1], Minorikawa Gaku[1], Takamatsu Mao[3], Baba Mao[4]

[1] Hosei University, Japan, [2] Hokkaido Institute of Technology, Japan. [3] YKK corp., Japan
[4] Alpen Co. Ltd, Japan

There are several types of sound localization methodsof which the holographicmethodsare mainly used for middle frequency sound localizationbecause of its high resolution. While, these methods havea demerit taking long time to measure sound fieldwhen applied for the high frequency sound localization.This problem is caused by the sampling law in the spatial domain. One purpose of sound localization methods is the application ofengine noise reductionto an automotive industry.However, the engine noise also includeshigh frequency noisewhich takes long time to measureby using conventional holographic methods. While, as a prototype engine is somewhat dangerous and difficultto drive for a long time, it is not necessaryto localize long time high frequency noise. We have developednew holographic methodconverted Nearfield Holography methodwhichcan quickly measure the high frequency noise, but has some deterioration in

reconstructed images. In this paper, the high frequency noise of a 1 cylinder engine is measured by our proposed method. As a result, it is found that the reconstructed images themselves are not sharp, but nearly indicate the noise source location , which means thatour proposedmethod is useful for the high frequency sound localization of engines.

SS38 Sound Visualization and Aurealization

Chair: Rindel Jens, Ich Jeong Guon

Monday 16:40-17:00, Hall Aalborg, Paper 0676 (contributed)
Fernandez-Grande Efren
Holographic reconstruction of sound fields based on the acousto-optic effect

Fernandez-Grande Efren[1], Torras-Rosell Antoni[2], Jacobsen Finn[1]

[1] Acoustic Technology, Department of Electrical Engineering, DTU - Technical University of Denmark, Denmark, [2] DFM, Danish National Metrology Institute, Denmark

Recent studies have shown that it is possible to measure a sound field using acousto-optic tomography. The acousto-optic effect, i.e., the interaction between sound and light, can be used to measure an arbitrary sound field by scanning it with a laser Doppler vibrometer (LDV) over an aperture; This can be described mathe- matically by means of the Radon transform of the acoustic field. An interesting feature of this measurement technique is that the spatial characteristics of the sound field are captured in the measurement. Therefore, the technique has an inherent holographic potential, implicitly yielding a full characterization of the sound field. In this study, a direct projection of the Radon transform from one plane to another and into the space domain, based on an elementary wave expansion is proposed. The relationship between the Radon and the wavenum- ber domains is examined, and the reconstruction potential of the method analyzed. The study includes both numerical and experimental results.

Monday 17:00-17:20, Hall Aalborg, Paper 0306 (contributed)
Labelle Ludovic
Acoustic holography on a vibrating plate

Labelle Ludovic[1], Roozen N.B.[1,2], Glorieux Christ[1]

[1] Katholieke Universiteit Leuven, Laboratory for Acoustics and Thermal Physics (ATF), Department of Physics and Astronomy, Belgium
[2] Katholieke Universiteit Leuven, Department of Mechanical Engineering, Belgium

In the framework of the implementation of an acoustic holography measurement method for the acoustic characterization of porous materials (Tamura method), a validating measurement was carried out on a vibrating plate. The experiment was carried out in a semi-anechoic room, on a square aluminum plate, which was excited by a shaker at one of its

resonance frequencies. The experiments were preceded by a numerical simulation predicting resonant vibration patterns. The plate was then suspended by means of thin wires at the nodal lines of a vibration pattern of interest, thus reducing the influence of the suspension to a minimum. Good correspondence was found between the numerical simulations and the experiments. The vibration pattern was scanned by means of a precise robot system, moving a microphone that was acquiring pressure signals. The resulting 3D map of signals was post-processed by an acoustic holography algorithm, yielding the 2D map of sound pressure close to the plate. A quantitative validation of the acoustic holography results was performed by simultaneously measuring the vibration amplitudes of the plate by means of a laser-vibrometer.

Monday 17:20-17:40, Hall Aalborg, Paper 0675 (contributed)
Zhang Hai-Bin
Comparative study of spatial complex envelope and cyclostationary near-field acoustical holography for visualizing amplitude modulation sound field

Zhang Hai-Bin, Jiang Wei-Kang
Institute of Vibration, Shock & Noise, Shanghai Jiao Tong University, China

There exists a kind of sound field induced by amplitude modulation acoustical signal. Near-field acoustical holography (NAH) method was modified to visualize this sound field and extract useful information. One of them is spatial complex envelope in time domain which was developed for capturing the distribution of amplitude modulation part of the signal in space and time domain. The main advantage of this method was to obtain the rough information of the sound field with less computing time. Another method named Cyclostationary near field acoustical holography (CYNAH) was developed for analyzing the cyclostationary sound field initially. Its target is to visualize the distribution of the amplitude modulation cyclostationary acoustical sources by taking the second-order cyclostationary statistics as the reconstruction variance. It is analyzed that it can also be applied to common amplitude modulation signal. Comparisons are carried out and found that the complex envelope visualizes the amplitude modulation part by transform in wavenumber domain and CYNAH does it by making transform in frequency domain, respectively. Numerical simulations are done to validate and compare these two methods. It is proved that both of them can locate the amplitude modulation sound source in different domains, respectively.

Monday 17:40-18:00, Hall Aalborg, Paper 0154 (contributed)
Zhang Xiaozheng
Reconstruction of particle velocity fields in the time-wavenumber domain using real-time nearfield acoustic holography

Zhang Xiaozheng, Bi Chuanxing, Zhang Yongbin, Xu Liang
Hefei University of Technology, China

Real-time nearfield acoustic holography (RT-NAH) based on the pressure-pressure impulse response function can only realize the reconstruction from the pressure on the measurement plane to the pressure on the reconstruction plane. In this paper, a pressure-velocity impulse response function is firstly deduced to establish the relationship between the pressure and the particle velocity, and it is used to realize continuous reconstruction from the pressure on the measurement plane to the particle velocity on the reconstruction plane in RT-NAH. The simulation results with a circular piston as the source and the experiment results with an impacted plate as the source, demonstrate that RT-NAH based on the pressure-velocity impulse response function can reconstruct the particle velocity fields effectively.

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SS52 Environmental health impact assessment of transportation noise at different scales

Chair: Lercher Peter

Tuesday 08:20-08:40, Hall Tirol, Paper 1125 (contributed)
Fenech Benjamin
Health effects from high-speed railway noise – a literature review

Fenech Benjamin[1], Cobbing Colin[2], Greer Richard[1], Marshall Tom[3]
[1] Arup, UK, [2] ARM Acoustics, UK, [3] HS2 Ltd., UK

In the EU it is a requirement to provide information on the potential effects of noise to support the development of new railways. This information includes an assessment of the noise effects on people and the mitigation strategies to avoid or reduce the potential adverse effects. In some communities there may be concern that noise exposure caused by high speed trains has unique characteristics that could result in a greater impact than that which might occur from conventional rail. Environmental noise can cause annoyance and sleep disturbance effects. The likely scale of annoyance and sleep disturbance can be correlated with noise indices. There is growing concern in some circumstances that long term exposure to environmental noise may cause indirect cognitive effects and physical health effects such as myocardial infarction. This paper reviews the evidence on the possible effects of noise from transportation on physical health and social well-being. The influence of parameters such as sound pressure rise time, noise event duration, source to receiver distances and simultaneous exposure to perceptible vibration is reviewed based upon recently published studies. Emphasis is given on the availability of evidence related to railway noise, and high speed railways in particular.

Tuesday 08:40-09:00, Hall Tirol, Paper 0961 (invited)
Giering Kerstin
Effect-related index for railway noise

Giering Kerstin[1], Augustin Sabine[2], Strünke-Banz Sandra[1]

[1] HS Trier, Umwelt-Campus Birkenfeld, Germany, [2] formerly HS Trier, Umwelt-Campus Birkenfeld, Germany

The Middle Rhine Valley in the western part of Germany is strongly affected by railway noise. Due to the new Betuwe-route and the NEAT route (Neue

Europäische Alpen-Transversale) the railway traffic will still be growing. Therefore, measures for noise reduction are necessary. An effect-related railway noise index describing the number of highly annoyed people during daytime and the average number of additional nocturnal railway noise-induced awakenings is suggested. Thereby it will become possible to carry out an effective noise protection which reduces the effects of noise and not only the noise level. This contribution describes the calculation of this index, the underlying exposure response functions for railway noise annoyance and railway noise-induced awakenings and gives some examples of the variation of the index by different noise abatement measures.

Tuesday 09:00-09:20, Hall Tirol, Paper 1003 (contributed)
Schreckenberg Dirk
Exposure-response relationship for railway noise annoyance in the Middle Rhine Valley

Schreckenberg Dirk
ZEUS GmbH, Germany

The railway line in the Middle Rhine Valley is part of the north-south transversal Rotterdam – Genoa. Residents living in the vicinity of the railway line suffer from high rail traffic density and, thus, high noise levels, in particular due to freight trains. Aiming at reducing the average sound level of the railway noise in the Rhine Valley by 10 dB the Ministries for Environment and Transport of the German states Hesse and Rhineland Palatinate published a noise control program called "Quite Rhine Valley" in 2010. Among others, for the purpose of noise monitoring the program includes the implementation of a railway noise impact index (MRI) describing the number of highly annoyed people during day time and the average number of additional nocturnal railway noise-induced awakenings (see contribution of Kerstin Giering et al. in the same Internoise session). This contribution presents results of a socio-acoustical survey with altogether 1211 residents carried out in the Middle Rhine Valley in order to provide an exposure response function for the 'annoyance part' of the MRI. Among others, the results indicate that the so-called railway bonus can be questioned at least for the noise situation in the Rhine Valley.

Tuesday 09:20-09:40, Hall Tirol, Paper 0625 (contributed)
Mietlicki Fanny
Health impact of noise in the Paris agglomeration: assessment of healthy life years lost

Mietlicki F.[1], Host S.[2], Kim R.[3], Da Silva R.[1], Ribeiro C.[1], Chatignoux E.[2]

[1] Bruitparif, Noise Observatory in Ile de France, France, [2] ORS Ile-de-France, Regional Health Observatory in Ile-de-France, France, [3] WHO European Centre for Environment and Health, Germany

Many studies have shown that environmental noise exposures are related to non-auditory effects such as sleep disturbance, annoyance and cardiovascular diseases. The Regional Health Observatory and Bruitparif applied WHO methodology in order to quantify impacts of environmental noise on the health of the population in the Paris metropolitan area, in terms of DALYs (disability-adjusted life-years). Health and noise exposure (coming from the strategic noise maps) data were aggregated at the "commune" (French counties) level. Our evaluation showed that around 66,000 healthy life years were lost every year in the Paris agglomeration due to noise exposure. The main health outcomes were sleep disturbance (nearly two thirds of the years lost) and annoyance. Traffic noise had the greatest health impact (about 87% of the DALYs loss). Health impacts related to aircraft noise were much lower (4% of the DALYs loss), but they should be taken cautiously, as the use of the Lden indicator appears inaccurate to account for the event nature of aircraft noise. This assessment gives a minimum approach of the health impact of noise in the Paris agglomeration and points that noise is a main public health interest. The results of this study will be presented.

Tuesday 09:40-10:00, Hall Tirol, Paper 1234 (contributed)
Lercher Peter
The assessment of the health benefits of a night curfew on truck traffic in an alpine valley: effects on sleep and annoyance

Lercher Peter
Division of Social Medicine, Medical University Innsbruck, Austria

Background: The WHO-JCR has provided a general methodology to assess the health impact of environmental noise at larger scale. Switzerland used this methodology in a recent assessment. Other countries use their own assessment strategies. At smaller scales (regional, community) the application of this methodology is limited due to the use of standard exposure effect curves. In order to ensure to meet local needs (alpine valley) we adapted the methodology. Methods: We used actual GIS noise map information and merged it with GIS population information to get the number of noise exposed (30 to 70 dBA, L_{day}, $L_{evening}$, and L_{night}). On the effect side we used annoyance, sleep disturbance, hypertension and myocardial infarction. A mix of standard and regional exposure response information was applied. An upper and lower

95% confidence interval was derived for the prevalence estimates. With cost calculations we relied on the experience of the HEIMTSA-project. Results: The status quo yields high annoyance (3000-5000 persons) and high sleep disturbance (3000-4000 persons) as most important contributors. However, sleep disturbance shows the highest gain through a night curfew in truck traffic in health terms (number of affected, DALYs) and even more in health cost.

Tuesday 10:00-10:20, Hall Tirol, Paper 1051 (contributed)
zur Nieden Anja
NORAH Study: Blood pressure monitoring using telemedicine - design and methods to investigate associations of blood pressure with aircraft, road traffic and railway traffic noise

zur Nieden Anja[1], Harpel Susanne[1], Lengler Azita[1], Möhler Ulrich[2], Schreckenberg Dirk[3], Seidler Andreas[4], Eikmann Thomas[1]

[1] Justus-Liebig-Universität Giessen, Institute for Hygiene and Environmental Medicine, Germany, [2] Möhler + Partner Ingenieure AG, Germany, [3] ZEUS GmbH, Germany, [4] TU Dresden, Institute and Outpatient Clinics of Occupational and Social Medicine (IPAS), Germany

The monitoring program for blood pressure (07/2012-04/2014) is designed as a longitudinal study aiming to analyze, whether blood pressure (averaged over measurements within 14 consecutive days out of 21-day-period) as well as the risk of cardio-vascular diseases in total is associated with aircraft noise exposure, road traffic and railway noise and whether the changes in the flight operations due to airport expansion correspond with changes in the average blood pressure over time. Participants (n=2000) are trained to assess their blood pressure in the morning and evening on 21 days. In addition, they fill in a questionnaire on cardio-vascular risk factors. The same participants are asked to repeat measurements in the follow-up one year later. The devices used for measuring blood pressure send the measured values to a cell phone via Bluetooth wirelessly. In turn the received values are forwarded in real time to a secure online database, using a protected internet connection (SSL encryption). Medical staff is monitoring the values to ensure frequency of the measurements and giving feedback to participants. The NORAH Study will be carried out from 2011 to 2014 by commission of the Environment & Community Center/Forum Airport & Region, Kelsterbach, Germany.

SS54 Alternative indicators for community noise effects assessment

Chair: Botteldooren Dick

Tuesday 11:00-11:20, Hall Tirol, Paper 0490 (invited)
Klein Achim
Physical and perceptual characterization of modulation sensations for improving the assessment of noise annoyance due to urban road traffic noise

Klein Achim[1], Marquis-Favre Catherine[1], Weber Reinhard[2]

[1] University of Lyon, France
[2] Oldenburg University, Institute of Physics - Acoustics Group, Germany

To date, European legislation requires member states to represent community noise by means of noise maps. Noise maps are produced based on the L_{DEN} (day-evening-night level) index which is also used for dose-effect relationships for noise annoyance prediction. However, for the assessment of noise annoyance in urban areas, its relevance is often questioned. Many studies showed that noise annoyance due to community noise is not solely based on the sound pressure level and other acoustical signal characteristics such as temporal and spectral features play an important role. This study aims at improving the perceptual and physical characterization of urban road traffic noise with respect to annoyance. In order to identify acoustical features underlying the perception of urban road traffic noise, a semantic differential test was conducted. The results of this test highlight the importance of different modulation sensations due to urban road traffic noise. It can be shown that psychoacoustic fluctuation strength and roughness correlate to a certain degree with sensations of “sputtering” and “nasal” that are related to noise annoyance. Noise annoyance assessment could benefit from an improved characterization of these modulation sensations.

Tuesday 11:20-11:40, Hall Tirol, Paper 0804 (invited)
Vincent Bruno
How to characterize environmental noise closer to people’s expectations

Vincent Bruno[1], Gissinger Vincent[1], Vallet Julie[2], Mietlicki Fanny[3], Champelovier Patricia[4], Carra Sébastien[1]

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The issue of resident's exposure to environmental noise is related to a minimum of two complementary approaches: acoustics, as regards of its physical characterization, and social sciences regarding exposure, perception and communication with the concerned public. Acoucité and Bruitparif (two French organizations in charge of management and organization of urban noise observatories in France) have worked since 2011 on a proposal for a new index closer to the feeling of the population. This research is conducted within the framework of the Harmonica project funded by the European Commission (LIFE). As a result, the data analysis of an extensive 800 person survey, complemented by 240 home interviews and 120 laboratory interviews with public, associations, politicians, technicians, and experts in acoustics, can suggest some paths to develop new indexes taking into account the continuous and eventful nature of noise while receiving a better understanding and acceptance of the general public. This type of index could supplement the information produced by the conventional indexes and indicators (Lden, L 10 ...). This article aims to present the results obtained in the framework of these approaches developed from the urban, peri-urban and rural population in France.

Tuesday 11:40-12:00, Hall Tirol, Paper 0829 (invited)
Ribeiro Carlos
At the heart of Harmonica project: the Common Noise Index (CNI)

Ribeiro Carlos[1], Anselme Céline[2], Mietlicki Fanny[1], Vincent Bruno[2], Da Silva Raphaël[1]

[1] Bruitparif, Noise Observatory in Ile-de-France, France, [2] Acoucité, Noise Observatory in the Greater Lyon agglomeration, France

The difficulty for the general public to understand the standard acoustic indicators expressed in decibels limits their suitability. Therefore, since 2011, Bruitparif and Acoucité (agencies in charge of assessing and monitoring noise in the two major French urban areas) have been working on a proposal to create a new index that is closer to what the population feels, based on a score from 0 to 10. This work is being carried out within the framework of the Harmonica project, financed by the European Commission (LIFE+ program). Four proposals of indices have been developed, based on different approaches, but all integrating both the continuous and the sporadic nature of noise. The new indices were adjusted and evaluated through *in situ* inhabitants' surveys and in laboratory with a larger public. The results were also compared with values supplied by the usual indicators. Easy to produce, the index selected will be tested on the information platforms

associated with the noise monitoring networks of Bruitparif and Acoucité, as well as on the European platform dedicated to communicating on the Harmonica project www.noiseineu.com (end of 2013). This article details the composition of the indices and the methodological approach used to create them.

Tuesday 12:00-12:20, Hall Tirol, Paper 1180 (invited)
Lercher Peter
Can noise from a main road be more annoying than from a highway? An environmental health and soundscape approach

Lercher Peter[1], Bockstael Annelies[2], Dekoninck Luc[2], De Coensel Bert[2], Botteldooren Dick[2]

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[2] Acoustics Research Group, Ghent University, Belgium

Background: In an early TNO-report (Miedema 1993) different exposure response curves were reported for highways and other road traffic. Other road traffic noise exposure showed less annoyance than noise from highways - but higher than railway noise exposure. In the later exposure response curves associated with the EU noise directive no separate account is made for other road traffic. Methods: Intensive traffic modeling, noise and survey information from two large studies in alpine valleys was used to generate enhanced exposure response curves. Further analyses were carried out by means of multiple logistic regression to explore the importance of modifying factors. Results: We found no uniform exposure response curves in the two valleys. Most important modifying factors were the relative position of the main road to the valley topography, settlement patterns, indicators of fluctuation/emergence, the number of heavy trucks and combined exposure (vibration, air). Conclusion: In complex situations (alpine topography, open settlement patterns, high signal to noise ratio) the accumulation of factors can in some cases lead to higher annoyance from main roads than from highways in a univariate perspective. Applying standard curves for Environmental health impact assessments may lead to misleading results. More inclusive approaches (soundscape, environmental health) are needed.

Tuesday 12:20-12:40, Hall Tirol, Paper 1306 (invited)
Kühner Dietrich
Alternative procedures for environmental noise assessment

Kühner Dietrich[1], Lercher Peter[2]

[1] Independent researcher, Germany
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It is simple algebra that a noise of 85 dB(A) lasting a minute during daytime has the same equivalent level, as a noise occurring 300 times for a minute with a level of 60 dB(A). This contradiction between noise duration and the public reaction to be expected will be examined using observations in the neighborhood south of the Frankfurt Airport before and after the opening of an additional landing strip. Based on this, the air craft noise situation resulting from the present and future air traffic at Zürich airport in the black forest area adjacent to the Swiss border is studied, comparing the concept of energy equivalent levels, loudness equivalent level and the daily duration during which air craft noise can be heard in view of measured background levels of less than 25 dB(A) in this area. To estimate the changes in loudness and the loudness equivalent level the averaged statistical distribution of the observed levels and the respective spectral structure is needed. This includes spectral structure of the background noise. As well as, of the sources under consideration, as it can be provided, using the hourly percentiles L_{90},L_{50},L_{10} and their percentile spectra. Using this, the loudness equivalent levels can be calculated. As can be seen from the increase in air traffic until 2030 at Zürich airport, the increase of the energy equivalent level may be 1 dB compared to 4.2 dB to the loudness equivalent level. This means that the loudness reacts far stronger to the increase of flight events.

SS56 Restorative aspects of sound exposure and quiet areas

Chair: Gidlöf-Gunnarsson, Nilsson Mats E.

Tuesday 14:00-14:20, Hall Tirol, Paper 0947 (invited)
van Kempen Elise
Characterizing urban areas with good sound quality: development of a protocol

van Kempen Elise, Devilee Jeroen, Swart Wim, van Kamp Irene

National Institute of Public Health and the Environment (RIVM), Centre for Sustainability, Environment and Health, The Netherlands

Due to rapid urbanization, the spatial variation between wanted and unwanted sounds will decrease or even disappear. Consequently, the characteristics of (urban) areas where people can temporarily withdraw themselves from urban stressors such as noise, may change or become increasingly scarce. Yet, hardly any research has been carried out into the positive health effects of spending time in areas with a good sound quality. One of the reasons is that it is very difficult to characterize these areas. For this, sound levels alone are not enough. Moreover, a good sound quality is not only composed by its acoustical aspects, but also by social, spatial and physical aspects other than sounds. A good overview of what aspects determine good sound quality and how these are interrelated is lacking. Although a general set of validated indicators that can be directly applied for the characterization of urban areas with good sound quality, is not available yet, building blocks for such an indicator set were derived from the literature. These form the basis of a protocol that will be used to describe sound qualities at a low scale and which will be presented in this paper.

Tuesday 14:20-14:40, Hall Tirol, Paper 0993 (invited)
Marafa Lawal
Factors affecting the perceptions of tranquil spaces in Hong Kong

Marafa Lawal, Watts Greg, Chan Sze Wing
Department of Geography and Resource Management, The Chinese University of Hong Kong, China

Previous research has indicated factors that influence the perceived tranquillity of a place yet before this body of research can be utilised in Hong Kong it is necessary to carry out a questionnaire survey in the local language of Cantonese. The word tranquillity does not translate directly so it is necessary to use appropriate synonyms. Surveys were carried out in two green open

spaces in Hong Kong i.e. Kowloon Park and Sha Tin Park both of which are set within highly urbanised areas. Questions were designed to elucidate the importance of tranquillity in the local culture and the factors that enhance or degrade the tranquillity of a place. It was found that low levels of man-made noise and abundance of natural features in the visual scene both made a positive contribution to a tranquil environment. On the other hand crowded conditions were detrimental as was the playing of amplified music. In terms of benefits it was found that relaxation and reduction of stress were found to be among the most frequently mentioned factors. An analysis of individual differences revealed that there was a statistically significant age effect in the importance respondents attached to the provision of such spaces.

Tuesday 14:40-15:00, Hall Tirol, Paper 1181 (invited)
Janssen Sabine A.
Evaluation of exposure to traffic noise in an urban recreational area

Janssen Sabine A., Salomons Erik M., Vos Henk, de Kluizenaar Yvonne
TNO (Netherlands Organization for Applied Scientific Research), The Netherlands

Environmental noise annoyance due to transportation noise in the home environment has been widely studied, and exposure-response relationships have been established previously for the expected percentage of annoyed residents with the most exposed façade exposure level as a determinant. However, relatively little is known about the evaluation of transportation noise when residents are residing outdoors, for instance when seeking relaxation or restoration in urban recreational areas. In an urban park in the Netherlands, 52 participants walked either in an area with a high level of road traffic noise due to a nearby highway, or in a more quiet area further away from the highway. Noise exposure was individually monitored during the walk, and the evaluation of the acoustic environment was assessed immediately after the walk. The individual variance in exposure (L_{Aeq}, L_{50} and L_{95}) was high enough to derive exposure-response relationships for annoyance by road traffic noise, interference with experience of natural quiet, perceived quietness and perceived soundscape quality. The results may have implications for urban planning concerning levels of transportation noise in outdoor urban recreational areas.

Tuesday 15:00-15:20, Hall Tirol, Paper 0494 (invited)
Payne Sarah R.
Measuring the perceived restorativeness of soundscapes: is it about the sounds, the person, or the environment?

Payne Sarah R.[1], Guastavino Catherine[2]
[1] University of Warwick, UK, [2] McGill University & CIRMMT, Canada

To determine the 'restorative aspects of sound exposure' a reliable and valid measure is needed. A Perceived Restorativeness Soundscape Scale (PRSS), which measures the level of Fascination, Being-Away, Compatibility, and Extent (FACE), has been proposed and shown to be reliable. This study aimed to test its validity further by establishing the comprehension and interpretation of the scale's items. Ten participants completed a questionnaire involving adapted items of the PRSS. Half the questions were phrased in relation to the soundscape (holistic), the other, near, identical half were phrased in relation to the sounds (specific). Participants rated their agreement with each item using a 7 point Likert scale and wrote the reason for their response. A semi-structured interview followed the questionnaire, which took place in two urban cafés. The question framing (holistic or specific) did not result in varied responses for these matched items. However, depending on the FACE component being measured responses varied in their reference to a) the place, soundscape, or individual sounds, and b) the individual's moods and desires, or the temporality of the sound(scape). Increased understanding of FACE components and amendments to the PRSS are necessary to improve the scale's comprehension and validity.

Tuesday 15:20-15:40, Hall Tirol, Paper 0915 (invited)
Bristow Abigail L.
Assessing and valuing restorative space on campus: a comparison between the UK and Hong Kong

Bristow Abigail L.[1], Chau Chi Kwan[2], Horoshenkov Kirill V.[3], Choy Yat Sze[4]

[1] School of Civil and Building Engineering, Loughborough University, UK, [2] Department of Building Services Engineering, The Hong Kong Polytechnic University, China, [3] School of Engineering, Design and Technology, University of Bradford, UK, [4] Department of Mechanical Engineering, The Hong Kong Polytechnic University, China

This paper examines: students' assessment and rating of restorative space on campus including the individual components of such environments; students' willingness to pay for restorative environments and a comparison between

responses in the UK and Hong Kong. In this exploratory phase pilot surveys were undertaken on two campuses: Hong Kong Polytechnic University and Loughborough University. Students were asked to rate the importance of and their satisfaction with a number of components of restorative space. A stated choice experiment was conducted within the survey using paired comparisons of visual stimuli which varied in terms of the presence of green plants; the presence of water; view of nature or a built environment and willingness to pay. The findings of this phase are of interest in indicating that respondents do value the presence of natural greenery and views in interior space. The sound environment, seating and lighting were seen as the most important features of restorative space in both Universities; whilst area of disagreement included greenery, more important in the Hong Kong sample and the temperature, more important in Loughborough. There was a high level of consensus on the sounds that contribute most to a restorative environment namely, trees or leaves, wind, water and music. The results will also feed into the second phase of the work will be lab based to enable the presentation of audio and visual stimuli together.

Tuesday 16:00-16:20, Hall Tirol, Paper 0924 (invited)
Pheasant Robert
Examining the role of auditory-visual interaction in the characterization of perceived wildness and tranquillity in valued open spaces

Pheasant Robert, Watts Greg, Horoshenkov Kirill
Bradford Centre for Sustainable Environments University of Bradford, UK

A review of the websites, marketing material or Landscape Character Assessment (LCA) reports belonging to any of the UK's 15 National Parks, will show wildness and tranquillity as two of the most valued 'special qualities' of these unique British landscapes. In fact they are so valued that the UK Government amended the 1995 Environment Act to specifically require all National Park Authorities to; "place emphasis on conserving and enhancing the valued attributes of wide open spaces and the wildness and tranquillity found within them". However, current Landscape Character Assessments methodologies within the UK rarely, if at all, incorporate objective acoustic measures within their predominantly uni-modal (visual) environmental appraisal, nor does the wild-land mapping of Scotland, recently commission by Scottish Natural Heritage. This paper reports the findings of a wildness pilot study that presented bi-modal audio-visual stimuli (video footage), to experimental subjects under controlled conditions, in order to obtain

reliable estimates of perceived wildness, naturalness, felt remoteness and tranquillity. The findings have identified important aspects of the soundscape that impact on these assessments and highlight the need for such factors to be considered in order to adequately characterize valued open spaces for planning, conservation and promotional purposes.

Tuesday 16:20-16:40, Hall Tirol, Paper 0640 (invited)
Watts Greg
Identifying restorative environments and quantifying impacts

Watts Greg, Pheasant Rob
Bradford Centre for Sustainable Environments, University of Bradford, UK

The UK has recently recognized the importance of tranquil spaces in the National Planning Policy Framework. This policy framework places considerable emphasis on sustainable development with the aim of making planning more streamlined, localised and less restrictive. Specifically it states that planning policies and decisions should aim to “identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason”. This is considered by some (e.g. National Park Authorities) to go beyond merely identifying quiet areas based on relatively low levels of mainly transportation noise as the concept of tranquility implies additionally a consideration of visual intrusion of man-made structures and buildings into an otherwise perceived natural landscape. This paper reports on applying a method for predicting the perceived tranquility of a place and using this approach to classify the level of tranquility in existing areas and then secondly to determine the impact of new build taking the example of the construction of a hypothetical wind farm in the countryside. For this purpose noise level measurements, photographs and jury assessments of tranquility at a medium sized land based wind farm were made. It was then possible to calculate the decrement of noise levels and visual prominence with distance in order to determine the improvement of tranquility rating with increasing distance. The point at which tranquillity was restored in the environment allowed the calculation of the position of the footprint boundary.

Tuesday 16:40-17:00, Hall Tirol, Paper 0772 (invited)
van den Berg Frits
Amsterdam quiet side policy

van den Berg Frits
GGD Amsterdam Public Health Service, The Netherlands

The national Dutch Noise Act stipulates limits for road traffic noise levels. When a new road or dwelling is built and the noise level at a dwelling façade complies with a preferred limit, no restrictions apply. If the noise level does not exceed a second maximum limit, the authorities can grant an exemption from the preferred limit. Levels exceeding the maximum limit are not permitted, though a façade with sufficient noise insulation and without open parts ('deaf façade') is possible if there is a 'quiet' (not exposed) façade. The municipality of Amsterdam formulated a policy to address this issue, as did some other European cities. As urban traffic noise levels usually exceed the preferred limit, the aim of this policy was to warrant a measure of environmental quality. One of the important elements of the policy is that there is a quiet side in the case of an exemption or a `deaf' façade. The request for such an exemption is put before a committee of officials that can advise to grant the exemption and discuss the planning and building details in relation to legal and local policy requirements. The paper will explain this policy in more detail and give examples.

Tuesday 17:00-17:20, Hall Tirol, Paper 0279 (invited)
Bartalucci Chiara
LIFE+2010 QUADMAP project (Quiet Areas Definition and Management in Action Plans): the proposed methodology and its application in the pilot cases of Firenze

Bartalucci Chiara[1], Borchi Francesco[1], Carfagni Monica[1], Governi Lapo[1], Bellomini Raffaella[2], Luzzi Sergio[2], Natale Rossella[2]

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[2] Vie En.Ro.Se. Ingegneria S.r.l., Italy

Current practices about selection, assessment and management of QUAs (Quiet Urban Areas) in EU Countries, though regulated by the EU Directive 49/2002/EC on Environmental Noise (commonly abbreviated END), appear to be extremely fragmented and inhomogeneous. In fact, each country during past years adopted a set of strategies strictly related to their specific contexts. Proposing a solution to overcome the lack of harmonized

methodologies for QUAs is the main aim of QUADMAP (QUiet Areas Definition and Management in Action Plans) project. The results of the project will facilitate urban planners to apply standard procedures for identification, delimitation and prioritization of QUAs. The project has a high level of demonstrativeness guaranteed by the fact that the proposed methodology will be tested on a number of case study areas. In particular, it will be tested on a set of pilot cases in Italy, Spain, and The Netherlands. The project started on 2011, September the 1st and lasts three years. At the beginning of 2013 the first version of the harmonized methodology has been defined. The project partners have being testing the procedures making up such a methodology since February 2013 in all pilot cases. The proposed methodology and an overview of the available results in pilot areas selected in the city of Firenze are presented in this paper.

Tuesday 17:20-17:40, Hall Tirol, Paper 1049 (invited)
García Igone
Application of the Methodology to Assess Quiet Urban Areas in Bilbao: Case Pilot of QUADMAP

García Igone[1], Aspuru Itziar[1], Herranz Karmele[1], Bustamante María Teresa[2]
[1] TECNALIA Research & Innovation, Spain, [2] Bilbao City Council, Spain

The aim of LIFE+ project QUADMAP is to propose a methodology for the selection, analysis and management of Urban Quiet Areas. Considering the study of the European state of art, a preliminary draft of instructions is done. The application of this guide in the pilot cases of the project will provide information to test and improve this methodology, which is the final result of the project. This communication presents the experience of the use of these instructions in one of the selected pilot cases in Bilbao: General Latorre square. The guide for the analysis of quiet urban areas is based in considering three complementary tools: expert analysis, sound measurements, and evaluation of perception through the application of questionnaires. The proposed methodology is devoted to provide useful information for the management of the area and its quietness. This objective implies more than reducing noise pollution and the exclusively consideration of the acoustic context of the place.

SS13 Aircraft Noise Effects

Chair: Schreckenberg Dirk, Flindell Ian

Tuesday 08:20-08:40, Hall Innsbruck, Paper 0300 (contributed)
Diop Assane
Assessing Noise Impact around Airports: A Fuzzy Modeling Approach

Diop Assane[1,3], Consenza Carlos Alberto Nunes[2], Faye Roger Marcelin[3], Mora-Camino Félix[4,2]

[1] ASECNA, Sénégal, [2] Labfuzzy, COPPE, Universidade Federal do Rio de Janeiro, Brazil, [3] Université Cheikh Anta Diop, Ecole Supérieure Polytechnique, Sénégal, [4] MAIAA, Ecole Nationale de l'Aviation Civile, France

In this communication the problem of assessing the noise impact of airport operations on surrounding communities is treated. The specific objective of this study is to provide a tool to predict the noise impact resulting from the modification of traffic patterns as a consequence not only of possible traffic increase but also of rearrangements of departure and arrival procedures and tracks. It is a general opinion that to access accurately the noise impact over people, or annoyance, noise cannot be only represented by an overall noise index and the corresponding level areas as produced by software like Integrated Noise Model (INM). The perception of traffic noise near airports is quite subjective and is dependent of many other parameters in general characteristic of the nearby air transport activity. So in this paper, fuzzy modeling based on the fuzzy dual formalism is used to generate from traffic information on one side and from a mapping of local activities on the other side, a quantitative evaluation of objective noise impacts at different locations around an airport. This will allow to identify the critical locations with respect to noise as well as to perform sensitivity analysis studies when comparing different traffic scenarios.

Tuesday 08:40-09:00, Hall Innsbruck, Paper 0577 (invited)
Lertsawat Krittika
Initiation of Noise Annoyance Scales Study for Preparation of the Social Survey around Airport in Bangkok

Lertsawat Krittika[1], Yamada Ichiro[2], Yano Takashi[3], Kovudhikulrungsri Lalin[4], Malailoy Supaporn[5], Phoolsawat Surocha[6]

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Foundation, Thailand, [6] Air Quality and Noise Management Bureau, Pollution Control Department of Thailand, Thailad

The future expansion of the Bangkok International Airport (BIA) is influenced by increasing of air traffic volumes and its congestion. BIA is now running at full capacity of Phase I, therefore the policy makers announced to manage the BIA multiple hub policy. The Don Mueang International Airport (DMK) has been operated again for international air transport services since last year. The noise situation around airport will be changed and broadened the noise affected area in the vicinity of the both airport by increasing air traffic volumes and policy change. The noise annoyance scales in Thai language initiative will facilitate to have the better understanding of community response to airport noise in Thailand. The ICBEN method is adopted in this study to prepare for social survey around airport in Bangkok, contributing to the future study on noise-dose relationship around airport. The first batch distribution, some of collected data, and research progress will be reported in this paper.

Tuesday 09:00-09:20, Hall Innsbruck, Paper 0842 (contributed)
Pelletier A.
SURVOL part 3: Environmental pollution (air, noise) exposure and social deprivation around the major Ile-de-France airports

Pelletier A.1, Ribeiro C.[1], Mietlicki F.[1], Dugay F.[2], Kauffmann A.[2], Lalloué B.[3,4,5], Isnard H.[6], Girard D.[7]

[1] Bruitparif, Noise Observatory in Ile de France, France, [2] Airparif, Air quality Monitoring Network in Ile de France, France, [3] EHESP, School of Public Health, France, [4] University of Lorraine, Institut Elie Cartan de Lorraine, France, [5] INRIA, project team BIGS, France, [6] InVS, The French Institute for Public Health Surveillance, France, [7] ARS, the Ile-de-France Regional Health Agency, France

The SURVOL project, led by the Ile-de-France Region Prefecture and the Ile-de-France Regional Health Agency, aims to strengthen environmental monitoring around the three major Ile-de-France airports: Paris – Charles de Gaulle, Paris - Orly, and Paris-Le Bourget. Bruitparif - a noise observatory in the Ile-de-France Region - has been in charge of implementing the Geographical Information System (GIS), in order to analyse and follow the changes over time of the relationships between the environmental variables related to noise and air pollution and the socio-economic characteristics of the population living in the SURVOL study areas. The GIS integrates data taken from the strategic noise maps created by Bruitparif, air quality data provided by air quality monitoring

network Airparif, and socio-economic data from INSEE (French National Institute for Statistics and Economic Studies). The cross-tabulation of this information has highlighted the first elements on the potential links that exist between social inequalities and exposure to noise and/or pollution. Statistical analysis highlights that a relationship exists between exposure to environmental pollution and social deprivation. This article presents the areas where social and environmental inequalities are highest in the Ile-de-France region and the results of the third part of the SURVOL project.

Tuesday 09:20-09:40, Hall Innsbruck, Paper 0493 (invited)
Guski Rainer
Gaps in theory, methods, and results about aircraft noise effects on residents

Guski Rainer
Department of Psychology, Ruhr-University Bochum, Germany

A theory of noise effects assumes that the repetition of short-term disturbances, and annoyance is detrimental to the long-term well-being of humans, giventhere is insufficient time and opportunity for recovery from the effects. This plausible assumption leaves open many questions, e.g., about the biological pathways from actual disturbances to long term health risks, about the specifications of "necessary recovery", and the relations between physiological and psychological reactions. A second level containing many gaps relates to the methods used in field research on noise, especially on aircraft noise. For instance, socio-acoustic surveys mostly select subjects stratified by noise levels, while medical epidemiological studies try to represent the whole population of an area. These two methods are incompatible and need modifications in order to use data and results from both research fields together. The third level of gaps relates to results of studies on noise effects. Even within the same approach, many links between different results are missing. For instance, in social surveys we find correlations between acoustic variables, annoyance judgments, and self-reported health symptoms, but it is open whether there is any causal link between these three aspects. The paper will provide suggestions for crossing – or avoiding – some of the gaps.

Tuesday 09:40-10:00, Hall Innsbruck, Paper 0305 (invited)
Gjestland Truls
Noise surveys can be simplified!

Gjestland Truls, Granøien Idar L. N., Gelderblom Femke B.
SINTEF ICT, Norway

Results form noise surveys around airports demonstrate a large spreadin annoyance response data. The noise dose such as L_{eq}, L_{DEN}, etc., is typically used as the acoustic indicator, and the large spread is often attributed to "non-acoustical factors", or more accurately "non-dose factors"(non-DENL factors). The CTL-method uses a pre-defined dose-response function (theduration-adjusted loudness function) and expresses the annoyance response differences between airport communities in terms of the Community Tolerance Level. The CTL value, in decibels, is an indicator that combines all other non-dose factors in a single number. In a noise survey the respondents are typically asked to assess the annoyance on a scale with pre-defined end points. The scale can either be numerical, e.g. "0 –10" or it can consist of categories with verbal labels such as "not annoyed", "moderately annoyed", etc. For data analysis purposes the responses are usually transformed into a quantity *annoyance score,* AS. The annoyance score denotes the magnitude of annoyance on a scale "0 –100". In this paperwe will show that the functions describing the annoyance caused by aircraft noise, either in terms of the annoyance score, AS, or in terms of the community tolerance level, CTLare non-airport specific, and the response differences between different airports or airport communities can be expressed by a single number.

Tuesday 10:00-10:20, Hall Innsbruck, Paper 1301 (contributed)
Flindell Ian
Aircraft noise assessment – alternative approaches

Flindell Ian[1], Le Masurier Paul[2], Schreckenberg Dirk[3]
[1] University of Southampton, UK, [2] MVA Consultancy, UK, [3] Zeus GmbH, Germany

Government policy makers need to balance the needs and rights of residents in close proximity to airports against the need to meet the ever-increasing demand for air travel. The UK Government has based their understanding of community annoyance on primary research conducted in the UK more than thirty years ago. In this paper, we compare more recent quantitative data against the historic data, and suggest that, using traditional models of aircraft noise annoyance, some adjustments to current noise metrics would

seem to be justified in order to better deal with current conditions as they exist today. On the other hand, we have also been investigating alternative qualitative and trading methods of data collection which in many cases have found substantially different results to the current assumed status-quo. The results suggest that standard questionnaires (such as the ISO standard 'annoyance' scales) do not always reflect respondent's underlying attitudes particularly well. In most cases, reported annoyance is not so much determined by the amount of aircraft noise measured using traditional acoustic metrics such as LAeq and Lden, as by a whole range of beliefs and attitudes about the way that the airport operates and engages in meaningful mitigation and compensation programms.

Tuesday 11:00-11:20, Hall Innsbruck, Paper 1177 (invited)
Hooper Paul
Exchanging aircraft noise information with local communities around airports: 'the devil is in the detail'!

Hooper Paul[1], Flindell Ian[2]

[1] Centre for Aviation, Transport and the Environment Manchester Metropolitan University, UK
[2] Institute of Sound and Vibration Research University of Southampton, UK

People who live near major European Airports and complain about aircraft noise often believe that they are being treated unfairly by the authorities and generally have no interest in, or understanding of, the standard methods of representing aircraft noise by using long time average sound level aircraft noise contours. In many cases, the standard methods of communicating with the public are too complicated, over-technical, and do not even focus on information which the public actually want or need to know. This paper draws upon the results of recent and mainly qualitative research to discuss improved noise communication strategies, which focus on providing information that the public are actually interested in; rather than on information that the authorities choose to provide for them. The preferred strategy should be to describe, explain and where appropriate, justify, so that residents either understand management action being taken on their behalf, or are at least confident that appropriate and balanced action has been and is being taken. The all-too-prevalent current attitude that the regulator knows best has not helped the increasing level of mis-trust, which has built up in many surrounding communities.

Tuesday 11:20-11:40, Hall Innsbruck, Paper 0252 (contributed)
Griefahn Barbara
Moderators that influence annoyance of residents near 6 European airports

Griefahn Barbara[1], Bolin Karl[2], Flindell Ian[3], Lambert Jacques[4], Lavandier Cathérine[5], Marki Ferenc[6], Müller Uwe[7]

[1] Leibniz Research Center for Working Environment and Human Factors at Technical University TU, Germany, [2] KTH – Royal Institite of Technology, Sweden, [3] ISVR – Institute of Sound and Vibration, UK, [4] IFFSTAR – Transport and Environment Laboratory, France, [5] I.U.T. de Cergy-Pontoise, France, [6] Budapest Universtity of Technology and Economics, Hungary, [7] DLR – Deutsches Luft-und Raumfahrtzentrum, Germany

The aim of the present study was to identify possible moderator variables that influence annoyance due to aircraft noise. The data analysed here were ascertained by extended questionnaires in three studies within the COSMA-Project that was funded by the European Union. There were a Field Study and a Telephone Interview, each performed with residents living in the vicinity of the airports Cologne-Bonn, London Heathrow or Stockholm-Arlanda and a Laboratory Study performed with residents living near the airports Budapest, Lyon or Paris. In each of the three studies (and the overall 9 subgroups) the participants completed extended questionnaires on long-term annoyance. In the field study sleep behaviour and acute annoyance that was rated each hour were additionally ascertained over a period of 4 days. Using a logistic regression model analysis odds ratios were determined for possible moderators. Based on the results a model was created that shows the most important negative and positive influences.

Tuesday 11:40-12:00, Hall Innsbruck, Paper 0249 (contributed)
Bartels Susanne
Predictors of aircraft noise annoyance: results of a telephone study

Bartels Susanne[1], Müller Uwe[1], Vogt Joachim[2]
[1] German Aerospace Center (DLR), Germany, [2] Technische Universität Darmstadt, Germany

As part of the EU-project COSMA (Community Oriented Solutions to Minimize aircraft noise Annoyance), a telephone study was carried out around Cologne/Bonn Airport in order to identify the most influencing variables of aircraft noise induced annoyance. More than 1200 persons from six areas with differing aircraft noise exposure were interviewed. Various acoustical (e.g., $L_{Aeq,6\text{-}22}$, $L_{Aeq,22\text{-}6}$, *flight altitude, predominant type of operation*) and non-acoustical variables (e.g,. *attitudes, noise sensitivity, noise insulation of*

home, features of surrounding area) were surveyed for every participant. Aircraft noise annoyance was measured by the semantic 5-point ICBEN scale. A distinction was made between annoyance in general and annoyance at night. Two multiple regression models showed that the L_{Aeq} – extracted in 5dB(A)-steps from noise contour maps – could explain only a small proportion of variance in the annoyance ratings (16.5 % for annoyance in general, 17.9 % for annoyance at night). Including non-acoustical variables into the regression model significantly raised the proportion of explained variance to 54.8 % and 52.3 %, resp., whilst integrating further acoustical variables beside the L_{Aeq} had no effect. Results are in line with findings of other studies stressing the enormous impact of non-acoustical variables on noise annoyance.

Tuesday 12:00-12:20, Hall Innsbruck, Paper 1052 (invited)
Márki Ferenc
Multi-level approach to predict hourly annoyance of airport residents

Márki Ferenc[1], Kovács Lóránt[2]

[1] Budapest University of Technology and Economics (BME), Dept. of Telecommunications, Hungary
[2] Kecskemét College, Dept. of Informatics, Hungary

In the 7th Framework project COSMA extensive field studies have been performed around 3 European airports. During these studies participants had to rate during 4 days each hour how much aircraft noise annoyed them. Parallel, continuous noise level measurements have been performed at participants' sites. From these measurements a bunch of acoustical parameters could be computed, which allow building of models to predict people’s hourly annoyance ratings. One of the approaches applied on the field studies is a multi-level neural network based approach by BME, which will be presented in detail in this paper. As each individual's hourly ratings are highly uncertain, the point by point accuracy (i.e. rating vs. predicted hourly annoyance) is not a meaningful prediction goal and should also not be the measure of goodness. Therefore specific grouping and averaging of data is presented and proposed as the right measure of quality. The results show that the predictor works quite well (group correlation is around 0.7-0.8). An additional benefit of the approach is that the most important parameters influencing annoyance can also be identified by the approach allowing for future studies to collect/compute just the necessary data.

Tuesday 12:20-12:40, Hall Innsbruck, Paper 0370 (contributed)
Bisping Rudolf
Individual versus generic acoustical predictive modeling of aircraft related annoyance

Bisping Rudolf
SASS GmbH, Germany

Aim of the study is the acoustical prediction of annoyance ratings of airport residents measured by the hourly ICBEN scale of groups of subjects and of individuals. Three different cases are considered: • Case 1: Generic (sample based) time series modeling is applied to data from 3 European airports (Arlanda, Cologne, Heathrow) • Case 2: Individual time series modeling is applied to subjects of Cologne airport. • Case 3: Without reference to time the data of individual subjects are predicted using again the data sets from all three airports. Dependent on time the case 1 generic modeling showed Goodnes Of Fit (GOF) – scores^2 with maximal values of r = 0,65. In the early morning hours and in the evening the mean GOF-scores are considerably less than in the time between. Individual modeling allowed a separation of subjects responding more sensitive to aircraft noise than other subjects which seem to be unaffected. Obviously both groups differ in their perception and/or motivation related to aircraft noise. This result is confirmed by the case 3 analysis. The data suggest that motivation plays a crucial role when trying to forecast annoyance by acoustical predictors. If the acoustical airport environment has no impact on the annoyance state of the resident no prediction is possible. Thus, as a conclusion for further predictive studies it seems to be necessary to run pretests to ascertain that varying and sufficient degrees of annoyance are given within the sample of residents.

SS14 Aircraft noise management and mitigation measures

Chair: Schäffer Beat, Kruger-Dokter Annette

Tuesday 14:20-14:40, Hall Innsbruck, Paper 1013 (invited)
Bissegger Martin
Noise management in the light of airport development

Bissegger Martin
Zurich Airport AG, Switzerland

Noise arising from the airport and aircraft operations has been one of the most challenging issues in the development of Zurich Airport for many years. Various mitigation measures such as a complete night flight ban between 23.30 and 06.00 h, noise charges and operational measures were imposed for diminishing the negative impacts. Aircraft noise is carefully monitored at Zurich Airport by numerous noise monitoring terminals. Legal noise limits (Leq) define "acceptable" noise loads during day and night in terms of noise protection and land use planning purposes. Also the severely affected people by noise are calculated yearly and compared to a defined limit value. Despite all these initiatives public debate on present noise loads and future development of air traffic in Zurich including the management of arrival and departure routes has been predominant in recent years. Any changes in the operational procedures lead to numerous complaints and heat up the political debate on airport development and operational restrictions. In this paper, we give an overview of different approaches, conflicts, and achievements of the last decade, and give some prospects on the future development of noise management.

Tuesday 14:40-15:00, Hall Innsbruck, Paper 0239 (invited)
Ogata Saburo
Continuity and validity of Aircraft Noise Index at Narita International Airport

Ogata Saburo[1], Hanaka Kazuyuki[1], Shinohara Naoaki[2]

[1] Narita International Airport Corporation, Narita International Airport, Japan
[2] Narita International Airport Promotion Foundation, Japan

In Japan, WECPNL has been used until March, 2013 as the aircraft noise index for 40 years. Japanese WECPNL was simplified from the original ICAO WECPNL index. It has played an important role to mitigate noise issues in response to demands in air in Japan. When the second runway opened in 2002, the

simplification caused a contradiction in calculation of sound exposure level. We call it as inversion problem in WECPNL. After that local governments around the airport requested the Ministry of Environment (MOE) and the Ministry of Transport (MOT) to revise the index. The MOE set up an expert working group to revise the index. Eventually, the Japanese Government decided to change aircraft noise index from WECPNL to *L*den which is almost the same as that used in Europe. This paper makes a review of noise measures carried out at Narita International Airport so far as well as it describes the background of this revision and its continuity and validity.

Tuesday 15:00-15:20, Hall Innsbruck, Paper 0251 (contributed)
Schäffer Beat
Estimating the effects of aircraft noise on the population using the Zurich Aircraft Noise Index ZFI

Schäffer Beat, Zellmann Christoph, Plüss Stefan, Thomann Georg*

Empa, Swiss Federal Laboratories for Materials Science and Technology, Lab. for Acoustics/Noise Control, Switzerland
* Present affiliation: Amt für Natur und Umwelt Graubünden (ANU), Switzerland

This paper reports on the Zurich Aircraft Noise Index (*ZFI*), a noise effect index which has been serving noise abatement policy of the canton of Zurich, Switzerland, since 2007. The *ZFI* is a single number representing a monitoring value for the number of persons affected by aircraft noise in the vicinity of Zurich airport, either by annoyance and/or sleep disturbance. The monitoring value is determined on a yearly basis and compared to a guide value defining the upper limit for the acceptable noise impact on the population. The government of the canton of Zurich takes preventive measures to avoid the guide value to be exceeded. In this paper, the experiences with the *ZFI* obtained over the years are reviewed. Firstly, the concept and imple- mentation of the *ZFI* and some key results are presented. Then, the strengths and limitations of the *ZFI* to assess the aircraft noise effects on the population, as well as the possibility to separate the effects of different influencing parameters using sensitivity analysis are discussed. Finally, measures to reduce the monitoring value are evaluated.

Tuesday 15:20-15:40, Hall Innsbruck, Paper 1054 (invited)
Bodossian Léa
ATM/ATC/Spatial planning as mitigation measures?

Bodossian Léa
Airport Regions Conference, Belgium

Improvement of operations and spatial planning are the two branches of the ICAO balanced approach that are the most likely to allow for progresses in terms of noise management. Still, to make it work, none of them can be considered individually, but the synergies between both lead to win-win situations. To make these synergies effective, there must be a common strategic vision between the local/regional authorities and the aviation industry representatives on how they are willing to have the airport inserted in the region. Two proposals are made to allow for these common strategies to be developed: • Agreeing on the fact that neither spatial planning has to be compatible with aviation activities, nor that aviation activities need to be compliant with spatial planning. One of the pillars cannot be subject to the other one. • Agreeing on defining spatial planning further than a set of legal texts to be used in order to regulate who lives where. On the contrary, spatial planning is to be considered as a process, a set of tools that allows the mitigation of aviation noise.

Tuesday 15:40-16:00, Hall Innsbruck, Paper 0366 (invited)
Eagan Mary Ellen
Implementing performance based navigation procedures at US airports: improving community noise exposure

Eagan Mary Ellen, Hanrahan Rhea, Miller Robert
Harris Miller Miller & Hanson Inc., USA

The Federal Aviation Administration (FAA) is implementing an ambitious program to modernize the US air traffic control system. NextGen technology – specifically Performance Based Navigation (PBN) – provides opportunities to address aircraft noise in a more precise and targeted way than ever before. This paper presents an overview of the process currently being used to develop and model the noise impacts of PBN. A critical success factor is the use of a collaborative team that includes procedure developers, air traffic control subject matter experts, airline representatives, performance specialists, and noise analysts, to analyze potential noise impacts of proposed procedural changes. Noise analyses

are prepared using FAA tools. Communication of results is complex, and best accomplished through graphical displays. PBN and NextGen technologies provide a unique opportunity to improve the noise environment around airports. However, procedures need to be carefully designed and evaluated by a collaborative multidisciplinary team in order to achieve maximum benefit.

Tuesday 16:20-16:40, Hall Innsbruck, Paper 0742 (contributed)
Kropelnický Radek
Development and implementation of progressive flight procedures from the aspect of Vodochody airport noise load

Kropelnický Radek, Ládyš Libor
EKOLA group, spol. s r.o., Czech Republic

The air traffic density keeps continuously rising and therefore it is the subject-matter of the interest of both experts and laic members of public who focus on its impacts upon environment and exposed population. Adverse impacts of the air traffic are monitored primarily during the landing and take of phase of the airplane flight. The presented project deals with possibilities of positive acoustic effects on the exposed area during the plane take off and landing. The project makes use of new GPS based airplane navigation during the approaching phase and at the start and it demonstrates realistic results of the verification simulation flights based on propose progressive flight procedures and the difference against the standard flight procedures that use the existing navigation means of Instrument Landing System (ILS). The new navigation systems make it possible for various airplane categories to manoeuvre during the approaching and take of phase. This can positively affect the noise load in the area adjacent to the airport. The predicted verification of these procedures was executed at the Vodochody airport. The contribution presents not only theoretical but also practical real project outcomes established based on measurements and analyses completed.

Tuesday 16:40-17:00, Hall Innsbruck, Paper 0158 (contributed)
Isermann Ullrich
Potentials and limits of noise abatement flight procedures

Isermann Ullrich
German Aerospace Center DLR, Institute of Aerodynamics and Flow Technology, Germany

During recent years, the scientific activities related to noise mitigation in the environment of airports have been focused strongly on the development of noise abatement flight procedures. Such procedures – which are part of the "Balanced Approach" to aircraft noise management that is recommended by the International Civil Aviation Organization ICAO – cannot be designed effectively without the use of aircraft noise calculation programs. This paper gives an overview on the potentials of noise optimized operational procedures as well as their limits due to flight-mechanical constraints. Moreover, it will discuss the specific demands on the noise calculation models used to develop them. Special attention is paid to the definition of noise optimized approach procedures and the corresponding need to model airframe noise.

Tuesday 17:00-17:20, Hall Innsbruck, Paper 0097 (contributed)
Hsieh Jen-Shuo
Correction Methods for Aircraft Noise Control Zone and Noise Contours Planning at Heliports of the Republic of China (Taiwan)

Hsieh Jen-Shuo, Chou Li-Chung, Hsieh Yein-Rui, Liu Jacob Chia-chun

Department of Air Quality Protection and Noise Control EPA Executive Yuan, Taiwan
Department of Water Resources and Environmental Engineering, Tamkang University, Taiwan

The results of noise contours planning and monitoring data at heliports of the Republic of China (Taiwan) are often doubted by the public because of the gap between the measured noise level and the real noise perceived by the public. Is it because that the helicopter flight paths adopted in the current model are different from the real ones? Or there are situations in which more than one helicopters taking off simultaneously or team flying being needed during flight training? Or the records of flight paths made by the control tower are not complete? All these factors may lead to the inaccuracy of follow-up dynamic flight data input by the Aircraft Noise Monitoring Center and influence the results of noise contours planning. In addition, the helicopter has particular flight characteristics, such as hovering flight, longer standby

time, slower flying speed, and lower flying altitude. However, the current model cannot achieve the level of real simulation of each flight situation due to such factors as meteorological conditions, flight speed, altitude and thrust when the helicopter is taking off or landing or hovering in the air. These factors tend to make a difference to the real take-off and landing flight paths, as well as standard operating procedures. A minor difference in the air may cause a huge variation as much as several kilometers on the ground. Besides, the low-frequency noise character of the helicopter may cause a difference to noise distribution. Therefore, we hope to establish correction methods for aircraft noise control zone and noise contours planning at heliports of the Republic of China (Taiwan) through on-the-spot measurement of aircraft noise. In terms of objective measurement, the mean deviation of noise level between A-weighting and C-weighting is 10 dB(A). However, whether or not this value represents a good correction to fit with surrounding residents' actual perception on helicopter noise will need to be supplemented with social investigation. The 50-50 method is usually used to confirm the correction. The definition of noise correction is "the variation between the helicopter noise and reference noise when they cause the same level of annoyance". Since the break-even point of the helicopter noise is 62dB, to reach equivalence of noise annoyance, the reference noise level needs to be corrected with ＋8dB(A) (subjective investigation: Investigation of people's actual perception of annoyance; 8dB(A) correction). Therefore, the correction is recommended to be 8dB(A) in order to fit with the public opinions and quench public complaints by meeting with the public's psychological perception.

Tuesday 17:20-17:40, Hall Innsbruck, Paper 0633 (contributed)
Løvholt Finn
On the low frequency sound transmission and induced vibration from aircrafts

Løvholt Finn[1], Norén-Cosgriff Karin[2], Madshus Christian[2], Brekke Arild[3]

[1] Norwegian Geotechnical Institute (NGI), Norway, [2] NGI, Norway, [3] Brekke & Strand Akustikk AS., Norway

Infrasound and audible sound at very low frequency may cause human annoyance by inducing building vibration, involving both rattling and whole body vibration sensing of humans. Here, we present the overview from a broad study on low frequency sound induced vibration by aircrafts, involving full scale field measurements, laboratory experiments, numerical simulations, and design of countermeasures. The basic mechanism verified

by a series of field measurements in Norway shows that the transmitted low frequency indoor sound excites sensible floor vibration that may lead to annoyance. Hence, improved sound insulation at the lowest frequencies also mitigates the floor vibration. For this purpose, a countermeasure applying increased stiffness for walls and roofs was proposed. The low frequency sound transmission and mechanical response for the countermeasure were measured in the laboratory. Furthermore, a detailed 3D Finite Element model of the full laboratory and detailed structure was established. The measured and simulated sound transmission and mechanical response were favorably compared. By using the Finite Element tool, a sensitivity study varying the building element junction stiffness was quantified. The effect of increasing the roof and wall stiffness as a possible countermeasure towards low frequency sound insulation and vibration reduction is discussed. Finally, results from acoustic simulations of the full building at low frequency are shown.

SS03 Modelling and Simulation of Road Vehicle, Tire and Pavement Noise

Chair: Pluymers Bert, Haider Manfred

Tuesday 08:40-09:00, Hall Brüssel, Paper 0506 (contributed)
Sarrazin Mathieu
Synthesis techniques for wind and tire-road noise

Sarrazin Mathieu, Colangeli Claudio, Janssens Karl, van der Auweraer Herman
LMS International, Belgium

In this study, innovative methods to provide a more realistic broadband synthesis of wind and tire -road noise are presented. Due to the missing masking effect of the ICE in electric vehicles, aerodynamic and tire-road noise get increased attention and hence more advanced synthesis approaches are investigated. Existing broadband noise algorithms, applied to traditional ICE vehicles, provide sound contribution estimates in a manner analogous to the real behavior of the human auditory system. The human ear's sensitivity is considered as sound filtered in overlapping band-pass filters. In NVH engineering applications, one-third octave band analysis is used, describing quite well the human hearing perception. Moreover, this allows compression of the analyzed source data to perform faster real-time synthesis. However, in some cases important information is lost by filtering in one-third octave bands. For this reason two new techniques are developed: a narrow-band and one-twelfth octave approach. The narrow-band approach is based on PSD spectra and utilizes an inverse Fourier Transform which is a very different approach than the 3-rd octave filtering. The twelfth-octave approach, on the other hand, still relies on band-pass filtering but performs this filtering in finer bands. It is demonstrated that both techniques provide an improved noise reproduction and allow a more natural sound perception.

Tuesday 09:00-09:20, Hall Brüssel, Paper 0449 (contributed)
Danilov Oleg
CAE methods for prediction of airborne noise in truck cabin

Danilov Oleg, Andre Frederic, Tufano Anna Rita
VOLVO GTT, API TER L10 0 01, France

Interior noise is an important part of the driver comfort in all types of trucks. Moreover, a quieter cabin allows to reduce the driver fatigue. Designing a truck with excellent acoustic comfort needs an important effort from different engineering services including powertrain, chassis, and cabin departments. The big diversity of engine and cab configurations, which is a truck specificity, cannot be covered by physical tests and imposes the use of CAE methods for interior noise prediction. SEA approach is efficient and an experimentally approved method for airborne noise in medium and high frequency range. The SEA model for truck cabin includes three main elements: interior air volume with its sound absorption properties, cab panels with their own transmission loss and finally external airborne excitation applied to these panels. The different ways of panel modeling is discussed. Nevertheless, the key element remains the model excitation, as the objective is to evaluate different type of engine or powertrain installations: for this purpose, energy boundary element method (SONOR) for predicting the noise propagation from engine sides to cab panels are discussed. Finally, some examples of part development involving virtual modeling process show the possibility of obtaining an excellent acoustic comfort with minimized cost.

Tuesday 09:20-09:40, Hall Brüssel, Paper 0751 (contributed)
Pai Ajith V.
Air intake system noise in a turbocharged petrol engine during transient operation

Pai Ajith V., Walsh S.J., O'Boy Dan J., Chen Rui
Department of Aeronautical and Automotive Engineering Loughborough University, UK

Engine downsizing is undertaken in the automotive industry in order to reduce the emissions and the fuel consumption of the vehicle. Turbocharging is one of the important methods to enable downsizing of the engine; however, increased noise is the side-effect of this introduction. The noise generation is assumed to be due to the operation of turbocharger very close to the surge zone of the compressor map. For example, the compressor map is typically measured under static laboratory test conditions and may be different in the dynamic environment of the intake system during engine operation. The aim of this paper is to outline the methods used by the authors to predict and measure the turbocharger noise generation and also to understand its fundamental mechanism. A naturally aspirated car is chosen to measure the noise generated at the intake system as a starting point. Analysis methods such as STFT for the acquired data measured are explained. This will form a basis for further analysis on a turbocharged car. A simulation methodology is outlined in order to predict the noise generation mechanism.

The static pressures predicted on various locations of intake system, such as upstream and downstream of compressor, are processed to obtain estimates of the sound pressure in both the frequency and the time domains. A modular turbocharger rig is designed to study the intake system dynamics during compressor surge operation and to further understand the noise generation mechanism. The paper is concluded by listing the future work planned.

Tuesday 09:40-10:00, Hall Brüssel, Paper 0048 (contributed)
Erensoy Emin
Validation of finite element modeling approach for a rubber sealed structure by performing experimental modal analysis

Erensoy Emin, Bötke Artun, Sevginer Caner, Yilmaz Şener
Hexagon Studio, Turkey

Adhesive bonding usage like rubber seal to assemble the glass in automotive sector is very common to use. However, creating finite element (FE) model of the structures assembled using such rubber seal is still quite difficult due to non-linear behavior of the bonding material. To build a reliable FE model of a vehicle such as Concept V1, which has a unique glazed roof structure, is became necessary. This paper aims to determine whether an acceptable linear FE model can be built for correlating and adjusting the FE models using the measured modal properties of structures. Verification of the FE modeling technique is performed progressively in three step to secure FE models in every steps forward. First of all, it is done by validating the properties of a simple welded structure. Secondly, experimental modal analyses are performed on test body without glass. Finally whole test body is tested to obtain the modal properties. The measured modal data are also used to adjust the properties of effective rubber seal model of the glass in order to minimize the error between the predicted and the measured natural frequencies and mode shapes.

SS04 Measurement Methods for Road Vehicle, Tire and Pavement Noise

Chair: Goubert Luc, Bendtsen Hans

Tuesday 11:00-11:20, Hall Brüssel, Paper 0134 (invited)
Oddershede Jens
CPX - OBSI Relation in Tyre/Road Noise Measurement Results

Oddershede Jens[1], Bendtsen Hans[1], Kragh Jørgen[1], Sohaney Richard[2], Rasmussen Robert[2]
[1] Danish Road Directorate, Denmark, [2] The Transtec Group, USA

In Europe, the Close-ProXimity method (CPX) is used for tyre/road noise measurement, while the On-Board Sound Intensity method (OBSI) is used in the USA. Results collected with the two methods are not directly comparable as they are based on different measurement principles and apply different measuring positions; CPX measures sound pressure levels while OBSI measures sound intensity levels. As part of a Danish research project, the Danish Road Directorate (DRD) initiated a study to compare results found by means of the two methods. The main objective was to clarify the relation between the results. Such a translation is desirable to be able to directly compare measurement results from Danish (European) and American pavement noise research projects. In this study, tyre/road noise measurements were performed on six different asphalt pavements in Denmark. The Transtec Group, Inc. performed OBSI measurements using a DRD van as a test vehicle. The DRD made CPX measurements using its CPX trailer. Both teams conducted measurements using the same tyres (SRTT) on the same pavements, on the same day, at 50 km/h and at 80 km/h, respectively. The study concludes that there is a speed dependent difference between results obtained using the two methods. These differences are specified in the paper.

Tuesday 11:20-11:40, Hall Brüssel, Paper 0984 (contributed)
Bühlmann Erik
Temperature effects on tyre/road noise measurements and the main reasons for their variation

Bühlmann Erik, Ziegler Toni
Grolimund & Partner AG – environmental engineering, Switzerland

Ambient temperature is one of the main sources of variation when conducting tyre/road noise measurements. Within the temperature

interval for CPX measurement proposed in the draft ISO standard (5° C to 30°C), overall noise levels can vary up to 2.5 dB(A). This would be likely to exceed all other sources of variation. Whilst the magnitude of the temperature effects and the fact that they vary dependent upon various parameters is generally acknowledged, little effort has so far been made to investigate these sources of variation. The present study aims to help fill this gap by further investigating relationships between temperature effects and their main influencing parameters. Multivariate regression analysis was used on extensive datasets collected in our previous study in 2011. This study concludes that three main influencing parameters should be considered in a refined semi-generic approach when correcting for temperature effects. Furthermore, the analysis showed consistent trends and evidence for the support of hypotheses about the temperature dependency of noise generation mechanisms.

Tuesday 11:40-12:00, Hall Brüssel, Paper 0967 (contributed)
Bühlmann Erik
Ageing of the new CPX reference tyres during a measurement season

Bühlmann Erik, Schulze Sebastian, Ziegler Toni
Grolimund & Partner AG – Environmental Engineering, Switzerland

Recently, new reference test tyres have been specified by the ISO to be used for tyre/road noise measurements with the close-proximity (CPX) method. Various studies have provided evidence that tyre ageing is accompanied by significant and continuous changes in the noise emission properties. It is therefore essential to consider the changing state of reference tyres when carrying out tyre/road noise measurements using the CPX method. A reliable quantification of these ageing effects and their influence on noise emission levels requires that individual reference tyre sets are monitored over time. This study aims at investigating the ageing process of the new reference tyres SRTT and Avon AV4 during one measurement season. Measurements, which test the indentation resistance of tyre rubber with the type A durometer, were repeated on a monthly basis. This revealed substantial increases in rubber hardness during the 2012 measurement season, exceeding 3 units Shore A for the SRTT tyre and 6 units Shore A for the Avon AV4 tyre. This corresponded with a considerable rise in noise levels, suggesting that tyre ageing is a primary influencing factor when carrying out tyre/road noise measurements using the CPX method. The study provides a simple tyre specific model for

estimating rubber hardness changes based on the number of measurement days. The evaluation of temperature data suggested that, due to the physical and environmental strain on in-service tyres, usage influences tyre ageing to a larger extent than standardised operational storage conditions. The data implies, moreover, that individual corrections for the CPX reference tyres SRTT and Avon AV4 are needed.

Tuesday 12:00-12:20, Hall Brüssel, Paper 0917 (invited)
Anfosso Lédée Fabienne
Wind noise influence on close-proximity tyre/road noise measurements with uncovered systems

Anfosso Lédée Fabienne[1], Kragh Jørgen[2]

[1] LUNAM Université, Institut Français des Sciences et Technologies des Transports de l'Aménagement et des Réseaux, France, [2] Danish Road Directorate, Denmark

When measuring tyre/road noise by the Close-ProXimity (CPX) method, microphones are fitted close to a test tyre mounted on a trailer or self-propelled vehicle, and the system is driven at speeds up to 110 km/h. When the trailer is covered by an enclosure, wind noise in the microphones is believed to be reduced. However, for uncovered systems, wind noise may contaminate tyre/road noise measurements. Wind induced noise was measured for two types of uncovered equipment, a test vehicle and an open trailer. For the latter, wind speeds were measured in running conditions at the microphone positions and wind induced noise levels were estimated from data provided by the microphone manufacturer. The S/N ratio at 80 km/h on a AC 11d surface was estimated to be 23 dB in the one-third-band octave at 315 Hz and 36 dB for overall A-weighted noise levels. For the test vehicle, wind speeds and induced noise levels were measured directly on the whole system in an anechoic wind tunnel. Overall wind noise levels at speeds up to 90 km/h were at least 10 dB lower than tyre/road noise on porous asphalt 0/10. Both experiments demonstrate the validity of tyre/road noise measurements by uncovered systems.

Tuesday 12:20-12:40, Hall Brüssel, Paper 0662 (invited)
Bartolomaeus Wolfram
Wind Influence on SPB-Measurements

Bartolomaeus Wolfram
Federal Highway Research Institute, Section F3: Tyre/Road Interaction, Acoustics, Germany

The influence of wind on measurements of the Statical Pass-By (SPB) noise of vehicles is not known very well. In the ISO standard [1] the maximum allowed wind velocity in the heigth of the microphone (1.2 m) is limited to 5 m/s. But an uncertainty is not given there. Measurements of long distance sound propagation (above 50 m) show a significant influence of wind (velocity, orientation and profile) and of temperature as well. The aim of this study is to look at the influence of wind at the distance where pass-by measurements (statistical or controlled) are conducted. In a first step a fixed sound source at a distance of 7.5 m was used. Analytical calculations, simulations with Finite Difference in Time Domain method (FDTD) and measure- ments with an incoherent reference source have been conducted. This study shows there is a clear influence of wind on sound propagation in the vincinity of an incoherent noise source. This influence is small in the situation of SPB or CB (Coast By) measurements for microphone heights above 1.2 m and wind velocitys well below 5 m/s.

Tuesday 12:40-13:00, Hall Brüssel, Paper 0999 (contributed)
Gade Svend
Use of handheld array for NVH measurement in the automotive industry

Gade Svend, Gomes Jesper, Hald Jørgen
Brüel & Kjær Sound & Vibration Measurement A/S,Denmark

The use of single layer and double layer microphone arrays, both hand held as well as robot operated, has been greatly extended within the last decade. This paper summarizes how a small double layer array with typically 128 microphones can be used for interior cabin measurements for mapping various acoustical properties. There are four major applications. The first one is general patch holography (or conformal mapping) of basic acoustical quantities like sound pressure, particle velocity and sound intensity. Optionally sound quality (SQ) metrics for describing human annoyance like loudness, sharpness, fluctuation strength and roughness etc. can also be mapped. Other applications are in-situ absorption measurement-for example inside a car cabin, intensity component analysis (e.g. incident, reflected, scattered, net intensity etc. can be separated) and finally sound pressure contribution from various panels inside cabins to an operators/drivers position. Some measurements aredone in operational condition and some are reference laboratory measurement of typical frequency response functions.

SS05 Road Vehicle Exterior and Interior Noise

Chair: Berge Truls, de Roo Foort

Tuesday 14:00-14:20, Hall Brüssel, Paper 0238 (contributed)
Tanabe Yosuke
Application of Sound Intensity Transfer Path Analysis to a Booming Sound in Vehicle Interior

Tanabe Yosuke[1], Inoue Akira[2]

[1] Hitachi, Ltd., Hitachi Research Laboratory, Japan
[2] Hitachi America, Ltd., Automotive Products Research Laboratory, USA

A booming sound in a vehicle interior excited by a pair of front speakers is analyzed by a new technology called Sound Intensity Transfer Path Analysis (SITPA). In this paper, we employ a sound intensity vector as a measure of the booming sound so that the confinement of acoustic energy in the field can be expressed by a reactive component of the sound intensity. SITPA, which extends the capability of conventional TPA, decomposes the sound intensity at the receiver into the contributions of each path of acoustic power flow in terms of partial sound intensities. Analysis shows that the active and reactive components of partial sound intensity generated by the interference of front-left and front-right speaker can be modified by modifying not only acoustic transfer characteristics of the vehicle interior but also phase-lag of input signals for speakers. The effect of modifying the phase-lag on the booming sound is experimentally examined under the scheme for minimizing and maximizing reactive sound intensity.

Tuesday 14:20-14:40, Hall Brüssel, Paper 0741 (contributed)
Putner Jakob
Analysis of the contributions from vehicle cabin surfaces to the interior noise

Putner Jakob[1], Lohrmann Martin[2], Fastl Hugo[1]

[1] AG Technische Akustik, MMK, Technische Universität München, Germany
[2] Müller-BBM VibroAkustik Systeme, Germany

In order to optimize the acoustic package of a vehicle, cost and weight are, besides the acoustical perfor- mance, the fundamental objectives. Detailed knowledge about the noise emitting surfaces in the vehicle interior is important for an efficient development process. To analyze contributions from vehicle cabin surfaces to the interior noise, the panel noise contribution

analysis method is applied. In a first step, a transfer path analysis from the surfaces to a response position in the vehicle is performed. For the reciprocal method a monopole sound source with measured volume velocity and particle velocity sensors near the panels are used. To preserve phase information while repositioning the panel sensors, pressure microphones complete the setup. The second step is to actually measure the particle velocity at predefined panel positions while the cabin is excited from the outside. The analysis results are contributions from the cabin surfaces to the interior noise, identifying critical panels, which have to be regarded in the further selection of damping and insulation during development of the acoustic package.

Tuesday 14:40-15:00, Hall Brüssel, Paper 1169 (contributed)
Boussard Patrick
Implementing digital engine sound enhancement techniques to define and refine vehicle interior sound image/quality

Boussard Patrick[1], Khurana Rakesh[2], Guyader Gael[3], Orange Francois[1], Orzechowski Jeffrey[2]
[1] Genesis Acoustics, France, [2] Chrysler Group LLC, USA, [3] Renault Centre Technique d'Aubevoye, France

The sound engine is very important for the sound image and quality of differentiating a vehicle in the current marketplace. This paper focuses on the new technology and tools named ASD (Active Sound Design) for Engine Sound Enhancement (ESE) and two cases of application: one in NVH Lab in Chrysler, the other in Renault which is now available in the market with the CLIO 4. The principle of ASD is to use additive sound to enhance the natural sound engine thru the existing audio system, without affecting other radio/media functions. The sound synthesis takes into account engine and vehicle speed, engine torque and throttle position, and the vehicle cabin transfer function. These tools appear as an easy and flexible new way because the sound design can be done in a few days, and can be changed, tuned, during the cycle of development. Once the image sound is defined, it can be programmed into the radio DSP, with no additional or minimal hardware required, for production. This all-digital audio enhancement tool was used in Chrysler NVH Labs to design, synthesize and explore a range of possible target vehicles and engine configurations (V6, V8) for marketing and vehicle integration group evaluation in a production vehicle, to help establish a target image sound for the launch of an upcoming Sporty version of an existing vehicle model. In the case of Renault, the technique has be used until production vehicle since the Renault Clio 4 is available with R-Sound Effect on the market since April 2013. Moreover, the driver can change the engine

sound (sporty car, powerful, or funny cars) and adjust the level of the sound effect.

Tuesday 15:00-15:20, Hall Brüssel, Paper 0887 (contributed)
Arango Santiago
Evaluation of Sound Pressure Levels inside Public Service Vehicles in Bogota, Colombia

Arango Santiago[1], Pacheco Jose[1], Behrentz Eduardo[1], Ramos-Bonilla Juan Pablo[2]

[1] Urban and Regional Sustainability Studies Group, Universidad de Los Andes, Colombia
[2] Department of Civil and Environmental Engineering, Universidad de Los Andes, Colombia

Exposure to high levels of noise is associated with negative health outcomes and a reduction in the quality of life. Noise levels inside the cabin of vehicles found in the public transportation fleet of the city of Bogota were analyzed, collecting 104 measurements in 20 vehicles. Ninety six (96) measurements were collected under controlled conditions and 8 were collected during real operational conditions. Measurements were collected in three different types of vehicles: Buses and small buses that are part of the traditional fleet of the public transportation system, and articulated buses used in a more recently implemented system. Noise levels were measured using a Class 1 sound level meter. Noise measurements were collected as Equivalent Continuous Noise Level (LAeq), (LA,Fast) and (LA,F,Min). The effect on noise levels of several factors was quantified, including vehicle speed, driving patterns, vehicle size, engine size and location, and cabin's sound proofing system. Articulated buses had noise levels considerably lower than buses and small buses. Vehicle speed and engine size were not correlated with noise levels. As a consequence of an aggressive driving pattern, noise levels increased up to 6 decibels (dB) and inadequate cabin's sound proofing raised noise levels up to 10 dB.

Tuesday 15:20-15:40, Hall Brüssel, Paper 0101 (invited)
Bergamini Alex
An experimental study on noise and annoyance reduction in a snow groomer cabin

Bergamini Alex
MAP SpA, Italy

Work generally covers more than one third of day-life: operating every night in a noisy cabin could sensitively affect Quality of Life. Some measurement sessions were performed in order to investigate the acoustics of a snow groomer cabin, deemed to be unsatisfactory as compared to the previous model, and to improve perceivable comfort at driver's ear. Machine emissions inside the cabin were acquired and analysed in situ at several operational states, correlating them to the sources acting during normal service through an operational transfer path analysis. Results indicated that mid frequency range mainly determined the overall levels because of high contribution of cooling fans, followed by engine and its air-intake. Tonal components were found at low frequencies due to transmission and special equipments; at high frequencies were produced by turbocharger. A general lack of both airborne and structure-borne dampening was supposed to be the main cause of such a behaviour. Therefore a refit proposal was designed in order to enhance absorption and damping through main noise paths. Eventually, a refitted snow groomer was tested and benefits of noise reduction, as well as improvement of sound quality, were found satisfactory, proofing the original absence of dissipation.

Tuesday 15:40-16:00, Hall Brüssel, Paper 0475 (contributed)
Humbad Niranjan
Design of experiments study for automotive HVAC console door flutter noise

Humbad Niranjan, Kleinow Aaron, Lietz Chris, Luptowski Christine, Parssinen Carol
Behr America, USA

A design of experiment (DOE) study was undertaken to minimize the testing required to evaluate the influence of various parameters affecting automotive HVAC console door flutter noise. The flutter noise was generated with the HVAC system operating in defrost full heat mode on high blower. The higher heat tended to soften the Santoprene ™ door seals, and high blower voltage tended to open the seal, both leading to increased door seal leakage and therefore leakage-related, flow-excited door flutter. The following factors were determined to be important: blower voltage, coolant temperature, the angle of the door in relationship to the sealing surface, and the durometer of the door seal material. An L18 factorial design was constructed with variations of these four parameters to evaluate this flutter noise, and additional voltage points were included to check for door seal whistle that can occur with higher durometer material. The results of this study show that higher durometer seals almost eliminated the door flutter — without

introducing whistle noise — irrespective of blower voltage, air temperature, or door angle. This study demonstrated that such investigations can be useful when effective countermeasures must be identified in a relatively short period of time.

Tuesday 16:00-16:20, Hall Brüssel, Paper 0761 (contributed)
Evans Graham
Transmission and driveline noise target setting using the Tone-in-Band method

Evans Graham[1], Senapati Uday[1], Syred Frank[2]
[1] Bentley Motors Limited, UK, [2] Sound and Vibration Technology Limited, UK

Frequently, Transmission and Driveline-related noise issues are not identified until late in vehicle development programmes. These issues, typically characterised as 'whines', can be masked due to the high background interior noise of early development mules and prototype cars. As the vehicle matures, refinement improvements to other subsystems result in lower background interior noise levels, meaning whines become more pronounced and objectionable. Little time is then available to resolve these issues or introduce revised parts. This is a growing concern with increasing customer expectations towards refinement, especially in the luxury car segment. In this paper the 'Tone-in-Band' Method is described and its application to the process of transmission and driveline whine target setting is proposed. A jury of assessors was subjected to whines of varying 'Tone in Band' levels, against a defined target level of vehicle background noise. The assessor's responses were used to define 'Audible' and 'Acceptable' levels of whine in the cabin. These levels could then be transposed into Transmission and Driveline target lines for in-gear acoustic performance. Targets defined using the 'Tone-in-Band' Method have been applied twofold – to the evaluation of proposed components for improved Noise, Vibration and Harshness (NVH) and to the monitoring of vehicle maturation. Consideration is given to the merits of the 'Tone-in-Band' Method compared to other target setting tools for similar applications.

Tuesday 16:20-16:40, Hall Brüssel, Paper 1045 (contributed)
Girstmair Josef
NVH optimization of engine subsystems for the early development phase

Girstmair Josef, Schaffner Thomas, Karaś Łukasz
VIRTUAL VEHICLE Research Center, Austria

In the last decennium automotive industry has been facing continuously growing expectations with regard to the noise quality of passenger cars. Since engine noise considerably contributes to the overall driving sensation as well as to the pass by noise, the acoustic optimization of the powertrain plays a major role in the development process. The current state of the art approach for NVH optimization of internal combustion engines is based on simulations and measurements on the entire engine assembly. Due to the fact that a complete engine model or hardware is needed, the biggest disadvantage of this approach is that the results are only available in a rather late stage of the development process. An efficient design process allowing for early stage conceptual choices and subsequent acoustical optimization is consequently not possible. In this paper it is shown that numerical optimization of the NVH performance of IC engines not necessarily requires a full engine model. It is instead suggested that improvements can also be obtained by early stage optimization of separate sub-systems, provided representative excitation and boundary conditions are applied. Several examples assessing the effect of subsystem optimization on the full system performance are given.

SS07 Noise from Hybrid and Electric Road Vehicles

Chair: García Juan Jesus, Genuit Klaus

Tuesday 17:00-17:20, Hall Brüssel, Paper 0102 (contributed)
Albers A.
Method for measuring and interpreting the surface velocities induced by torsional vibration in the drivetrain of a battery electric vehicle

Albers A., Fischer J., Behrendt M., Schwarz A.
IPEK – Institute of Product Engineering at KIT, Germany

The driving comfort is a factor of growing importance for buying decisions. For battery electric vehicles (BEV) the acoustic quality will as well be an elementary distinguishing feature, since the masking of an internal combustion engine is no longer present. Opposing the importance of the acoustic quality is the lack of knowledge of how to measure and interpret the high frequency noise generated by an electric powertrain with respect to the influence on the passengers. In this contribution a method for measuring and interpreting the transfer path of acoustic phenomena for an electric powertrain with a permanent magnet synchronous machine (PMSM) and a two stage transmission is presented. Thereby the excitation of the PMSM housing and the excitation of the gearbox by the PMSM are analyzed. The surface velocities are measured by the use of PSV 400 3D Scanning Vibrometer in a special setup. The measurements are performed in the context of the IPEK-X-in-the-Loop Framework on a powertrain test bench in an anechoic chamber. These measurements will be validated using the same setup on the IPEK acoustic roller test bench.

Tuesday 17:20-17:40, Hall Brüssel, Paper 0606 (invited)
Kubo Norio
EV concept sound design experiments – Japanese style

Kubo Norio
Yokohama Institute of Acoustics, Inc., Japan

Signal Processing methods have been discussed for sound designing of electric or hybrid vehicle since these cars does not make any engine sounds. The discussion have been started from adding artificial engine sounds for safety reason but it extended that sounds represent concept of vehicle, which is ‘concept sound design’. By using three signal processing methods, which are previously discussed, experimental sound designs are examined in

this paper. Key components of experimental sounds are related to typical Japanese sounds such as a boom of a temple bell, a wind chime and a chime made of chopsticks.

Tuesday 17:40-18:00, Hall Brüssel, Paper 0807 (contributed)
Singh Sneha
Detection and emotional evaluation of an electric vehicle's exterior sound in a simulated environment

Singh Sneha, Payne Sarah R., Jennings Paul A.
WMG, University of Warwick, UK

Electric vehicles are quiet at low speeds and thus potentially pose a threat to pedestrians' safety. Laws are formulating worldwide that mandate these vehicles emit sounds to alert the pedestrians of the vehicles' approach. It is necessary that these sounds promote a positive perception of the vehicle brand, and understanding their impact on soundscapes is also important. Detection time of the vehicle sounds is an important measure to assess pedestrians' safety. Emotional evaluation of these sounds influences assessment of the vehicle brand. Laboratory simulation is a new approach for evaluating exterior automotive sounds. This study describes the implementation of laboratory simulation to compare the detection time and emotional evaluation of artificial sounds for an electric vehicle. An Exterior Sound Simulator simulated audio-visual stimuli of an electric car passing a crossroad of a virtual town at 4.47 ms^{-1} (10 mph), from the perspective of a pedestrian standing at the crossroad. In this environment, 15 sounds were tested using experiments where participants detected the car and evaluated its sound using perceptual dimensions. Results show that these sounds vary significantly in their detection times and emotional evaluations, but crucially that traditional metrics like dB(A) do not always relate to the detection of these sounds. Detection time and emotional evaluation do not have significant correlation. Hence, sounds of a vehicle could be detected quickly, but may portray negative perceptions of the vehicle. Simulation provides a means to more fully evaluate potential electric vehicle sounds against the competing criteria.

SS26 Acoustics of Educational Facilities / Classroom Acoustics

Chair: Pelegrin García David, Prodi Nicola

Tuesday 08:20-08:40, Hall Freiburg, Paper 1009 (invited)
Durup Nick
Vocal Stress and Acoustics in Schools – A Pilot Study

Durup Nick[1,2], Shield Bridget[1], Dance Stephen[1], Sullivan Rory[2]

[1] Department of Urban Engineering, Faculty of Engineering, Science and Built Environment, London South Bank University, UK, [2] Sharps Redmore Acoustic Consultants, UK

Recent surveys indicate that approximately 60% of UK teachers experience vocal problems during their career. This is estimated to cost £15 million annually in teacher absence and can have a significant human cost for those involved. Research being carried out by London South Bank University is investigating the impact of classroom acoustics on teachers' vocal levels to determine if acoustic modifications to classrooms could reduce the vocal load placed on teachers. Measurements of teachers' vocal levels will be made using an Ambulatory Phonation Monitor (APM) in a range of classrooms reflecting the range of acoustic conditions currently found in UK schools. The APM measures vocal parameters directly from skin vibrations on the neck and allows the voice to be monitored independently of the general noise climate. A pilot study is currently underway. Details of the pilot work, background and proposed methodology are detailed along with initial findings.

Tuesday 08:40-09:00, Hall Freiburg, Paper 0982 (contributed)
Campbell Colin
Classroom acoustic research findings on speech behaviour of teachers and students

Campbell Colin, Svensson Carsten P.
Saint-Gobain Ecophon, Sweden

Looking at three extensive acoustic field measurement investigations carried out over the last 15 years, we can see that with improved room acoustic treatment the speech and activity sound levels in classrooms are reduced much more than would be theoretically expected. It is interesting and vital to understand how these benefits affect the core teaching and learning processes and how we in turn need to look beyond single number room evaluations and rather focus on how we can have a better interpretation of the complete room acoustic responses. Looking at the subjective speech

behaviour in connection with sound level measurements and the corresponding questionnaires and post occupancy evaluations we can understand more about the vocal load, sound levels and listening conditions in different classroom acoustic conditions.

Tuesday 09:00-09:20, Hall Freiburg, Paper 0892 (invited)
Hodgson Murray
Acoustical Evaluation of Technology Educational Shops

Hodgson Murray, Summan Ahmed
Acoustics & Noise Research Group, SPPH-MECH, University of British Columbia, Canada

Technology Educational Shops (TES) are designed to develop high school students' technological literacy. Their acoustical conditions play a dominant role in the quality of these environments. TES are, at the same time, classrooms for learning and industrial workshops for making things. Each use has its own standards governing its acoustical characteristics: ANSI S12.60-2002 for classrooms and the Ondet & Sueur DL2 criteria for workshops. A major conflict could exist by using the same room for two different purposes. This study investigated this conflict by evaluating the acoustical characteristics of 20 unoccupied wood, metal and automotive shops. It conducted measurements of background noise level (BNL), reverberation time (RT), speech intelligibility index (SII) and DL2. Results showed that BNLs and RTs in most TES were higher than the acceptability criteria for unoccupied core learning spaces. SII values indicated bad/poor speech intelligibility for normal and raised voice levels and reasonable/good speech intelligibility for loud and shout voice levels. DL2 values were found acceptable in TES larger than 100 m2 in floor area. In general, these results indicate the poor acoustical conditions of TES as classrooms, and the need for special sound control measures.

Tuesday 09:20-09:40, Hall Freiburg, Paper 0322 (invited)
Sala Eeva
Acoustics of comprehensive school classrooms in Finland

Sala Eeva[1], Hakala Suvi[2], Rantala Leena M.[2], Holmqvist Sofia[3], Jonsdottir Valdis I.[4]

[1] Turku University, Finland, [2] Department of Speech Communication and Voice Research, University of Tampere, Finland, [3] Department of Logopedics, Åbo Akademi University, Finland, [4] Thad er malid. Akureyri, Iceland

The pedagogy and teaching have changed during the last 20 years. Nowadays teaching is a multi-dimensional process that consists of teamwork. In this mode of teaching pupils are in small groups round the classroom which are small in size and most of the time a teacher goes near pupils to talk to them. The teacher also talks to the pupils while walking round the classroom and only sporadically from the front of the classroom. Acoustics of the classrooms is the basis for speech communication, speech production and hearing, and learning. In our study acoustics of comprehensive school classrooms (N=40) were measured and compared to the values of national acoustic standard (SFS 5907). According to the standard in ordinary school classrooms reverberation time T_{60} (s) should fall within 0.5-0.6 seconds at octave bands 250, 500, 1000, 2000, 4000 Hz, while STI-values should be ≥0.80 and ≥0.85 in teaching space suitable for pupils with poor hearing, language impairments or other learning disabilities. The results showed that 14 classrooms fulfilled the reverberation time criteria, in 9 classrooms the reverberation time was shorter and in 17 classrooms longer than the criteria. There was only one classroom where the STI-value was ≥0.80 and no classroom where the STI-value was ≥0.85. Classrooms in use are acoustically poor.

Tuesday 09:40-10:00, Hall Freiburg, Paper 0353 (contributed)
Harvie-Clark Jack
The practical application of G and C_{50} in classrooms

Harvie-Clark Jack, Dobinson Nicholas
Apex Acoustics Ltd, UK

Reverberation time remains the primary indicator of room acoustic response. However, previous work has shown that reverberation time alone can be insufficient to describe the acoustic conditions in non-diffuse environments, especially in classrooms where the majority of absorption is typically on one surface. Alternative parameters have been proposed to evaluate the acoustic response of such rooms: Strength, G, and Speech Clarity, C_{50}. These correlate better with loudness and speech intelligibility, in the absence of background noise, than reverberation time and distance from the source. There is currently little guidance on the spatial distribution of source and measurement positions or the averaging of measured values for these parameters. This paper investigates the practical use of G and C_{50} to describe the acoustic response of classrooms. Measurements and modeling are used to investigate the spatial variation with frequency, source position,

measurement distance, and room size. Correlation between modeled and measured values is investigated. Guidance on source and receiver positions is proposed to achieve consistent results, so that the parameters Strength and Speech Clarity may usefully describe the room response rather than one particular measurement set up.

Tuesday 10:00-10:20, Hall Freiburg, Paper 0362 (invited)
Nilsson Erling
Calculations and measurements of reverberation time, sound strength and clarity in classrooms with absorbing ceilings

Nilsson Erling
Saint-Gobain Ecophon AB, Sweden

The acoustic evaluation of classrooms is very much focused on the reverberation time as the main room acoustic parameter. Although room acoustic research since many years noticed its shortcomings and also presented several more relevant descriptors, very little of this knowledge have been used in practice. In many ordinary rooms like classrooms, the typical acoustic solution is a suspended absorbing ceiling. The non-uniform distribution of the absorbing material leads to a non-diffuse sound decay and to a low correlation between reverberation time and parameters related to sound strength and speech clarity. Measurement of reverberation time T20, sound strength G, and speech clarity C50 has been carried out in 14 classrooms. Two different ceiling absorbers have been tested in each classroom, making a total of 28 configurations. Measured results are compared with estimations based on classical diffuse field assumptions and formulas taking non-diffusivity into account. It is concluded that in typical classrooms where the main absorption is situated in the ceiling there will be an improvement in the correspondence between measurements and calculations if the degeneration of the diffusivity during the sound decay is taken into account.

Tuesday 11:00-11:20, Hall Freiburg, Paper 0997 (contributed)
Kawai Keiji
Mitigation of noise in nursery classrooms by sound absorption, Part 3: A case study on acoustically renovated classrooms

Kawai Keiji, Fujihara Saori
Kumamoto University, Japan

This study reports an acoustical renovation of actual nursery classrooms where the teachers complained about their physical symptom, such as headache, and difficulty of verbal communication due to the excessive reverberation in a new classroom where any sound absorptive materials were not used. For the mitigation of the situation, an acoustical renovation was conducted in two rooms by installing Helmholtz resonator panels to the walls and by hanging additional sound absorbing boards made of polyester fiber in one of the rooms. The reverberation times of the two rooms reduced by the renovation from 2.7 s and 0.9 s to 0.6 s and 1.1 s at 1 kHz octave band, respectively. The sound and scene in the rooms was recorded using video camera and sound level meter, and the teachers answered a questionnaire before and after the renovation. The answers of the questionnaire indicated a considerable improvement of their well-being in the rooms. The noise level decreased by 1-3 dB in average, which was no more than the expected physical reduction by sound absorption. Bustling atmosphere of the rooms was compared by means of counting number of shouting and, though not a statistical difference, less frequency of shouting was observed after the renovation.

Tuesday 11:20-11:40, Hall Freiburg, Paper 1131 (invited)
Shield Bridget
Acoustics and noise in English secondary schools

Shield Bridget[1], Conetta Robert[1], Cox Trevor[2], Mydlarz Charlie[2], Dockrell Julie[3], Connolly Daniel[3]

[1] London South Bank University, UK, [2] Institute of Education, University of London, UK, [3] University of Salford, UK

A recent project has investigated acoustical conditions in secondary schools in England, in order to examine the effects of the acoustic environment on teaching and learning of 11- to 16-year-olds. The project consisted of detailed acoustic and noise surveys of 185 teaching spaces in 13 schools; questionnaire surveys of around 2500 pupils and 200 teachers; and cognitive testing of students in different noise conditions. This paper presents the results of the acoustic and noise surveys of unoccupied teaching spaces, and compares them with the current standards on the acoustic design of schools in England, introduced in 2003. It is shown that the legislation has been effective in improving the acoustic environment in schools. Noise levels measured during 274 lessons in the same 13 schools are summarised, and the levels associated with different subjects and teaching activities examined. The lesson noise levels have been compared with unoccupied acoustic data

to identify any influence of acoustic design on operational school noise levels. It was found that the better the acoustic design of the school, the lower were lesson noise levels.

Tuesday 11:40-12:00, Hall Freiburg, Paper 0436 (contributed)
Visentin Chiara
Applying a combined metric based on fluctuation characteristics to outline the impact of noises in the classrooms

Visentin Chiara, Prodi Nicola
Dipartimento di Ingegneria, Università di Ferrara, Italy

In a companion paper by the same authors (*N. Prodi and C. Visentin, "Revising fluctuation noise characteristics for describing the reception of speech in rooms with a combined metric", Proc. of INTERNOISE 2013, Innsbruck 15-18 September 2013*) a novel combined objective metric for assessing the role of noise fluctuations on word recognition in rooms was presented and discussed. The parameter is termed "speech fluctuation quality index" SFQI and includes both an indirect evaluation of the noise modulations on the signal plus noise combination and a loudness discrimination correction. The approach, matched to closed set DRT tests, allows to evaluate each noise separately and this feature is mostly relevant in classrooms, where the dist urbances are of various nature and each has its own fluctuation attributes. In the present work it is shown how the SFQI is able to segregate the noises, and works when STI substantially fails. The pupils' performance is thus much better depicted especially when the "listening efficiency" subjective data are considered in the analysis. Applications of this objective/subjective approach will be fostered in other contexts too.

SS25 Room Acoustics

Chair: Guigou-Carter Cathy, Patricio Jorge

Tuesday 12:00-12:20, Hall Freiburg, Paper 0334 (contributed)
Xiangyang Zeng
Study of scattering characteristics of periodic structures based on boundary element method

Xiangyang Zeng, Haitao Wang, Jianjun Zhang
School of Marine Engineering, Northwestern Polytechnical University, China

Periodic structure is a kind of typical acoustic structure for building acoustics. It is very important to obtain its scattering properties for the acoustic design of these structures and the research of room acoustic modeling. In this paper, to quantitatively analyze the scattering characteristics of periodic structures, the boundary element method is applied to study the sine-shaped, triangular and rectangular periodic structures in various conditions. The factors that affect the scattering properties including the distance of the sound source and receivers, the number of the receivers, and the shape and dimensions of the sub structures are analyzed. The results show that the distances of the receivers and sound source have more influence at high frequencies than that at low frequencies as well as the impact of the number of receivers. The shapes and dimensions have obvious impact on the scattering coefficient. The scattering ability of the periodic structure with more rough profile is generally stronger.

Tuesday 12:20-12:40, Hall Freiburg, Paper 0411 (contributed)
Wang Haitao
Correction of the random-incidence scattering coefficient measured by the reverberation chamber method

Wang Haitao, Xiangyang Zeng
School of Marine, Northwestern Polytechnical University, China

The random-incidence scattering coefficient is a basic index to describe the scattering properties of surfaces in room acoustics. The measurement of the index can be implemented in a reverberation chamber according to ISO 17497-1 in which the scattering coefficient is calculated by the absorption coefficients which are measured in different cases. The set-up consists of sound sources, receivers and a round base plate over a turntable. In many cases, the test sample is made of thin plate which would cause that there

are air gaps between the sample and the turntable. Consequently, there would be absorption of the energy caused by the gaps which leads that the absorption coefficients are usually greater than those in the ideal condition. In order to improve the accuracy of the measurement, the correction of the random-incidence scattering coefficient measured by reverberation chamber method is presented in this paper. The effects of the energy loss caused by the gaps are analyzed and compensated. The application of the correction for a practical measurement shows that the values after corrections decrease to some extent and have better agreements with those obtained by numerical calculations.

Tuesday 12:40-13:00, Hall Freiburg, Paper 0642 (contributed)
Toyoda Emi
Experimental study of the effect of air absorption on the sound absorption measurement in a reverberation room

Toyoda Emi, Yoshimura Junichi
Kobayasi Institute of Physical Research, Japan

Changes in air absorption can have a large effect on the measurement accuracy of sound absorption in a reverberation room. The effect is significant under low-temperature and low relative humidity conditions. For this reason, ISO 354 has established that a lower temperature limit of 15ºC and a lower relative humidity limit of 30% should be used. The purpose of this study is to clarify the tolerances for changes in temperature and relative humidity, which minimize the effect of air absorption, even if the conditions are out of the standard. In order to confirm the effect of air absorption, the temperature and relative humidity are monitored continuously for several years in our reverberation room. From these results, the seasonal changes in temperature and relative humidity were examined. Also, in order to examine the effect of humidity on air absorption under low-temperature conditions, the changes in temperature and relative humidity were monitored while humidifying the air in the reverberation room. Next, measurements of sound absorption were performed under different relative humidity conditions by humidifying. The sound absorption coefficient could be measured accurately when the absolute values of the correction for the change in air absorption were less than approximately 0.2. Consequently, the tolerances for changes in temperature and relative humidity were established. It is possible to minimize the effect of air absorption if the

relative humidity is controlled within the tolerance, even if the temperature is low.

Tuesday 14:00-14:20, Hall Freiburg, Paper 1195 (invited)
Häusler Clemens
"The true sound absorption" measurement versus calculation

Häusler Clemens
Bauphysik Kalwoda, Austria

The reverberation time is the oldest and best-known criterion in room acoustics. Absorption is the most important, and in practice usually the only acoustic input to calculate the reverberation time. But how accurate is these absorption (and hence also the calculated reverberation time)? Alternatively to measurements the sound absorption can be calculated. From 1989 to 1998 Prof. Fridolin Mechel published all necessary information about the calculation in his sound absorber Trilogy on a total of 2866 pages. A comparison between measured and calculated values give information about "The true sound absorption" and points out the shortcomings of the reverberation chamber, especially at low frequencies. The calculation cannot only check the measured values, but can also quickly optimize absorber. Depending on the required absorption at low, medium or high frequencies the desired absorber can be quickly developed on the computer. A very special case is the calculation of acoustic elements. Due to the small size - compared to the wavelength in the air - the absorption at low frequencies will be extremely increased.

Tuesday 14:20-14:40, Hall Freiburg, Paper 0560 (contributed)
Yeon Jun-oh
Evaluations of the Acoustics Characteristics of Cellulose Absorbers

Yeon Jun-oh, Kim Kyoung-woo, Yang Kwan-seop

Green Building Research Division, Building Research Department, Korea Institute of Construction Technology, Korea

Eco-friendly material applied to building would be one of the materials which is must developed for global environmental conservation and reduction of carbon dioxide. For development of eco-friendly material, a cellulose sound-absorbing material has been developed with waste paper through adjustment

of various mix proportions. The developed cellulose sound-absorbing material has been tested for its acoustic properties such as acoustic absorption coefficient and dynamic elastic modulus. The absorption coefficient was evaluated by developing six samples and using impedance tube and reverberation chamber. As a result of the evaluation, 0.64(NRC) was secured in absorption coefficient and 4.7 MN/m^3 was indicated in dynamic elastic modulus. Also, for practical use of developed sound-absorbing material as inner heartwood in drywall, comparison test of sound reduction index was performed with existing glass wool sound-absorbing material and constructed drywall of gypsum board. The results have shown 55dB(Rw+C) of sound reduction index in glass-wool wall and 46dB(Rw+C) in cellulose.

Tuesday 14:40-15:00, Hall Freiburg, Paper 0788 (contributed)
Le Muet Yoan
Combining thermally activated cooling technology (TABS) and high acoustic demand: Acoustic and thermal results from field measurements

Le Muet Yoan[1], Peperkamp Hanneke[2], Machner Rainer[3]
[1] Saint-Gobain Ecophon, France, [2] Peutz, The Netherlands, [3] Saint-Gobain Ecophon, Germany

New office buildings use thermal capacity of the structure mass to provide thermal comfort. This technique provides stable thermal conditions and is perceived to be a long-term energy efficient solution. A priori, this kind of technique is not compatible with traditional suspended ceilings, covering a room from wall to wall. This is due to the fact that the ceiling, positioned between the soffit and the users, would then be a mask for radiation and would stop convection. How then can we quantify their acoustic and thermal impact on slab's cooling capacity? In order to investigate the subject we performed dynamic measurements in the summer period of June to August 2012 in the Woopa building located in Lyon, France. The aim of this research was to quantify the reduction of the cooling capacity due to a glass wool suspended ceiling by measuring the temperature increase in the room. The purpose of this paper is to show the acoustic and thermal tests that have been conducted, the set-up used, the measurement methods, as well as to present examples of projects and give data to encourage dialogue and coordination between the acoustician and other building engineering disciplines.

Tuesday 15:00-15:20, Hall Freiburg, Paper 0337 (contributed)
Kitapci Kivanc
Speech intelligibility in multilingual spaces

Kitapci Kivanc[1], Galbrun Laurent[1], O'Rourke Bernadette[2], Turner Graham H.[2]
[1] Heriot-Watt University, School of Built Environment Edinburgh, UK
[2] Heriot-Watt University, School of Management and Languages, UK

The cultural and social diversity of modern urban environments, can affect oral communication within spaces where multiple languages are used. In such environments, the intelligibility of speech is influenced not only by room acoustic parameters, but also by languages' characteristics and socio-cultural factors related to the individuals using those languages. The aim of the present study is to examine how physical, linguistic and socio-cultural factors affect communication of multilingual environments. More specifically, the study considers four languages (English, Polish, Chinese and Arabic), and investigates the relationship between speech intelligibility parameters measured from physical tests and listening tests. Speech intelligibility comparisons focus on results obtained from the speech transmission index (STI), word lists based upon the diagnostic rhyme test (DRT), and phonemically balanced sentence lists. In its second stage, the research will look at how socio-cultural factors affect speech intelligibility and communication.

Tuesday 15:20-15:40, Hall Freiburg, Paper 0268 (contributed)
Prodi Nicola
Revising fluctuation noise characteristics for describing the reception of speech in rooms with a combined metric

Prodi Nicola, Visentin Chiara
Dipartimento di Ingegneria, Università di Ferrara, Italy

The intelligibility of speech in rooms can be described by standardized objective measures (i.e. measurable quantities such as STI or others) or by subjective scores obtained in listening tests by means of a given test corpus (rhymed words, sentences etc.). Regarding the objective indicators, and STI in particular, there has been concern on how to deal with types of nonlinear processing such as compression or spectral subtraction, and also on how the peculiar effects of different kinds of time variant noises can be accounted for. This latter point is considered in the work by revising a former approach

based on the wide band analysis of the noise fluctuation characteristics. The improvement consists in introducing an indirect estimate of the peculiar noise fluctuation impact. This approach is further developed by correcting for the different loudness values of noise and signal. The new objective indicator is matched with both the word intelligibility scores and the listening efficiency data. Two case history applications are reported to support the combined metric.

Tuesday 15:40-16:00, Hall Freiburg, Paper 1232 (contributed)
Sakuma Tetsuya
Effect of absorbing panels on acoustic quality in small rectangular meeting rooms

Sakuma Tetsuya, Guo Jing
Graduate School of Frontier Sciences, The University of Tokyo, Japan

In general, small meeting rooms with reflective walls, such as gypsum boards or steel partitions, have low acoustic quality due to loud reverberation and sound coloration. Moreover, most of the rooms have rectangular shape, which can cause a flutter echo problem even if using an absorptive ceiling and floor. In this paper, objective and subjective experiments are performed to investigate the effects of absorbing panels for walls on acoustic quality in a small rectangular meeting room. First, three types of panels with different frequency characteristics are installed on two parallel walls in an original room where only the ceiling is absorptive. In the four rooms including the original room, two kinds of subjective experiments are done regarding: i) impressions after 10 minutes discussion by 4 persons in each room, ii) auditory pairwise comparisons of reverberation in each combination of rooms. Second, only the comparison test is done for a different set of four rooms, installing a specific type of panels in different amounts and arrangements. In objective aspects, room acoustic parameters are determined from impulse response measurements, and the relationship between objective and subjective results are discussed.

Tuesday 16:00-16:20, Hall Freiburg, Paper 0959 (invited)
Hufenbach Werner A.
Acoustical behaviour of new multifunctional ceiling panels made of textile-reinforced concrete composites

Hufenbach Werner A.[1], Kolbe Frank[1], Dannemann Martin[1], Friebe Stefan[1], Ortlepp R.[2]

[1] Technische Universitaet Dresden, Institut für Leichtbau und Kunststofftechnik (ILK), Germany
[2] Technische Universitaet Dresden, Institut für Massivbau, Germany

The building requirements concerning fire protection and room acoustics often require separate mounted subceilings. Currently used subceilings often contain separate parts for the fire protection and the acoustic customization. The newly developed structures made of textile-reinforced concrete and lightweight aggregate concrete combine these two functions in one prefabricated element. Beside the thermal insulation and the noise absorption of these elements, the static behaviour and the lightweight potential were investigated. The open-pored lightweight concrete reduces the temperatures at the textile-reinforced concrete layer and helps to reduce the reverberation time of the room. It was figured out, that the usage of elements with an s-shaped cross section produces the best results. These elements create air chambers, which provide further heat and noise absorption in addition to the lightweight aggregate concrete itself. The acoustical behaviour of different concrete mixtures was analysed by measuring the absorption coefficient in an impedance tube and in a reverberation chamber. Furthermore, the transmission loss was measured in a window test stand. It could be shown, that the usage of open-pored lightweight concrete has a significant influence on the absorption coefficient, whereas the type of lightweight additions (e.g. foam glass, expanded clay or expanded slate) is of minor relevance.

Tuesday 16:20-16:40, Hall Freiburg, Paper 1024 (contributed)
Blinet Thibaut
Sound absorption optimization of thin ceiling panels at low frequencies

Blinet Thibaut, Jacqus Gary, Guigou-Carter Catherine, Jean Philippe, Chéné Jean-Baptiste
CSTB, France

Commonly used in the manufacture of suspended ceiling panels, stone wool is a porous material suitable to deal with acoustic absorption problems. For practical and economic reasons, these panels are generally implemented with small thicknesses (~15 to 40 mm) and therefore limit the sound absorption efficiency in low frequencies. In this work, different approaches are highlighted to improve the low frequency behavior of this kind of system (introduction of resistive layer, air gap, or second scale of porosity, etc…). If these aspects have been and are still widely discussed, the innovation here is to study them together and at several scales: from the material scale (stone wool) to the system (ceiling) via the finished product one (panel). The sound absorption of such products is investigated throughout both experimental (normal incidence and diffuse field measurements) and simulation (finite transfer matrix approach, finite element method) approaches. Another purpose of this paper is to highlight the sturdiness but also the limitations of the approaches studied throughout many comparisons between theory and measurement.

SS21 Insulation of Air-borne and Structure-borne Sound

Chair: Zeitler Bernd, Guigou-Carter Cathy

Tuesday 16:40-17:00, Hall Freiburg, Paper 0690 (contributed)
Lin Shuo-Yen
Improvement of sound insulation performance of double-layer wall by using vibration absorbers

Lin Shuo-Yen[1], Tsujimura Sohei[2], Yokoyama Sakae[2], Sakamoto Shinichi[2]

[1] Graduate School, The University of Tokyo, Japan
[2] Institute of Industrial Science, The University of Tokyo, Japan

The sound insulation performance of double-layer wall reduces because of a mass-air-mass resonant problem. To solve this problem, applying vibration absorbers in double-layer wall is a solution to improve the sound insulation performance at resonant frequency band. In theory, we simply modeled a double-layer wall as a MKC system and estimated the sound insulation performance by equations of motion. Then a parameter study on the effect of vibration absorbers was conducted. In experiments, the sound insulation performance of a double-layer wall is measured by sound intensity method in 1/5 scale model. The vibration absorber is made of materials as paper and urethane form and its natural frequency is made the same as the resonant frequency of double-layer wall. We made various arrangements of materials in double-layer wall to study the mechanism of vibration absorbers.

Tuesday 17:00-17:20, Hall Freiburg, Paper 0406 (contributed)
Schneider Martin
Complaints about low frequency noise with floating floors

Schneider Martin, Fischer Heinz-Martin
Hochschule für Technik, Germany

A common building construction to reduce impact noise of floors in multifamily dwellings is a floating floor. It consists of an elastic interlayer with a screed on top. The concrete floor, the interlayer and the screed can acoustically be represented by a mass spring mass system. This construction reduces airborne and impact sound transmission above its resonance frequency. In the last decade complaints were expressed that at low frequency a rumbling or rattling due to the floating floor disturbs residents. A survey among building acoustic engineers was carried out to collect measured impact sound

insulation. In this survey it is distinguished between measurements where people complained about impact sound insulation and measurements due to the approval of the building. The second set of measurements is used to quantify an average acoustical standard of a floating floor in multifamily dwellings. There are no big differences found in the measured weighted normalized impact sound pressure level $L'_{n,w}$ and in both cases the majority of the construction fulfilled the increased requirement of the German standard DIN 4109. Below 100 Hz differences are found in the measured impact levels. The average impact level of the complaints is in the frequency range below 100 Hz about 10 dB higher and the spectrum adaptation coefficient $C_{I50-2500}$ of the complaints is about 8 dB lower than the average. The quota for complaints seems to decrease when the spectrum adaptation coefficient $C_{I,50-2500}$ is small. This can be achieved when the resonance frequency of the floating floor is reduced below 50 Hz.

Tuesday 17:20-17:40, Hall Freiburg, Paper 0374 (contributed)
Prato Andrea
Problems and possible solutions in the evaluation of laboratory airborne sound insulation at low frequencies

Prato Andrea[1], Schiavi Alessandro[2]

[1] INRiM – Thermodynamical Division, Italy, [2] INRiM – Mechanical Division, Italy

Airborne sound insulation laboratories with typical volume between 50 m^3 and 80 m^3 are characterized by a non-diffuse field in the low-frequency range (50-100 Hz). New approach and measurement methodology are necessary in the evaluation of sound insulation with respect to ISO 10140:2010 standard. In the coupled system room-partition-room, in addition to natural modes of each system component, modal transmission from source to receiving room through the partition is observed. A first characterization of spatial distribution of natural and transmitted modes shows large spatial variation and maximum sound pressure levels in the 3-D corners of the rooms. A modal sound insulation, different from sound reduction index for diffuse field, is defined as the point-by-point difference between the maximum sound pressure levels of source room modes that occur in both source and receiving rooms. Different methods, measurement procedures, normalization terms and related problems are investigated to get a correct evaluation of modal sound insulation and a discussion on the meaning of such index is developed. Furthermore a new method to extend sound insulation measurement to all

frequencies between 44 Hz and 112 Hz (the lower and upper bounds of the 50 Hz and 100 Hz third octave bands respectively) is proposed.

Tuesday 17:40-18:00, Hall Freiburg, Paper 0774 (invited)
Homb Anders
Improvement of the sound insulation of windows with cultural value

Homb Anders
SINTEF Building & Infrastructure, Norway

There are still a large number of older windows that are worthy of preservation in Norway. It is beneficial to upgrade solutions with respect to the U-value, sound insulation and other properties. SINTEF Building & Infrastructure has carried out a project related to this where we have seen what can be achieved by installing a secondary casement in addition to the existing window. Optimization of double glazing in the secondary casement has been done with respect to U-value, but in this project we have also measured sound insulation properties. These measurements also include the effect of different sealing solutions. We have also carried out calculations of the sound reduction index. The paper will present results from this project with comparison of measured and calculated sound insulation properties. It is possible to achieve high sound insulation of windows with a secondary casement. But the project also shows that the sealing between the sash and frame is very decisive for the sound insulation result.

SS29 Standardized Noise Prediction Methods

Chair: Dutillieux Guillaume, Probst Wolfgang

Tuesday 08:20-08:40, Hall Strassburg 1, Paper 0011 (contributed)
Kropsch Michael
Manual for the assessment of noise originating from farms

Kropsch Michael, Lechner Christoph
AREC Raumberg-Gumpenstein, Austria

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 noise experts 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 vocalization 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 Forum Schall and the Austrian Federal Ministy of Agriculture, Forestry, Environment and Water Management. It was published in spring of 2013 via the homepage of the Austrian Federal Environment Agency.

Tuesday 08:40-09:00, Hall Strassburg 1, Paper 1183 (invited)
Di Martino Marc
Reference software libraries for NMPB 2008

Di Martino Marc[1], Dutilleux Guillaume[2], Van Maercke Dirk, Defrance Jérôme[2]
[1] Sétra, France, [2] CETE de l'Est – LRPC Strasbourg, France, [3] CSTB, France

Engineering methods for outdoor noise calculation prove difficult to specify completely without any ambiguity in an official standard or a technical guide, even when a professional software developer is involved during specification. Implicit assumptions and unforeseen consequences in

particular configurations are to be expected. Therefore, there is always some room for interpretation when a programmer has to translate a paper specification into software. Mistakes are also likely to occur during this process. In the case of NMPB 2008 test cases have been provided with the standard to be implemented. But these test cases are available in limited number and a more general test bed is helpful. In order to satisfy this need, reference software libraries for NMPB 2008/NF S 31-133:2011 have been released in 2013. The software covers road emission, rail emission and point to point propagation. It is designed either to help commercial software developers to check their own implementation or to be directly embedded in software. This paper outlines the adjustements made between the written standard and the source code of these libraries, in the spirit of the on-going ISO 17534 project. The functionality provided by the software and the related terms of use are described.

Tuesday 09:00-09:20, Hall Strassburg 1, Paper 0266 (contributed)
Le Bourdiec Solène
Code_TYMPAN™ open source software dedicated to the calculation of industrial noise in the environment

Le Bourdiec Solène, Thomasson Denis
EDF R&D, France

Code_TYMPAN™ is an open source software for industrial noise calculation in the environment. It allows to deal with 3D realistic geometries and has a convenient Human Machine Interface to help engineers to build 3D models to achieve analysis needed in environmental noise studies. Code_TYMPAN™ allows to define the user’s simulation from basic components and geometrical solvers. It includes different solvers: a classical one based on ISO 9613 extended to industrial applications and a more sophisticated one called ANIME3DSolver. The latter one uses an efficient 3D ray tracer taking into account multiple diffraction and meteorological effects. This ray tracer is based on acceleration structures. The aim of this paper is to present the possibilities offered by Code_TYMPAN™. Some simulation results on more or less complex scenes will be shown together with the 3D ray tracer computing time. Outlooks for further developments will also be discussed.

Tuesday 09:20-09:40, Hall Strassburg 1, Paper 0632 (contributed)
Hida Takahiro
Open area field measurements of industrial plants noise

Hida Takahiro
JGC Corporation, Japan

Industrial plants such as refinery, petrochemical and gas treatment plants emit huge noise in surrounding community due to a lot of noise source. Noise from these plants will affect wide area, therefore it is very important to conduct accurate prediction and design of noise control in design phase. Using our empirical data measured on the operating plants field, we can improve prediction techniques and take effective noise control measures. This paper will present the outcome of our field measurements performed at sea and desert areas. These open area noise measurements are valuable, because we can obtain plant noise property at long distance without any obstacles during sound propagation from plants to receivers. By ensuring the consistency of field conditions between measurement and calculation, we evaluate the attenuation property and ground factor for calculation based on ISO 9613-2 method.

Tuesday 09:40-10:00, Hall Strassburg 1, Paper 0103 (invited)
Hetzel Roland
Influence of Teperature Inversion on Outdoor Noise Propagation – A Case Study

Hetzel Roland, Halbritter Jürgen
Siemens AG, Germany

Atmospheric conditions can have major influence on outdoor sound propagation. This paper discusses the influence of temperature inversion on outdoor noise propagation. Effects of temperature inversion will be described and an overview of related outdoor sound propagation algorithms and methods will be discussed. A case study based on measurements of meteorological conditions and noise levels at power plants shows effects of temperature inversion on noise propagation. For the case study atmospheric conditions were measured using a weather mast and alternatively weather balloons with temperature and wind sensors. Simultaneously noise measurements were performed in different directions and at different distances. Finally sound power levels of noise sources were determined and 3D noise models were established using those source data. Results of sound

propagation modeling and noise measurements will be compared and discussed.

Tuesday 11:00-11:20, Hall Strassburg 1, Paper 0067 (contributed)
Hoislbauer Heinz
Noise emission from road tunnel openings

Hoislbauer Heinz, Strohmayer Gerhard
TAS Sachverständigenbüro für Technische Akustik SV-GmbH, Austria

A study on the subject of sound radiation from tunnel openings has been carried out. The basic of this study were measurements on real tunnel objects as well as simulations. The goal of this work was the creation of a calculation model for the radiation of noise produced by tunnel openings. An overview of the main points of the study will be given. On the basis of measurement data of real tunnel objects a model which depends on several parameters like the size, the shape and the portal design was developed. A method for incorporating the results of this study into standard programs for the calculation of sound propagation will be presented. This method also shows the basic outline for a possible appendix to the guideline for road noise calculation (RVS 04.02.11) in Austria.

Tuesday 11:20-11:40, Hall Strassburg 1, Paper 1156 (invited)
Krapf Klaus-Georg
Specific aspects of the quality assurance of software for calculation of aircraft noise

Krapf Klaus-Georg[1], Ibbeken Sebastian[2]

[1] Wölfel Meßsysteme SoftwareGmbH + Co. KG, Germany
[2] Wölfel Beratende Ingenieure GmbH + Co. KG, Germany

There are various fundamental approaches to meet the extremely high accuracy requirements for the calculation of aircraft noise zones. On the one hand noise calculations are officially performed by virtue of their "normative function". Secondly calculation software is provided as a "black box" that describes the necessary inputs. The results are "defined" to be correct. And finally the method of calculating aircraft noise is consistently defined and the implementation in the corresponding software is quality assured. The last of these approaches was used during the implementation of the amended Aircraft Noise Act in Germany (published in 2007). Quality testing is described in DIN 45687 (currently discussed as ISO/WD17534-1/2) and mainly includes

consistent description of the method to be implemented within the software, normative test cases (for "test airport" aircraft noise) and data interface definition for exchanging project data between different programs. This paper describes this approach and compares it with the other above-mentioned methods. Consequences for the European harmonization of calculation methods in aircraft noise in the CNOSSOS process will be drawn accordingly.

Tuesday 11:40-12:00, Hall Strassburg 1, Paper 0975 (invited)
Hartog van Banda Sven Erwin
Implementing noise prediction standards in software – challenges and experiences

Hartog van Banda Sven Erwin[1], Manvell Douglas[2]
[1] DGMR Software, The Netherlands, [2] Brüel & Kjær, Denmark

Although most noise prediction standards still originate from the 80's and are based on empirical findings that are valid for a limited number of situations, there is a growing demand and user expectation for state of the art functionality in the software. Complex 3D models, use of spatial data, data management, web enabled use, fast calculations, user friendliness, new Operating Systems, etc. As a result more demands are placed on the Environmental Noise Calculation Software Industry. At the start of the 80's the software could be written by a single acoustician with some software knowledge. Nowadays the development and support of such specialized software requires a team of specialists consisting of Acousticians, GIS specialists, Mathematicians, Help writers, Translators and Software developers with various skills. One of the challenges of the software development team is unclear documentation of a prediction standard and the absence of official software certification procedures. The software development team will have to interpret the calculation standard themselves and make choices for implementation. This paper gives insight in the challenges and experiences as well as the process, disciplines and the skills needed for implementation of noise prediction standards into software.

Tuesday 12:00-12:20, Hall Strassburg 1, Paper 1096 (invited)
Gillé Michael
DIN 45687 Test City "QSDO" – a New Type of Standardized Test Case

Gillé Michael[1], Kunzmann Bernd[2], Stapelfeldt Hartmut[3], Kurz Corinna[1]

[1] Braustein+Berndt GmbH, Germany, [2] Deutsches Institut für Normung e. V., Germany, [3] Stapelfeldt Ingenieurgesellschaft mbH, Germany

Software products for noise propagation calculation have to use acceleration techniques to do large-scale calculations in a reasonable time. Finding the right calculation settings resulting in a minimized calculation time as well as in quality assured results is an ongoing process. This issue has been discussed in the DIN 45687 committee for a long period and it is especially interesting for noise calculations regarding the END. To fulfil this objective, the DIN committee now presents the test city QSDO (**Q**ualitäts**s**tadt **Do**rtmund), a new kind of test case which has been designed in cooperation with the German noise propagation software industry. It describes the model data of the city of Dortmund and can be seen as a realistic, extensive and complex test case. Designing a sustainable, consistent and clear data model was a great challenge here. The first version is designed as a test case for road traffic noise and will be extended for further noise sources, international standards and by more detailed model data. Using road traffic noise as an example, this paper describes the development of the test city QSDO in general, some difficulties on the way to a proper data model, the general proceeding in finding the reference results as well as first experiences and insights.

Tuesday 12:20-12:40, Hall Strassburg 1, Paper 1158 (invited)
Probst Wolfgang
Measures to increase accuracy and precision of software-based noise prediction

Probst Wolfgang
DataKustik GmbH, Germany

Following some similar national activities around quality assurance of software for noise calculations, an International Standardization activity was started with WG 56 of ISO/TC43/SC 1. The aim of this standard is to clarify the requirements that must be fulfilled by the software products and by the calculation methods to be implemented. Goal of this strategy is a complete transparency of the implemented calculation routines to keep them open for discussion between experts, to give software developers the possibility to check the correct implementation and to enable software users to verify this. Important steps discussed in this frame are additional specifications to adapt the methods better to the needs of software realization and test cases to support the correct implementation and verification. With the example of the calculation method ISO 9613-2 some important steps are demonstrated and discussed.

SS09 Railway Airborne Noise

Chair: Hecht Markus, Yasushi Takano

Tuesday 14:00-14:20, Hall Strassburg 1, Paper 0119 (invited)
Fischer Fredy
Railway Noise in Switzerland – current and projected measures

Fischer Fredy, Walker Urs
Federal Office for the Environment FOEN, Switzerland

In 2000, about 265,000 persons in Switzerland were exposed to harmful or annoying railway noise. Since 2001, an extensive concept of noise remediation has been implemented for their protection which will be finalised in 2015. Mainly it comprises measures regarding rolling stock, realisation of noise barriers, and the installation of soundproof windows. Thus, approx. 170,000 persons can be protected from excessive railway noise while keeping mostly to the deadlines and costs planned initially. However, the minimum objective concerning the number of people to be protected as established by law is just missed. Therefore additional measures have been planned in Switzerland. The railway sound emissions will be reduced with priority by introducing emission limit values for existing railroad freight cars starting from 2020 and by measures to promote quiet rolling stock and a quiet infrastructure. 230 m Franken are available for the implementation of these measures. Due to this noise remediation concept, more than 50,000 persons can be protected additionally against railway noise above the immission limit values.

Tuesday 14:20-14:40, Hall Strassburg 1, Paper 0443 (contributed)
Ginn Bernard
Recent advances in Rail Vehicle Moving Source Beamforming

Ginn Bernard, Gomes Jesper, Hald Jørgen
Brüel & Kjær Sound & Vibration Measurement A/S, Denmark

A measurement technique is described for the localization and visualization of noise sources on moving rail vehicles using beamforming. The Delay-And-Sum (DAS) beamforming, is often used on stationary (fixed) sources. However the method can also be applied to moving sources such as rail vehicles, road vehicles and aircraft fly-overs, as well as rotating blades on wind turbines. Recently, deconvolution techniques have been introduced as post-processing after DAS to improve the spatial resolution and reduce the level of ghost sources in the calculated noise maps. This paper describes a commercially available system which includes DAS and deconvolution techniques, dedicated to the rail vehicle industry. Special consideration is paid to the configuration of the test site and its influence on the measurement results. The advantages of various microphone array designs for measurements on bogies, rails and pantographs are discussed. Guidelines are given for the selection of an appropriate array (half-wheel, logarithmic wheel) for the source of interest and illustrated with practical results from noise emission measurements on regional trains.

Tuesday 14:40-15:00, Hall Strassburg 1, Paper 1189 (contributed)
Kirisits Christian
Comparison of measurements and calculations to investigate the effect of multiple-reflections between absorptive noise barriers and trains

Kirisits Christian[1], Meidl Harald[2], Dinhobl Günter[2], Gutschelhofer Helmut[2], Punk Joachim[1], Kirisits Helmut[1]

[1] Kirisits Engineering Consultants, Austria, [2] ÖBB-Infrastruktur AG, Austria

Multiple reflections between absorptive noise barriers and trains can reduce the insertion loss. The possible effects were studied and compared to two engineering methods: Austrian ONR 305011, where sound propagation is based on ISO 9613-2 ignoring potential multiple reflections, and an adaptation based on the concept for multiple reflections from the French NF S31-133. Measurement positions at different heights were located up to 30 m from the barrier along a railway line. In order to normalize for varying emission a reference microphone was positioned at the same distance to this railway line without any barrier present. The whole measurement was performed twice, with a concrete and aluminium barrier, respectively. Measurement results were compared relative, between reference points and measurement points at different heights and distances. These differences were compared to those predicted by ONR 305011. From these results there is no evidence that the A-weighted total value is increased. However, at frequencies below 1 kHz significant differences can be observed. Increase of sound levels linked to a reduction of insertion loss due to multiple reflections could also be shown when using an adaptive method based on NF S31-133.

Tuesday 15:00-15:20, Hall Strassburg 1, Paper 1029 (contributed)
Jeon Jin Yong
The room acoustical design in high-speed trains for speech privacy

Jeon Jin Yong, Jang Hyung Suk
Department of Architectural Engineering, Hanyang University Seoul, South Korea

The acoustic environments of rooms on two high-speed trains were investigated to identify design elements that could improve acoustic comfort, with consideration of noise disturbance and speech privacy. A questionnaire survey was distributed to train passengers to determine if respondents were annoyed by other people's noise. Acoustic measurements, adapted from methodology originally used in an open plan office, were also conducted to evaluate speech privacy on the train. These measurements, which employed a speech source, were made at different positions within the passenger cars to evaluate speech privacy. Results showed that the speech levels in the trains' passenger cars were easy to hear and could act as an annoyance to the passengers.

Tuesday 15:20-15:40, Hall Strassburg 1, Paper 0634 (invited)
Yoshizawa Takashi
Interior noise prediction of a rolling stock using statistical energy analysis method

Yoshizawa Takashi[1], Takano Yasushi[1], Mochida Toshihiko[2], Sebata Michio[2], Makino Kazuhiro[2]
[1] Hitachi Research Laboratory, Japan, [2] Rail Systems Company, Hitachi, Ltd., Japan

A model of statistical energy analysis (SEA) of railway carbodies was developed to predict interior noise in rolling stock. Since the carbody shell is made of double skin structures of extruded aluminum and their coupling loss factors (CLFs) cannot easily be estimated from theoretical equations, sectional finite element method (FEM) models of the carbody shell were used to calculate CLFs between each SEA subsystem. The whole carbody shell was modeled as SEA subsystems using these CLFs, and interior panels and the passenger rooms were also added as SEA subsystems to the carbody shell model. The input power of an operational device was then calculated from measured acceleration data to simulate interior noise in the passenger room due to the operational device located under the carbody. Calculated input power was applied to the SEA model, and it was found that the simulated vibration level in the carbody, as well as interior noise in the passenger rooms, agreed well with the experimental results.

Tuesday 15:40-16:00, Hall Strassburg 1, Paper 0315 (contributed)
Locher Barbara
Noise emission model for parked trains

Locher Barbara[1], Wunderli Jean Marc[1], Hafner Michael[2], Köstli Kornel[3]

[1] Laboratory for Acoustics/Noise Control, Switzerland, [2] Swiss Federal Railways SBB, Switzerland, [3] Federal Office for the Environment FOEN, Switzerland

Passenger trains usually remain connected to the power network when being parked overnight. In this operating mode, auxiliary systems are still active and components such as ventilations and compressors sporadically radiate sound. As the parking plots are often in close vicinity of dwellings, inhabitants complain about sleep disturbance. Therefore the Swiss authorities decided to elaborate guidelines for the assessment of parked trains and to encourage measures to mitigate the impact. As the propagation distances are often small compared to train dimensions, a precise localizationand an individual description of each relevant sound source is essential. Therefore a measurement and data analysis concept has been developed to derive the sound power of individual sources on vehicles at rest. The results of own measurements as well as data from homologations have been pooled in an emission database. The latter has been combined with the propagation model of ISO 9613-2. With the resulting calculation tool a clustering of trains with similar noise emissions ismade and minimal distances arederived, which shall be used by operators to optimize the daily planning of parking processes. Apart from such operational actions the potential and restraints of technical mitigation measures are presented.

Tuesday 16:00-16:20, Hall Strassburg 1, Paper 0613 (invited)
Czechyra Bartosz
The use of acoustic field imaging for diagnostics of tram bogies

Czechyra Bartosz

Poznan University of Technology, Institute of Combustion Engines and Transport Division of rail Vehicles, Poland

One of the biggest problems in the operation of trams are generated vibroacoustics effects. Dynamic wheel-rail interaction is the dominant source of sound and vibration propagated to the environment, but not the only one.The main aim of this article is to indicate the possibility of using the acoustic field visualization to fast diagnostic and fault detection of the tram

drive unit (bogies). Author presents the methodology of an experiment conducted under normal tram operating conditions. Technical aspects of preparing the measurement process is described, too. It shows the measurement equipment used during experiment and sample of test objects. There are presented an algorithm structure for the analysis of acoustic signals with particular emphasis on the identification of the acoustic signal filtering parameters by using the rail vibrations and para-seismic vibrations signals. Presented results show there are the technical possibilities of using a new, high efficiency method for quick fault detection in tram drive unit and the localization of the undesirable sound sources.

Tuesday 16:20-16:40, Hall Strassburg 1, Paper 0977 (contributed)
Bader Tobias
Investigation of measures on a short steel railway bridge

Bader Tobias
TAS Sachverständigenbüro für Technische Akustik SV-GmbH, Austria

In the area near a railway bridge, the implementation of active and passive noise abatement measures (mainly noise barriers) in the context of the noise reduction of the existing railway lines was finished in 2011. In addition, it was intended to carry out additional measures (absorber plates and rail dampers) to achieve further noise re duction at the two-track railway-bridge. For the reconstruction work, a proof of the emission-related effectiveness of the individual reconstruction steps was made via noise measurements. The measurements were carried out without the use of a reference tra in while the track was fully active. Due to the approximately 80 trains per series and the use of a reference point outside of the area of effect the influence of individual train behaviors could be reduced. The measurements were carried out in third-octave bands and the effect of the measures could be analyzed in further detail. The setup of the measurement will be shown. Some single event results and the methods for calculation will be presented. Finally the difference between the measurements and therefore the influence of the taken measures in the near field of the bridge was derived.

Tuesday 16:40-17:00, Hall Strassburg 1, Paper 0273 (contributed)
Belderrain Maria Luiza
Modeling and simulation of noise impact along a new railway section in Sao Paulo, Brazil

Belderrain Maria Luiza[1], Vaidotas Rafael[1], Montemurro Wanderley[2]

[1] CLB Engenharia Consultiva, Brazil, [2] Acoustic Control Engenharia, Brazil

This paper discusses the modeling and simulation of noise impact along a new railway section that will be operating in the urban area of Sao Paulo, Brazil, within a few years. In order to validate the study, background noise measurements were taken along the 13 km of the future railway section, covering 10 points near sensitive receivers. Each sampling measurement lasted about 15 minutes in both periods: day and night. Next, the terrain was modeled, including streets and buildings, and then a simulation map of the existing noise levels was generated for model calibration purposes. SoundPlan simulation software was used to build and calibrate the model with the Leq values obtained from the measurements. Once the modeling of the environment was ready, the focus shifted to the modeling of the train as a linear noise source. Noise measurements were performed on similar trains. The results were then used to produce another simulation map where the train is moving at 90 km/h. The comparative analysis of both simulation maps will eventually allow the design of mitigating systems, such as noise barriers aimed at decreasing the receivers' nuisance.

SS30 Mitigation Measures and Products

Chair: Petz Markus, Gerges Samir N. Y.

Tuesday 08:20-08:40, Hall Strassburg 2, Paper 0106 (contributed)
Dilmen H.
Noise control for rooftop chiller units: an application in Istanbul

Dilmen H.[1], Arisoy A.[2], Cay M.[3], Meredith D.[4]

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A telecommunication corporation located in downtown Istanbul installed 20 rooftop chillers on their six- story building to air condition their newly introduced client internet server hall in spring 2010, causing growing annoyance in the mostly residential neighborhood towards summer. After a series of night-time acoustic measurements had been performed to characterize the noise emitted by the chillers, a three- dimensional noise model of the area was created. Using this model, a noise control plan was developed to bring down the contribution of the chiller units to the overall environmental noise level. Following the manufacturing and installation of the application, a series of night-time measurements were then performed anew, which showed that the application had mitigated the contribution of the noise emitted by the rooftop units to within regulation limits.

Tuesday 08:40-09:00, Hall Strassburg 2, Paper 0602 (invited)
Gramowski Christoph
Noise reduction at steely railway bridges – numerical approach and field measurement results

Gramowski Christoph[1], Meiler Martin[2]
[1] Schrey & Veit GmbH, Germany, [2] SIMetris GmbH, Germany

Three steely railway bridges have been equipped with vibration absorbers. At first finite element simulations have been performed to investigate the dominating noise emitting areas. Parallel measurements at similar bridges provided a database for the validation. The FEM simulations carried out include eigenfrequency analysis of the bridge as well as transient virtual train passage in order to determine the critical sound emitting frequencies of

the bridge. In a second step the vibration absorbers have been analyzed using harmonic response analysis. The main objective of this step is to optimize the damping characteristic according to the noise emission spectrum of the bridge. The measurement was executed in five different ways. They include exciting of the bridge by a sinusoidal force and by train pass-bys, measuring the point impedance of absorber installation zones and measuring the track decay rate. These results are used in the dynamic tuning and construction process. Not all measurement ways lead to useful results but the comparison of the three bridges lead to a detailed structure born noise understanding. The comparison between simulation and measurement result shows the possibility for an effort reduced approach to develop high efficiency bridge noise vibration absorbers.

Tuesday 09:00-09:20, Hall Strassburg 2, Paper 0792 (invited)
Desanghere Geert
QUIET-TRACK: Track optimisation and monitoring for further noise reduction

Desanghere Geert
Akron nv, Belgium

QUIET-TRACK is a new European research project (started in 2013) for track optimisation and monitoring for further noise reduction on urban track. Quiet-Track will focus on very effective track based rolling noise mitigating solutions for trams, regional trains, surface metro and trains in an urban environment. Special attention will be given to embedded track systems. Quiet-Track will develop efficient on-board monitoring systems for rail roughness and of track decay rates, as input to the noise models. Within the scope of this project, Akron will focus on the extension of the existing Wheel-Rail software: development of method for accurate noise calculations below 250 Hz, where the SEA method used in the existing wheel-rail noise computation schemes (Remington model) is not valid. The modelling tools will be enhanced by introducing the real wheel-rail contact conditions in the models (especially important in curves where multi point contact is possible). Technology based on multi-body dynamics and acoustical finite element analysis will be integrated in the software. In this paper, the actual use, value and shortcomings of the existing wheel-rail software will be studied and documented based on a sensitivity analysis of the different input parameters and comparison with in-situ measurements.

Tuesday 09:20-09:40, Hall Strassburg 2, Paper 1030 (invited)
Höjer Martin
CityHush - Summary and conclusions

Höjer Martin[1], CityHush Project partners[2]
[1] Tyréns AB,Sweden, [2] CityHush, Sweden

The European-funded CityHush project starts from a vision: the quiet city! Implementing quiet zones with the help of quiet electric (or hybrid) vehicles, quiet tyres and road surfaces, as well as design solutions for buildings and noise barriers to mitigate low-frequency noise, the noise level inside the zone was expected to be reduced by more than 10 dB(A) units. Road traffic noise is the major noise problem in European cities. Changing to electric vehicles can bring about a significant noise reduction. In order to make the possible benefits tangible as early as possible – with only a small share of the vehicle fleet being electric in the beginning – CityHush was proposing quiet zones, so called Q-Zones. This paper summarizes the work performed during the three years long project performed by 15 European partners.

SS33 Noise Monitoring and Measurement

Chair: Nordby Svein Arne, Wulf-Andersen Peter

Tuesday 09:40-10:00, Hall Strassburg 2, Paper 0120 (contributed)
Praticò Filippo Giammaria
Acoustic absorption and surface texture: an experimental investigation

Praticò Filippo Giammaria[1], Vaiana Rosolino[2], Iuele Teresa[2]

[1] DIMET - DIIES Department University Mediterranea of Reggio Calabria, Italy
[2] Department of Civil Engineering, University of Calabria, Italy

The objective of the study described in this paper is to study the relationship between *in situ* acoustic absorption coefficient (extended surface method, ISO 13472-1) and pavement surface properties (texture in terms of level spectra and aggregate indicators). Additionally, also drainability and sand height were considered. A porous European mix was investigated. The acoustic absorption coefficient was measured according to the ISO 13472-1, Acoustics - Measurement of sound absorption properties of road surfaces in situ – Part 1: Extended surface method, 2002. Acoustical absorption coefficients were analysed by taking into account contract specifications and requirements. Surface texture was investigated according to the standards ISO 13473-1; ISO/CD TS 13473-4; ISO 13473-3. Additionally, in order to assess the overall state of the surface also drainability was measured in the same locations. Results were compared and analysed. Analysis of these results may allow to derive how acoustic absorption properties may vary as a function of the surface texture and drainability for a given friction course. A tentative theoretical framework for synergistically pursuing texture and acoustic targets was formulated. Outcomes of this study are expected to benefit both practitioners and researchers.

Tuesday 11:00-11:20, Hall Strassburg 2, Paper 0009 (invited)
Buzduga Valentin
The overall efficiency of the windscreens used in the acoustic noise measurements on wind turbines

Buzduga Valentin
Scantek, Inc., USA

This paper deals with the characterization of the windscreens used in the acoustic noise measurements on wind turbine generator systems. The discussion is focused on two main aspects: determining the insertion loss introduced by windscreens in the measuring channel and evaluating the efficiency of these devices against wind effects. The International Standard IEC 61400-11:2012 only asks for characterization of the insertion loss of the secondary windscreens. For more accurate results from noise measurements, the insertion loss of the primary windscreens should be also considered. The paper highlights the advantages of the methods based on the constant divergence of the sound pressure for determining the insertion loss of the windscreens. Also, the paper proposes a new method for evaluating the sound pressure level produced by the wind turbine alone, by using the principle of the constant divergence of the sound pressure. The paper discusses the theoretical approach, experimental results and standardization aspects.

Tuesday 11:20-11:40, Hall Strassburg 2, Paper 0703 (contributed)
Robinson David P.
On the identification of faults and age-related deterioration in outdoor microphones by means of electrostatic calibration with broadband signals

Robinson David P.
Cirrus Research PLC, UK

Deterioration of microphones in permanent long-term outdoor noise monitoring systems may go undetected by conventional single-frequency calibration. This paper describes a new calibration technique using pseudo-random noise to stimulate the diaphragm electro-statically. The technique was employed to measure microphone capsules before, during and after accelerated ageing; herein, high temperatures, vibration and application of contaminants and corrosive agents were employed to simulate the effects of long-term outdoor conditions. The paper presents results on the performance of the calibration technique, and concludes with a discussion of the potential to identify deterioration of capsules before the acceptance limits of measurement standards are exceeded.

Tuesday 11:40-12:00, Hall Strassburg 2, Paper 0432 (contributed)
Skinner Chris
The Art of Baseline - Lessons Learnt and Best Practice in Large Scale Baseline Sound Monitoring

Skinner Chris, Shields Paul, Billin Heather
URS Infrastructure and Environment UK Ltd, UK

This paper presents a discussion of best practice for undertaking large scale baseline sound surveys, based on the experience of the URS Acoustics and Vibration Team over many projects. A set of processes have been developed to ensure consistency in data collection and processing, and provide robust data on the existing acoustic climate that is fit for purpose for use as baseline for Environmental Statements or to provide information on long-term variations in sound levels. Approaches include the use of GIS systems to store, manage and visualise measurement locations, standardised measurement procedures with standard forms to ensure that methods are complied with and all necessary data are recorded. For long-term measurements sites, multiple visits are recommended to allow detailed notes of the soundscape to be taken at different times of day. Geo-referenced photographs should be taken of all monitoring sites and their surroundings. The use of audio recordings to allow for future subjective and/or quantitative analysis of the sound climate is also discussed. Suggested methods are included for the optimum utilisation of the measured data from long-term and short term monitoring satellite locations, together with the processing of these results.

Tuesday 12:00-12:20, Hall Strassburg 2, Paper 0478 (contributed)
Živadinović Emil
Environmental Noise Monitoring and Measurement in the City of Novi Sad in 2012

Živadinović Emil[1], Bijelović Sanja[1,2], Dragić Nataša[1], Popović Milka[1,2], Milošević Siniša[1], Lalović Živojin[1]

[1] Institute of Public Health of Vojvodina, Serbia, [2] University of Novi Sad, School of Medicine, Serbia

Noise is the hazard in the environment and, therefore, can cause adverse effect to human health. Environmental noise monitoring in the city of Novi Sad was implemented according to legal basis and standardized/accredited methodology. During 2012, there were performed 101 24-hour noise measurements in the network of 16 monitoring spots classified into four zones due to Urban City Plan. Daily noise (L_{day}) ranged from 50,8dB(A) to 73,8 dB(A), evening noise ($L_{evening}$) ranged from 48,6dB(A) to 71,5 dB(A), night noise (L_{night}) ranged from 47,2dB(A) to 66,6 dB(A) and total noise (L_{den}) ranged from 54,4dB(A) to 74,1 dB(A). The estimated percentage of highly annoyed population (%HA) by traffic noise ranged from 17% to 26% during the day, and from 9% to 13% during the night. In order to improve and protect human

health in Novi Sad there is a need for development of noise managemant Strategy and Action plan for decreasing noise level.

Tuesday 12:20-12:40, Hall Strassburg 2, Paper 0010 (invited)
Mennitt Daniel
Mapping sound pressure levels on continental scales using a geospatial sound model

Mennitt Daniel, Fristrup Kurt, Sherrill Kirk, Nelson Lisa
National Park Service, USA

Local acoustical conditions measured by ANSI type 1 sound level meters are influenced by events and processes ranging from soft animal vocalizations at 10 meter scales to thunder and transportation noise at 10-100 km scales. Because many wildlife habitats, geological processes, and anthropogenic impacts occur on a regional scale, acoustical analyses must encompass a similar extent. Using long-term sound pressure level measurements from hundreds of sites across the contiguous United States, geospatial models have been developed to predict sound levels. These models do not directly apply the physics of sound propagation or characteristics of individual sound sources. Instead, these geospatial sound models incorporate spatial representations of biological, geophysical, climatic, and anthropogenic factors to assess expected contributions to the existing sound pressure level from both anthropogenic and natural sources. These methods enable mapping of sound pressure levels at regional and national scales.

Tuesday 12:40-13:00, Hall Strassburg 2, Paper 1010 (contributed)
Rosin Christophe
Aircraft Noise Monitoring: Threshold Overstepping Detection vs Noise Level Shape and Audio Pattern Recognition Detection

Rosin Christophe
Acoustics Department, Aéroports de Paris, France

The standard monitoring system of aircraft noise is based on cross-referencing of noise levels and aircraft sources. However, the detection method of aircraft noise events by threshold overstepping has reached its limits because of noise reduction at source, high precision requested for indices of aircraft noise and exhaustiveness of noise events required. Aircraft Noise Management at Paris-Charles de Gaulle airport is based on a noise budget index. The "Aircraft Noise Global Index" is calculated from measured

maximum noise level of all aircraft movements on the airport. Aéroports de Paris has implemented a "multi-validation" aircraft noise event detection method, which is a combination of the analysis of flight track, noise level shape, and pattern recognition technique from the audio signal. This "multi-validation" method warrants the automatic detection of all aircraft noise events with complete duration and improves the correlation ratio with the flight paths by validating the aircraft source acoustically before the correlation. This paper presents a comparison of former "threshold" and new "multi-validation" detection methods (correlation ratio…) applied on noise measurements from Aircraft Noise Global Index monitoring stations for the whole year 2012.

Tuesday 14:00-14:20, Hall Strassburg 2, Paper 1199 (invited)
Lightstone A. D.
Challenges of measuring noise compliance of wind farms

Lightstone A. D., Du Guangsheng (Sam)
Valcoustics Canada Ltd., Canada

Compliant or marginally non-compliant wind farms can be expected to produce immission (receptor) sound levels at or close to the ambient. Making valid sound measurements to prove compliance, in the presence of significant wind, presents difficulties and challenges. To address the practical difficulties and standardize procedures, the Ontario Ministry of the Environment (MOE) issued a protocol for measuring noise compliance of wind farms. The sound limits are a function of wind speed and ambient sound. A major problem is that ambient sound inherently increases with wind speed and on its own may exceed the wind turbine immission limits. Thus, the measured receptor sound levels must be properly attributed to the actual source(s). Complainants (and sometimes regulatory enforcement staff), with no expertise in acoustics, usually incorrectly assume that if the measured sound levels exceed the limits, the wind farm is automatically out of compliance. Other challenges in satisfying the measurement protocol and coming to valid conclusions about compliance include choice of measurement locations, data sampling, use of secondary windscreens, total duration of the measurement campaign, dealing with other interfering sound sources and data analysis. The problems and potential solutions, expected to be applicable in any jurisdiction, will be discussed.

Tuesday 14:20-14:40, Hall Strassburg 2, Paper 0538 (contributed)
Geréb Gábor
Real-time source-selective noise monitoring (ReSoNo)

Geréb Gábor
Budapest University of Technology and Economics, Hungary

Unattended noise monitoring technique has spread widely in the last decade as a solution for noise measurement in 24/7. However, the lack of human operator on site results uncertainty in the determination of the measured noise immission's sources. Therefore, we initiated the research and development of an automated system that can substitute the human operator during the measurement. We analyzed the way how the human operator is able to determine the sources of noise on site and we modeled the necessary perception and cognition processes with electronic sensors, signal processing and artificial intelligence. We designed a system with audio and video sensors, real-time signal procession, measurement database and an evaluation algorithm able to learn. The resulted system prototype has a built-in certified sound level meter, cardioid microphones and video cameras covering 360°, all connected to a signal processing FPGA; the processed data is collected together with the measured noise level on a site-PC, which runs an evaluating software able to learn. Results are forwarded to an online server for examination. Source-selective noise monitoring can be a large step forward in environmental noise control, but the perspectives opened by an intelligent environmental monitoring system are even greater.

Tuesday 14:40-15:00, Hall Strassburg 2, Paper 0776 (contributed)
Wessels Peter
Automatic classification of urban traffic noise onboard an acoustic monitoring system

Wessels Peter, van Zon Tim, Basten Tom
TNO, The Netherlands

Recent developments in acoustic monitoring systems make it possible to measure complex noise situations, like urban traffic noise, continuously. Monitoring provides more insight in the noise situation, from which more specific and (cost) effective measures can be taken. Monitoring also allows direct evaluation of the effect of mitigation, or to act directly upon sudden unwanted noise situations. However, continuously monitoring with high sample rates results in large quantities of data, which need to be processed to obtain the relevant information. Intelligent onboard processing is an

efficient way of dealing with this issue. Additionally, onboard processing results in less data communication which is often of practical relevance. In this paper a classification module is presented that is configured for usage during urban traffic noise monitoring. The module is designed to help manage the amount of data by marking areas of interest by assigning classes to the recorded audio. The classification module thus adds additional value to the collected data. A monitoring system equipped with the module could, for example, automatically publish reports describing multiple aspects of the sound.

Tuesday 15:00-15:20, Hall Strassburg 2, Paper 0778 (contributed)
Vaucher De La Croix Daniel
Vibration & Noise measurement activities applied to the construction industry: how modern technology helps in offering efficient monitoring services

Vaucher De La Croix Daniel, Aflalo Erik, Frénéat Christian
ACOEM, France

The construction of large infrastructures in dense urban areas comes along with a number of environmental challenges. Roads, railways, subways and large building construction necessarily have a significant impact on residents, and on surrounding buildings as well. This becomes a serious concern for large projects extending over months or even years. In this context, noise and vibration induced by the construction activities are major source 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 mitigate risks and prevent potential interruption of the construction site’s activity which would increase the overall project costs. The proposed paper will present how today’s communication technologies provide an essential added value to noise and vibrations monitoring activities that can be proposed by engineering & consultant offices. Operational requirements for system deployment will be reviewed on an illustrative project. Benefits to the different parties will be further highlighted on selected examples where adequate measures could be taken in the right timing and kept the project running while minimizing its environmental & noise impact.

Tuesday 15:20-15:40, Hall Strassburg 2, Paper 0504 (contributed)
Oh Seung-Tae
Assessment of Vibration and Noise characteristics with the variable speed and loaded conditions of Hydro Turbine generator

Oh Seung-Tae[1], Lim Jin-Woo[2], Ock Ji-Hyo[2], Lee Hwa-Min[3], Jung Sang-Yong[4]

[1] Rotating Machinery Research Team, Hyosung Power & Industrial System R&D Center, Korea
[2] Generator Design Team, Hyosung Industrial Machinery Performance Unit, Korea
[3] Department of Computer Software Engineering Soonchunhyang University, Korea
[4] School of Electronic and Electrical Engineering, Sungkyunkwan University, Korea

The assessment of vibration and noise characteristics for Hydro-Turbine machinery has always been a new experience and challenge along with the ISO (International Standard Organization). This study outlines the main results of noise and vibration between different load conditions and different speed conditions. This research deals in more detail with differences between the theoretical results and Noise and Vibration measurement with the basis of ISO 10816-5 Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts - Part5 (Machine sets in Hydraulic power generating and pumping plants). Through the measured results for the noise and vibration on 15MW hydro-turbine generator will reflect on the low vibration design on a developed the vertical water-turbine generator.

Tuesday 15:40-16:00, Hall Strassburg 2, Paper 0007 (contributed)
Zhao Xiaojian
Noise Source Identifying in wind-tunnel

Zhao Xiaojian, Zhao Lei, Chen Nong
China Academy of Aerospace Aerodynamics, China

Conventional Beamforming algorithm is the basic method for Aero-acoustics test in wind-tunnel, but usually its resolving power is not very high for low frequency sound signal. And it also has low SNR due to background noise of wind tunnel. Some other methods including modification algorithm and CLEAN method applied to remedy the conventional algorithm. The modification algorithm is a new idea which based on conventional Beamforming method and the results show that it improves the resolving power obviously for low frequency sound source. But due to its great side lobe, the modification algorithm is not always perfect. The optimization results with CLEAN algorithm prove that CLEAN algorithm has its prominent advantage in aero-

acoustics study, and it both improves the resolving power of low frequency noise and increases the SNR of sound source. CLEAN algorithm is truly a great necessity for engineering. Coefficient K is introduced when evaluating the performance of the phase array. It avoids the discussion of the effect to phase array for frequency analyses and distance from the phase array to source plane changing respectively, and improves the performance of phase array design to some point.

Tuesday 16:20-16:40, Hall Strassburg 2, Paper 0630 (invited)
Wetlesen Thorvald
Cloud computing for noise monitoring

Wetlesen Thorvald
Norsonic, Norway

Cloud computing is the use of computing resources that are delivered as a service over the Internet. This means that software, hardware and network resources are centrally managed. The ubiquitous availability of high-capacity networks and reduced cost of both client and server hardware have led to a tremendous growth in cloud computing. The concept gives a huge benefit for both acoustic consultants and noise polluters that avoid investing time and money on expensive server hardware and installation, configuration and maintenance of software. The service provider verifies the presence and the quality of the measurements and delivers final measurement reports. This way the client can focus on their core activity. The article explains how cloud computing can be used for noise monitoring networks and give real life examples.

Tuesday 16:40-17:00, Hall Strassburg 2, Paper 0469 (contributed)
Manvell Douglas
On-demand noise monitoring: technical challenges for providing a global service

Manvell Douglas
Brüel & Kjær Sound & Vibration Measurements, Denmark

Noise monitoring is sometimes required for short durations in connection with environmental impact assessments, limit compliance investigations, troubleshooting, etc. Often this requires rapid response and deployment of equipment at locations where the system needs to be set-up for correct data acquisition in accordance with the legislation, standards and location-

specific issues covering that particular application. At the same time it is beneficial to have secure, real-time storage and real-time access of data from any portable device to enable the user to monitor both the noise being measured and the status of the monitoring units. To reduce operating costs and to optimize investment, today's technology can also offer additional savings if they can be made scalable to fit a wide range of applications over a wide geographical range of countries. Such a solution must meet several challenges including rapid deployment and setup, ease of access (ordering/shipping, setup and return to base). This paper investigates the technical challenges for providing a global service for on-demand noise monitoring for short durations while maintaining a professional, cost-effective solution that meets requirements.

Tuesday 17:00-17:20, Hall Strassburg 2, Paper 0719 (contributed)
Nakajima Yasutaka
A case study of the new multi-function, multi-point measurement instruments

Nakajima Yasutaka, Kurosawa Yu, Sato Naru, Shinohara Kenji, Yonemoto Yuichi, Sakaue Daisuke, Ozaki Tetsuya, Ueta Toshihiro, Ohya Masaharu, Iwahashi Kiyokatsu
Rion Co. Ltd., Japan

There are various demands of multi-point measurements such as decay of distance in environmental measurements. In multi-point measurements which across a road and inside-outside of room, it takes time and effort to setup of cables. In situ or travel measurements, it is troublesome to bring some measurement units such as frequency analyzers, data recorders and sound level meters. We have developed the new measurement instruments which solve those issues. The instrument makes it possible for one person at one point to know the information of multi-points such as ambulance sound or unwanted sound, and reduces post processing as a result.

Tuesday 17:20-17:40, Hall Strassburg 2, Paper 0617 (contributed)
Sato Naru
Simplifying of noise monitoring using new low power noise monitoring system

Sato Naru, Kazama Ryosuke, Ohya Masaharu
S&V Measuring Instruments, Rion Co., Ltd., Japan

We have developed a new monitoring system of low power consumption, multi-point noise monitoring in wide areas, such as environmental noise,

road traffic noise, and aircraft noise. In medium-term noise monitoring which continues longer than one month, there is always a problem of the power supply for sound measurement devices and data transfer devices. It usually requires a lot of time and effort to provide a power supply. The new system can reduce power consumption and makes it easier and simpler to monitor noise. We examined the potential of the new system and measurement results.

Tuesday 17:40-18:00, Hall Strassburg 2, Paper 0527 (contributed)
Creixell Ester
A method for recognition of coexisting environmental sound sources based on the Fisher's linear discriminant classifier

Creixell Ester[1], Haddad Karim[2], Song Wookeun[2], Chauhan Shashank[2], Valero Xavier[3]

[1] Danmarks Tekniske Universitet, Denmark, [2] Brüel & Kjær Sound and Vibration Measurement, Denmark, [3] La Salle - Universitat Ramon Llull, Spain

A method for sound recognition of coexisting environmental noise sources by applying pattern recognition techniques is developed. The investigated technique could benefit several areas of application, such as noise impact assessment, acoustic pollution mitigation and soundscape characterization. This study distinguishes from other investigations by focusing on cases where the noise sources appear mixed (i.e., several noise sources might be present at the same time in one location), which is a more realistic and frequent situation in cities than a single sound source without other interfering noises. The identification and, furthermore, the estimation of the contribution of each source to the overall level is one important goal in the current investigation, which would improve environmental noise assessment in complex situations. The method for recognizing the noise sources in adverse conditions is based on the Fisher's Linear Discriminant classifier, and estimates noise source contributions based on a distance measure of vector projections. The method is able to identify mixed sources in 96% of the 27 tested signals and to correlate the contribution of the individual sources with their sound pressure level. The results obtained from tests in real city environments show an accurate performance in the description of the sound scenarios.

SS23 Lightweight Constructions and Systems

Chair: Koujoumji Jean-Luc, Perez Abendaño Marianna, Zeitler Bernd

Tuesday 08:20-08:40, Hall Grenoble, Paper 1244 (invited)
Hagberg Klas
AkuLite and AcuWood finish what happens now?

Hagberg Klas
SP Wood Technology and Engineering Acoustics, Sweden

The research project AkuLite ended 30th April this year and AcuWood will finish the 30th of September and almost four years of acoustic research with a focus on acoustics and vibrations in multi-storey residential buildings with light weight structures terminates thereby. However this is not the same thing as all activity ceases in lightweight acoustic and vibration construction research. High activity has been undertaken during late 2012 and beginning of 2013 in order to set up projects that can continue after AkuLite and AcuWood. Despite great progress in both projects and a clearly elevated level of knowledge everything is, of course, not yet solved. However, the goals are fulfilled and now it is time to enter the next phase. AkuLite and AcuWood have both been an exciting journey with a great number of dedicated participants involved. The projects consisted of a total of ten institutions/research practitioners and about 35 to 45 different industries throughout Europe. The main focus for the projects were to deliver new proposals for evaluation measures regarding sound insulation in order to provide right target values for the construction industry when they develop new building systems for the future.

Tuesday 08:40-09:00, Hall Grenoble, Paper 0935 (invited)
Simmons Christian
Findings from the AkuLite project: New single numbers for impact sound 20-5000 Hz based on field measurements and occupants' surveys

Simmons Christian[1], Ljunggren Fredrik[2], Hagberg Klas[3]

[1] Simmons akustik och utveckling, Sweden, [2] Luleå University of Technology, Sweden, [3] WSP, Sweden

Impact sounds at very low frequencies as well as floor vibrations may bother occupants in high rise apartment buildings where floors and walls are supported by timber (or steel) frames. Disturbing impact

sounds at medium and high frequency may occur in buildings with conrete floors. A weighted single number should preferably handle both types of sounds such that it is neutral with respect to building materials. This paper presents a brief overview of some main findings of the Swedish 'AkuLite' joint research project and discuss two single numbers for impact sound evaluated in the frequency range 20-5000 Hz as well as a deflection criterion. These single numbers were based on results from field surveys where the occupants have rated the performance of their buildings as well as physical measurements in these. In a companion paper by Ljunggren et al, the airborne and impact sound single numbers are evaluated by means of correlation analyses. In listening tests by Thorsson, walking impact sounds were recorded on different types of floor and played back to test subjects by means of paired comparisons. Jarnerö made a survey on floor vibrations. Their results support the hypothesis, that an extension of the frequency range down to 20 Hz as well as introducing a stricter deflection criterion could improve the correlation of physical parameters to occupants' rating of annoyance from impact sounds.

Tuesday 09:00-09:20, Hall Grenoble, Paper 0636 (invited)
Geyer Christoph
The acoustical performance of Swiss timber constructions

Geyer Christoph[1], Bütikofer Rudolf[2], Müller Andreas[1], Schuppisser Bernhard[1], Sanavi Ali[1]

[1] Bern University of Applied Sciences, Switzerland
[2] EMPA Swiss Federal Laboratories for Materials Science and Technology, Switzerland

The double storey lightweight test suite in Dübendorf, Switzerland allows for investigations of direct and flanking transmissions of ceiling/wall systems. In the test series reported in this document, the separating element was a timber floor with a very high sound insulation, such that flanking sound transmission through various flanking test walls dominated in most cases. The flanking sound transmission for airborne and impact sound of a variety of 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 investigated for better understanding of sound transmission in timber buildings. The findings are reported. The results indicate that there are timber constructions available for the separating and flanking elements to achieve a high level of acoustic separation,

which is necessary to build multi-storey houses with timber constructions. Measurements also show that the flanking sound transmission of timber stud walls is much lower than the flanking sound transmission of massive timber walls.

Tuesday 09:20-09:40, Hall Grenoble, Paper 0409 (contributed)
Reinhold Steffi
Measured Sound Insulation of Double Leaf Plasterboard Walls – Influence of Different Construction Parameters

Reinhold Steffi, Schneider Martin, Fischer Heinz-Martin
Hochschule für Technik Stuttgart, Germany

The sound insulation of plasterboard walls is influenced by various factors. Some of them are already well known, such as the number of layers, cavity fillings with porous material and the cavity depth. The structural coupling has a further influence on the sound insulation of plasterboard walls. In the wall test facilities at the HFT Stuttgart the sound insulation of different lightweight walls was investigated. This paper presents the results of measured sound insulation of approximately 40 plasterboard walls depending on constructive properties, such as different cavity depth, different materials of plasterboard and number of layers, different cavity fillings, different elastic interlayers for decoupling plasterboard walls from adjacent components, and different joint fillings around the perimeter of the wall. Besides the standard building acoustics evaluation of the sound insulation a variety of additional acoustical measurements (e.g. experimental modal analysis) were carried out to deepen the understanding of the sound transmission of lightweight walls. One major goal of the study is to achieve a high sound reduction index of plasterboard walls. Based on the different measured constructions of plasterboard walls could be gained insights, which lead to an improvement in the sound insulation when the best construction design parameters are considered.

Tuesday 09:40-10:00, Hall Grenoble, Paper 0546 (invited)
Wareing Robin
Acoustic treatment of panels: Effect of attachment method

Wareing Robin[1], Pearse John[1], Davy John[2], Latimer Michael[3]

[1] Department of Mechanical Engineering, University of Canterbury, New Zealand, [2] School of Applied Sciences, Royal Melbourne Institute of Technology (RMIT) University, Australia, [3] Pyrotek Products Ltd, New Zealand

Sound transmission loss of panels can be improved by attaching a layer of material specifically designed to increase the sound transmission loss properties of the system. Such a material finds use in a number of practical applications, such as the treatment of inter-tenancy walls and machinery enclosures. This paper explores the effect different attachment methods have on the sound transmission loss, from fully bonded (glued) to loosely bonded (pinned). This paper also investigates methods of modeling the transmission loss of the system. The acoustic treatment used in this research was a multi-layered sheet consisting of a decoupling foam layer, a mass loaded barrier layer, and an absorptive foam layer incorporating a protective face sheet. The treatment was attached to a plywood panel. Transmission loss measurements were performed on a 1550 × 950mm sample following the intensity method described in ISO 15186-1. A significant variation in the transmission loss of the system was observed between 200 – 2000 Hz, with a trend of increased transmission loss as the attachment stiffness was reduced. Several methods were utilized to model the system with reasonable levels of success. Variations in measured and modeled transmissio n loss are discussed, and possible reasons for these variations are explored.

Tuesday 10:00-10:20, Hall Grenoble, Paper 1161 (contributed)
Kirkegaard Poul Henning
FEA of the variations in sound insulation in nominally identical prefabricated lightweight timber structures

Kirkegaard Poul Henning, Andersen Lars Vabbersgaard
Aalborg University, Department of Civil Engineering, Denmark

The sound transmission between adjacent rooms in a building occurs directly through separating structures as well as over different paths that include flanking building elements. However the variations in sound insulation necessitate higher safety margins to the legal requirements, which results in higher production costs. Better knowledge about sources for these variations can lead to lowered production costs. The present paper presents a numerical analysis of the variations in sound insulation of nominally identical prefabricated lightweight timber panels. By using the commercial finite-element (FE) code ABAQUS, low-frequency sound transmission has been considered between coupled rooms. By using a substructure approach, the wall and floor panels are assembled to construct a global virtual building model. The walls and the ceiling of each room are modelled as a lightweight wooden panel consisting of shells supported by joists. Using this model, a parameter study is carried out regarding variation in sound propagation related to different elastic connections between the wall elements. It is found that different elastic connections can have a significant influence on the sound propagation.

Tuesday 11:00-11:20, Hall Grenoble, Paper 0723 (contributed)
Völtl Raphael
Simultaneous operational vibration analysis of different layers of lightweight timber floors

Völtl Raphael[1], Schanda Ulrich[1], Kohrmann Mathias[2], Buchschmid Martin[2], Müller Gerhard[2]

[1] Hochschule Rosenheim University of Applied Sciences, Germany
[2] Technische Universität München, Germany

Within the scope of the research project "VibWood", operational vibration analyses of timber floor constructions were carried out. In order to understand the vibration behaviour of and the sound transmission through the layers of the constructions the coupling between them was investigated. The transfer function from the point of excitation to a pattern of receiving positions located on each of the layers of the construction was measured using a swept sine excitation. As a result, the frequency range of decoupling between the base floor and the floating floor and between the base floor and the suspended ceiling could be identified and the individual vibration behavior analyzed. The measurements also included the radiated sound power from the suspended ceiling. There is indication that there is not necessarily a correlation between the eigenmodes of the suspended ceiling and the maxima of the radiated sound power.

Tuesday 11:20-11:40, Hall Grenoble, Paper 0192 (invited)
Bard Delphine
In situ and laboratory measurement of service equipment decoupling in lightweight constructions

Bard Delphine[1], Desarnaulds Victor[2], Lissek Hervé[3], Beffa Robert[4]

[1] Division of Engineering Acoustics, Lund University, Sweden, [2] EcoAcoustique SA, Switzerland, [3] Laboratoire d'Electromagnétisme et d'Acoustique, Switzerland, [4] University of Applied Sciences Western Switzerland, Switzerland

The latest version of the Swiss standard for building acoustics (SIA181) introduced a new measurement method, based on a balanced-arm hammer, for evaluating the decoupling performance of service equipment. This method was developed for reproducing in a standard manner 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 equipment configurations but also some workmanship errors. Laboratories investigations have also been conducted to understand and optimize the decoupling of two type service equipment systems.

Tuesday 11:40-12:00, Hall Grenoble, Paper 1063 (invited)
Kouyoumji Jean-Luc
Predicting Sound Transmission Loss on of lightweight timber framed construction using SEA

Kouyoumji Jean-Luc
FCBA, Institut Technologique, Research Division, France

Predicting Sound Transmission Loss (STL) of lightweight constructions has to deal with anisotropic structures with multiple build-ups possibilities. Each design of wall or floor is associated to a modeling strategy. The article presents modelling examples that predict such structures. The framework of the methodology is Statistical Energy Analysis. Sound Transmission Loss is calculated using a multilayered model and vibrational transmissions between subsystems are modelled using SEA: connections, leaks, damping and coupling loss factors. The approach is, first, based on predicting acoustic transmissions then connections are introduced to model intra-wall vibrational transmissions. A second alternative to deterministic calculation of coupling is the use of reverse SEA that measure coupling and damping loss factors. SEA is a convenient theory to mix multilayered Transfer Matrix Method with measured characteristics for a better Sound Transmission Loss prediction. In the article we present measured and calculated results that

give a good idea of the validity of the methodology. After validation, the model is used to calculate similar structures with small variation in its composition. Thus, for a wide range of walls one can obtain multiple STL derived from a limited measurement campaign. Within this work, we derived more than 30 calculated STL from only 8 measurements.

Tuesday 12:00-12:20, Hall Grenoble, Paper 1019 (invited)
Ågren Anders
In situ measured flanking transmission in light weight timber houses with elastic flanking isolators

Ågren Anders, Ljunggren Fredrik
Division of Engineering Acoustics, Luleå University of Technology, Sweden

There is a strong trend to industrially produce multi-storey light weight timber based houses. This concept allows the buildings to be manufactured to a more or less prefabricated extent. Most common types are volume/room modules or flat wall and floor modules. When assembling the modules at the building site, elastomer isolators are used in several constructions to reduce flanking transmission. The sound insulation demands in the Nordic countries are relatively high and therefore the flanking transmission must be well controlled, where elastomer isolators are an alternative. Decoupled radiation isolated walls is another. There are though no working studies or mathematical models of the performance of these isolators. They are only treated as simple mass-springs systems that operate vertically, i.e. one degree of freedom. In this paper there is an analysis of experimentally data of the structure borne sound isolating performance of elastomer isolators that are separating an excited floor from receiving walls. The performance dependence of structure type is also presented. An empirically based regression model of the vibration level difference is derived. The model is based on measurements of six elastomer field installations, which are compared to five comparable installations without elastomers. A goal is that the model can be used for input in future SEN prediction models for modeling of sound insulation.

Tuesday 12:20-12:40, Hall Grenoble, Paper 0886 (invited)
Zeitler Berndt
Flanking Sound Insulation of Wood Frame Assemblies With High Axial And Lateral Load Bearing Capacity

Zeitler Berndt, Schoenwald Stefan, King Frances
National Research Council, Canada

As part of a multidisciplinary research project to develop design solutions for mid-rise wooden buildings for the Canadian market, a comprehensive study was conducted on the flanking sound insulation performance of wood frame assemblies that have high axial and lateral load bearing capacity. The axial load bearing capacity depends mainly on framing details and can be increased by strengthening the wall framing by using either more studs at a smaller spacing or by using studs with greater dimension (2 or 3 studs joined together). The lateral load bearing capacity or racking resistance of walls depends on the wall membrane and can be increased by attaching wood board materials (e.g. plywood) in different configurations to the framing. In this paper the effect of shear membranes on the flanking sound insulation of wall-floor systems are presented.

Tuesday 12:40-13:00, Hall Grenoble, Paper 1120 (invited)
Guigou-Carter Catherine
Modeling lightweight junctions

Guigou-Carter Catherine, Coguenanff C., Bailhache S., Villot M.
CSTB, France

A finite element modeling approach to evaluate vibrational level difference is proposed in order to avoid the in-situ junction characterization which is quite long and cumbersome. Furthermore, junctions and the connected elements (walls, floors) can be constructed in laboratory with the inconvenience of being relatively expensive. The large variety of elements types and junctions is also a problem in terms of physical characterization. Therefore, it would be much more efficient to have an estimation of vibrational level difference from numerical calculations. The FEM software NASTRAN has been selected for these numerical calculations. The effect of different parameters, such as the floor joist type, the floor joists direction with respect to the separating wall, the relative position between wall studs and floor joists as well as the excitation type, are numerically investigated on the direction averaged vibrational level difference. A parametric study is

performed on a Te junction on which vibration level difference has been measured; it leads to the definition of intervals in which measured results can be expected to fit.

Tuesday 14:00-14:20, Hall Grenoble, Paper 0877 (invited)
Schoenwald Stefan
Sound insulation performance of Cross Laminated Timber Building Systems

Schoenwald Stefan[1,2], Zeitler Berndt[1], Sabourin Ivan[1], King Frances[1]

[1] National Research Council - Construction, Canada
[2] Currently at EMPA – Acoustics/Noise Control, Switzerland

In recent years Cross Laminated Timber (CLT) was introduced as an emerging building system in the North American market. CLT elements consist of multiple layers of wooden beams that are laid-out cross-wise and laminated together to form solid wood panels for floors and walls. As part of a multi-disciplinary research project a comprehensive study was conducted on the impact and airborne sound insulation of this type of elements in order to create a data base that allows building designers to predict the acoustic performance of CLT systems. Parametric studies were carried out on the direct impact airborne sound insulation of CLT floor assemblies (with/ without various floor topping and gypsum board ceiling variants), on the direct airborne sound insulation of CLT walls (with/without gypsum board linings), as well as on the structure-borne sound transmission on a series of CLT building junctions. The results were then used as input data for predictions of the apparent impact and airborne sound insulation in real CLT buildings using the ISO 15712 (EN12354) framework that was originally developed for concrete and masonry buildings. The paper presents the prediction approach as well as results of prediction and measurement series for apparent impact and airborne sound insulation.

Tuesday 14:20-14:40, Hall Grenoble, Paper 1104 (invited)
Pérez Mariana
Acoustic design through predictive methods in Cross Laminated Timber (CLT) panel structures for buildings

Pérez Mariana, Fuente Marta
TECNALIA c/ Geldo, Spain

Industrialization is a strategic trend in the construction sector that offers several distinct advantages over traditional construction: tight costs, minimization of work-related accidents, on-site construction time reduction, etc. However, when prefabricated or lightweight construction solutions are used in buildings, standardized methods to design and predict the acoustic performance of buildings from the performances of elements EN 12354-1 and -2, are no longer valid. As consequence, further work is needed related to the laboratory characterization of building systems, the behavior of junctions between prefabricated and/or lightweight components, the use of resilient materials, etc. This paper shows the results of R&D activities carried out to predict the acoustic behavior of cross laminated timber buildings. A two storey experimental facility has been built for the characterization of vibration attenuation in junctions. An approach of flanking transmission characterization method based on EN 10848 series has been used.

Tuesday 14:40-15:00, Hall Grenoble, Paper 0592 (contributed)
Mahn Jeffrey
Competitive wooden floor systems - multi-objective optimization based on acoustics improvement

Mahn Jeffrey[1], Hopkins Carl[2], Schanda Ulrich[3], Krajči Luboš[4]

[1] University of Canterbury, New Zealand, [2] Acoustics Research Unit, School of Architecture, University of Liverpool, UK, [3] University of Applied Sciences, Germany, [4] K+I Consultancy for Acoustics and Building Physics Ltd., Switzerland

The objective of this research project is the design of lightweight timber floor systems which have similar thicknesses to those of concrete floors but which perform better than concrete in terms of their environmental life cycle impact and in terms of airborne and impact sound insulation. The availability of superior lightweight acoustic designs will increase the share of timber based floors within the Swiss construction market and will contribute to higher wood utilization in general. A program for systematically developing validated finite element models for the development of lightweight timber floor systems has been proposed. The use of Swiss hardwoods in floor systems will be studied and implemented where possible.

Tuesday 15:00-15:20, Hall Grenoble, Paper 1182 (invited)
Hiramitsu Atsuo
Floor impact sound insulation of wooden three-story school building for full-scale fire experiment

Hiramitsu Atsuo
National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, Japan

"The Act for Promotion of Use of Wood in Public Buildings" was promulgated in October 2010. Among the public buildings, there arises a tendency to employ wooden construction for school buildings, because it is effective to improve the educational environments such as stress relief. However three-story school buildings shall be fireproof buildings in Japan, it becomes the problem of the spread of the wooden building. Then, wooden three-story school (specimen) of one-hour quasi-fireproof buildings construction was constructed as part of the research of the review of building code, and the full-scale fire experiment was done. This wooden building consisted of two independent zones of framework construction and wood-frame construction. In the meantime, the floor impact sound insulation of wooden construction is generally lower than of concrete construction. Thereby it is expected that the floor impact sound insulation becomes a problem. Therefore the floor impact sound insulations were measured in the wooden three-story school building. The results showed that the floating floors improved the floor impact sound insulation in wooden construction. In addition, the effectiveness of the ceiling specification and floating floors were investigated.

Tuesday 15:20-15:40, Hall Grenoble, Paper 0963 (contributed)
Coguenanff Corentin
Acoustic performance optimization under parameter and model uncertainties of a wood based floor

Coguenanff C.[1,2], Desceliers C.[2], Guigou-Carter Catherine[1], Jean P.[1]

[1] CSTB, France, [2] Université Paris -Est, Laboratoire Modélisation et Simulation Multi Echelle , MSM E UM R 8208 CNRS, France

In order to sustain wood as a viable option in building construction in Europe, some needs in terms of acoustic properties prevision have to be fulfilled. Considering the wide range of sound insulation behavior observed at low frequencies induced by uncertainties in the design or in the properties, a probabilistic approach is proposed to quantify the robustness of lightweight separating systems. The complexity of those structural assemblies, the non accessibility to various parameters and the difficulty to model specific phenomena lead to set aside a deterministic prevision. In this study, a methodology to perform the optimization under uncertainty of the acoustic transmission loss through a multi-layered wood based floor with given constraints (e.g Eurocode 5) will be presented. A design-parametric, probabilistic, computational finite element model is then built up, the uncertainties being taken into account with non-parametric approaches constructed using the MaxEnt principle. The previously appointed design criteria are of topological, mechanical and stochastical order.

Tuesday 15:40-16:00, Hall Grenoble, Paper 0199 (invited)
Churchill Claire
Development of SEA models of composite heavyweight-lightweight floors by incorporating measured stiffness data for suspended ceiling hangers

Churchill Claire[1], Hopkins Carl[2]
[1] EMPA, Switzerland, [2] Acoustics Research Unit, University of Liverpool, UK

Previous work indicated that Statistical Energy Analysis (SEA) can be used to predict the sound reduction index of a composite heavyweight-lightweight floor (Churchill, Hopkins, Krajci) formed from concrete cast over OSB and timber beams with a suspended plasterboard ceiling. This was possible over the majority of the building acoustics range (100Hz-2000Hz) although it required Experimental SEA (ESEA) to determine the coupling loss factor across the suspended ceiling hangers. The transmission path involving the suspended ceiling hangers tends to dominate in the frequency range 200Hz-5000Hz. Hence it would be advantageous if the stiffness of the suspended ceiling mounts could be measured such that it could be included in point connector models to calculate a coupling loss factor across the hangers. This paper uses the measurement approach by Brunskog to characterise the stiffness of the suspended ceiling hangers. These data are then incorporated into the SEA model. SEA models are compared with laboratory measurements of the sound reduction index.

Tuesday 16:00-16:20, Hall Grenoble, Paper 0006 (invited)
Davy John
The variable effective bending stiffness of lightweight laminated Panels

Davy John[1], Cowan Andre[2], Pearse John[3], Latimer Michael[4]

[1] School of Applied Sciences, Royal Melbourne Institute of Technology (RMIT) University, Australia, [2] Marshall Day Acoustics Ltd, New Zealand, [3] University of Canterbury, Mechanical Engineering, New Zealand, [4] Pyrotek, New Zealand

The sound insulation of laminated panels is reduced in the vicinity of their mass stiffness mass resonant frequency. However for laminated panels with lightweight skins and stiff cores, this mass stiffness mass resonant frequency is above the normal frequency range of interest for sound insulation. Such panels can be modeled as homogeneous isotopic panels when predicting their sound insulation. The sound insulation of three such panels was modeled using simple sound insulation prediction methods, but the agreement between theory and experiment was not very good. The effective bending stiffness was determined over a wide frequency range from the resonant frequencies of three beams of different lengths. The effective bending stiffness was found to reduce with increasing frequency as has been predicted in the literature. This decrease is due to the shear stiffness of the core short circuiting the bending stiffness of the laminated panel. Unfortunately the agreement between theory and experimental was still not very good. This is because many of the prediction frequencies occur in the critical frequency dip because of the variation of the bending stiffness with frequency. The effective bending stiffness was also determined by calculating the value of bending stiffness that made the theory agreed with experiment.

Tuesday 16:20-16:40, Hall Grenoble, Paper 1073 (invited)
Ghinet Sebastian
Assessment of acoustic performance of composite structures with viscoelastic treatments

Ghinet Sebastian[1], Osman Haisam A.[2], Grewal Anant[1]

[1] National Research Council Canada, Aerospace Portfolio, Canada
[2] United Launch Alliance, System Analysis and Integration, USA

The main objective of the current work is to assess the acoustic performance of viscoelastic treatments versus the case when the treatment is incorporated as an equivalent added mass layer in various configurations of isotropic or

composite structures under diffuse field excitation. The Discrete Laminate Method (DLM) was used in a Transfer Matrix Method (TMM) framework to compute the sound transmission loss of the structure with added noise control treatment. The numerical approach was compared with numerical results from the literature and experimental data, and was shown to accurately predict the sound transmission loss of composite structures with incorporated noise control treatments. Moreover, parametric studies of various configurations were considered in order to identify promising behavioral trends for optimal noise control treatments design.

SS15 Building Acoustics / Architectural Acoustics – General

Chair: Bard Delphine, Mahn Jeffrey

Tuesday 16:40-17:00, Hall Grenoble, Paper 0988 (contributed)
Yan Feng
The use of damping to reduce the contribution of flanking paths to sound transmission in buildings

Yan Feng, Wilson Robin, Rutherford Peter, Craik Robert J.M.
University of Nottingham University Park, UK

The importance of flanking paths to sound transmission in buildings has been noticed recently. Damping treatments make it possible to increase the internal losses in of structures and provide an opportunity to enhance the attenuation of long transmission paths. A number of numerical comparisons have been made to demonstrate the effectiveness of a global increase in structural damping of a simple physical system. Statistical Energy Analysis (SEA) has been adopted as the analytical framework. The results show that, by applying a damping treatment, the contribution of flanking paths to sound transmission can be reduced and sound insulation improved.

Tuesday 17:00-17:20, Hall Grenoble, Paper 1060 (contributed)
Rodrigues Rui
The heritage challenge concerning XIX century buildings – Acoustic study of traditional constructive solutions

Rodrigues Rui, Queirós Dóris
Faculdade de Engenharia da Universidade do Porto (FEUP)/NI&DEA/GEQUALTEC, Portugal

Traditional buildings that regularly characterize the Centre of our cities, present us the challenge of being updated without losing their uniqueness. This paper presents the research carried out by the NI&DEA group focused in the development of acoustical constructive solutions for the rehabilitation of traditional XIX century buildings. Original constructive solutions are typified regarding both architectonic and acoustic characteristics supported both by measurements and models. Working mainly with models (B.Sharp, Meisser, E. Gerretsen and London) original solutions were conveniently tested by site measurements for validation. This paper aims to present the gap between the characteristics of original constructive solutions as tested by site measurements and the same as predicted by theoretical models. In order to apply technical improvements to enhance the performance of traditional

constructive solutions, we first need to understand how these solutions work and perform in real life conditions. Airborne sound insulation (D_{nTw}, D_{2mnTw}) and impact sound insulation (L'_{nTw}) tests were performed on external walls with windows or doors, wooden slabs and interior partitions. The potential demonstrated by these enhanced traditional solutions predicted a shift in current paradigms of building rehabilitation and will allow acousticians to support the heritage challenge for buildings.

Tuesday 17:20-17:40, Hall Grenoble, Paper 0894 (contributed)
de Souza Jéssica J. Lins
Comparison of simulations and measurements for a simplified acoustic enclosure

de Souza Jéssica J. Lins[1], Paul Stephan[1], Brandão Eric[1], Dietrich Pascal[2]

[1] Federal University of Santa Maria, Brazil, [2] RWTH Aachen University, Germany

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, simulations with BEM within 0 Hz to 6 kHz and an analytical model developed by researchers at the ITA. 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.

Tuesday 17:40-18:00, Hall Grenoble, Paper 0558 (contributed)
Odabas Erinc
Acoustical Design and Experimental Validation of an NVH Listening Room

Odabas Erinc[1], Caliskan Mehmet[1], Girgin Ziya[2], Ozkan Aytekin[2]

[1] Middle East Technical University, Department of Mechanical Engineering, Turkey
[2] TOFAS Turkish Automobile Factory Inc, Turkey

NVH Laboratory of TOFAS, Turkish joint venture of FIAT Inc., necessitated a professional listening environment to evaluate noise data obtained from

several performance tests on their vehicles. Despite limitations on listening room volume and boundaries, geometry of the environment is kept quite simple while the acoustical comfort parameters defined for a listening experience are preserved. The preliminary design stage focused on two main objectives, namely, isolation of the environment from its surrounding to lower interior background noise levels to minimum and sustaining high level acoustical comfort for listening experiences. Rectangular form is chosen for the environment for the sake of simplicity in design and construction. In dimensioning the environment within limited available space, room modes are taken into account for low frequency response. The computer simulation for the design is performed on room acoustic software, ODEON v12. Predictions obtained from the software for mid-to-high frequency behavior are comparatively evaluated with acoustical measurements. The outcomes from both software and measurements conducted with respect to ISO 3382 are found to be in agreement and consistent indicating that the objectives set at the design stage is fully accomplished.

SS61 Noise in educational settings

Chair: Hygge Staffan, Jones Dylan

Tuesday 08:20-08:40, Hall Igls, Paper 0105 (invited)
Christensson Jonas
Speech Intelligibility in Swedish Forests – An Example of Good Classroom Acoustics

Christensson Jonas
Saint-Gobain Ecophon AB, Sweden

For thousands of years we have developed our hearing in an outdoor environment full of natural sounds, as babbling brooks, wind from trees, bird songs and human voices. The problem is that students and teachers spend a major part of their time indoors, in a sound environment with very few natural sounds. The effect is problem for students to understand what the teacher is saying and voice problems for teachers. It is important that teaching places provide good speech intelligibility for listeners and good speech comfort for speakers. Being able to listen without effort is important for good learning and we know that incorrect room acoustics is a burden that impedes learning. An interesting teaching place is the Swedish forests, where we can talk to each other over long distances without having to raise our voice. I have made several listening tests in the forest and also measured the forest "room acoustics".

Tuesday 08:40-09:00, Hall Igls, Paper 0324 (contributed)
Sala Eeva
Activity noise in comprehensive school classrooms in Finland

Sala Eeva[1], Holmqvist Sofia[2], Rantala Leena M.[3], Hakala Suvi[3], Jonsdottir Valdis I.[4]

[1] Turku University, Finland, [2] Department of Logopedics, Åbo Akademi University, Finland, [3] School of Social Sciences and Humanities, University of Tampere, Finland, [4] Thad er malid. Akureyri, Iceland

School classrooms are spaces where young children learn skills and get knowledge for studying, to graduate and qualify themselves as professionals in different occupations. Young children need best possible conditions for learning. Noise interferes with voice production in classrooms. Noise is a risk factor for voice disorders that are very common among teachers. Noise

decreases speech perception and even more in children than adults. Children with specific language impairment or hearing loss perform under that of normal children. Noise affects attention, language learning, mathematical performance and memory. Noise has dose-response function on cognitive function: the higher the noise levels the greater their effects. 92 % of teachers experience activity noise annoying. Children are also annoyed by noise; intermittent noise has been shown to disturb more than constant one. The average noise disturbance is best determined by L_{Amax} levels. In this study activity noise levels were measured during classroom instruction in comprehensive school classrooms (N=40). It was found that activity noise levels in classrooms during classroom instruction are high for speech communication and learning: L_{Aeq} 69±6.2 dB, L_{10} 68±4.2, L_{50} 55±4.7 and L_{90} 42±4.1 dB(A). Activity noise levels did not correlate to any other acoustic parameter than room gain. The reason for this may be that activity noise levels also depend on many other background variables than acoustics.

Tuesday 09:00-09:20, Hall Igls, Paper 1130 (invited)
Dockrell Julie
Pupils' perceptions of noise in English secondary schools

Dockrell Julie[1], Connolly Daniel[1], Shield Bridget[2], Conetta Robert[2], Mydlarz Charlie[3], Cox Trevor[3]

[1] Institute of Education, University of London, UK, [2] London South Bank University, UK, [3] University of Salford, UK

A recent project has investigated acoustical conditions in secondary schools, in order to examine the effects of the acoustic environment on teaching and learning of 11- to 16-year-olds. The project has included objective acoustic surveys, subjective surveys of pupils and teachers and cognitive testing of pupils. For the subjective surveys an online questionnaire concerning the acoustic environment in schools was developed. Around 2600 pupils and 200 teachers from six secondary schools in England responded to the questionnaire; this paper reports the pupils' responses. Pupils were asked to identify sounds heard in their school, to rate spaces in their school in terms of ease of hearing the teacher, and to comment on the effects of noise. They were also asked to identify rooms in which it was hardest and easiest to hear and understand the teacher. Examining the differential responses between various groups of pupils showed that those with particular learning needs were more affected by noise than other pupils. Acoustic surveys were also undertaken in the six schools, and, where possible, the subjective data has been compared with data on noise and reverberation times in the schools.

Tuesday 09:20-09:40, Hall Igls, Paper 1121 (invited)
Socher Michaela
The influence of native-language music and foreign-language music on the processing of the Reading Span Task

Socher Michaela[1,2], Leistner Philip[1], Kaup Barbara[2], Liebl Andreas[1]
[1] Fraunhofer Institute for Building Physics, IBP, Germany, [2] University of Tübingen, Germany

Most people do not consider to be negatively affected by background music while reading or learning. Several studies have shown that irrelevant background sound with certain temporal and spectral structure affects cognitive performance. This effect is called Irrelevant Sound Effect (ISE). In this study the influence of music with German vocals and music with English vocals on the processing of the reading span task is compared. Subjects had to work on an English and a German version of the reading span task The reading span task contained a serial recall subtask and a sentence verification subtask. Both turned out to be negatively affected by background music. The degree of disturbance in the English version of the reading span task depended on the language of the background music. The performance on the serial recall task was more negatively affected by music with English vocals, while the sentence verification task was more negatively affected by music with German vocals. It is concluded that different cognitive processes are involved and that music with vocals influences the processing of a native-language task and the processing of a foreign-language task in different ways.

Tuesday 09:40-10:00, Hall Igls, Paper 0971 (invited)
Hygge Staffan
Acoustical conditions in the classroom II - Recall of spoken words in English and Swedish heard at different signal-to-noise ratios

Hygge Staffan, Kjellberg Anders, Nöstl Anatole, Keus Marijke, Hurtig Anders, Ljung Robert, Sörqvist Patrik
University of Gävle, Sweden

An experiment will be reported which assessed speech intelligibility and free recall of spoken words in Swedish (native tongue) and in English heard under different signal-to-noise (S/N) ratios (+3 and +12 dB), and with/without the spoken words being repeated back orally directly after presentation (shadowing). All participants encountered all experimental conditions. Twelve wordlists with 12 words each were generated in English as well as in Swedish.

The words were chosen according to their ranks in category norms for the two languages, and no category was the same for the two languages. Blocks of counter balanced presentation orders, S/N-ratios and shadowing/no shadowing were generated. After each wordlist the participants wrote down the words they could recall. Pre-experimental measures of working memory capacity were taken. The basic hypotheses for the recall of the words were that working memory would be overloaded when the S/N-ratio was low, there was no shadowing and when the language was English. A low score on working memory capacity was expected to further enhance these effects. While writing this abstract data collection is still in progress but results will be presented at the conference.

Tuesday 10:00-10:20, Hall Igls, Paper 1308 (invited)
Jones Dylan M.
Auditory distraction in memory tasks: Can it be controlled?

Jones Dylan M.[1], Hanczakowski Maciej[1], Beaman C. Philip[2]
[1] Cardiff University, UK, [2] University of Reading, UK

Irrelevant sound accompanying the processes of encoding and retrieval of verbal events impairs memory performance. However, the degree of impairment is highly dependent on a range of factors. Some of them lie outside rememberers' control, like the semantic content of distracting sound or the nature of a test used to assess memory. Others, like a strategy used to encode memoranda, rest under control of the rememberer. In this paper the factors that modulate memory impairment are outlined and discussed in terms of multiple mechanisms contributing to memory impairment under auditory distraction. The mechanisms of a capture of attention by distraction, interference of automatic seriation of distraction and voluntary seriation of memoranda, semantic inhibition of distraction, and blocking of memoranda by semantically related distracters are described. Results that demonstrate how these mechanisms determine memory impairment under auditory distraction are also discussed. Particular attention is devoted to the possibility of voluntary control over the workings of these mechanisms and the conditions under which the negative impact of auditory distraction upon memory performance could be minimised.

SS51 Combined Exposures

Chair: Klaeboe Ronny

Tuesday 11:00-11:20, Hall Igls, Paper 0321 (contributed)
Morihara Takashi
A study on community response to road traffic and railway noises and vibrations in Hue, Vietnam

Morihara Takashi[1], Shimoyama Koji[2], Nguyen Thu Lan[2], Nguyen Huy Quang[2], Yano Takashi[2], Kawai Keiji[2]

[1] Department of Architecture, Ishikawa National College of Technology, Japan
[2] Graduate School of Science and Technology, Kumamoto University, Japan

To indicate a basis data on the noise policy in developing countries, we have been conducting social surveys on transportation noise in Vietnam since 2005. The main mode of transportation in Vietnam is motorcycle; the traffic volume is increasing every year and the number of registered motorcycles in 2009 was about 27 millions. This may result in an increase in noise levels. The objective of the present study is to compare the exposure-response relationships between a survey in Hue, which is a middle-scale city in Vietnam, and surveys conducted in other Vietnamese larger cities or other countries. The social survey was conducted in 2012 with face-to-face interview method to investigate the effects of railway and road traffic noises and vibrations. The sample size was 1,035 respondents (the response rate was 86%). Noise and vibration levels for each house were obtained by measuring them for 24 hours at several representative points. The result of road traffic noise exposure-response relationships in Hue were almost the same as the result from Da Nang city, while that was lower than the EU curve. Noise annoyance caused by railway varied widely across divided sites. It was shown that the interaction between Site and awakening affected railway noise annoyance.

Tuesday 11:20-11:40, Hall Igls, Paper 0270 (invited)
Morel Julien
Annoyance due to combined road traffic and industrial noises: a simulated environment experiment

Morel Julien[1], Marquis-Favre Catherine[2]
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Total annoyance due to combined noises is still difficult to predict adequately. Actually, no total annoyance model leads to a consensus among the scientific community. In this context, the paper describes a simulated environment experiment where subjects perform activities in a simulated living room while exposed to noise sequences combining road traffic and continuous industrial noises. The effects of acoustical factors (exposure to road traffic noise, and exposure to industrial noise) on annoyance are firstly investigated. Then psychophysical and perceptual models of total annoyance are tested in order to (1) compare them using the data collected during the simulated environment experiment, and (2) confront them to data collected *in situ*. The results of this study confirm that perceptual models are able to predict annoyance better than psychophysical models.

Tuesday 11:40-12:00, Hall Igls, Paper 1150 (invited)
Dekoninck Luc
Traffic noise and particulate matter exposure; how can we distinguish between them in effect studies?

Dekoninck Luc[1], Botteldooren Dick[2], Int Panis Luc[3], Dons Evi[2]

[1] University of Ghent, Information Technology, Acoustics, Belgium, [2] Flemish Institute for Technological Research (VITO), Belgium, [3] Transportation Research Institute (IMOB), Hasselt University, Belgium

Evaluating the health effects of traffic related air pollution at the one hand and noise at the other suffers from the uncertainties resulting from the co-exposure to noise and air pollution. In air pollution research, it has recently been observed that a large fraction of the diurnal exposure of traffic related components of air pollution such as black carbon (BC) is inhaled while in-traffic. Exposure at home or at work contributes only between 40% and 80% of the diurnal exposure, depending on the time-activity pattern, the travelled routes and the modal choice. The in-traffic exposure to BC is strongly affected by local traffic conditions (road type, traffic intensity, congestion, speed) and factors affecting dispersion (street canyons, microenvironment, meteorological conditions). To investigate combined exposure, a personal BC exposure measurement database with GPS registration is used. A strong relationship between noise levels extracted from noise maps and the measured BC level was observed for both indoor and in-car activities. A

model for BC exposure based on L_{DEN} noise levels and meteorological conditions could be established for different microenvironments allowing predicting the exposure to BC based on noise maps. Epidemiological evaluations based on stratification of the in-traffic contribution of personal BC exposure can be used to distinguish between the health effects of noise and air pollution. The in-traffic contribution of aggregated personal BC exposure can be estimated by evaluating the time-activity pattern on noise maps.

Tuesday 12:00-12:20, Hall Igls, Paper 1064 (invited)
Klæboe Ronny
Cost-Benefit Analyses of Tree Belts for Noise Reduction - Including Aesthetic and Amenity Values

Klæboe Ronny[1], Veisten Knut[1], Mosslemi Marjan[1], Van Renterghem Timothy[2], Van Maercke Dirk[3], Leissing Thomas[3]

[1] Institute of Transport Economics, Norway, [2] Acoustics Research Group, INTEC, Ghent University, Belgium, [3] Centre Scientifique et Technique du Bâtiment (CSTB), France

The noise reduction effects of using a tree belt to protect 19 buildings exposed to road traffic have been calculated. Given a context where a large number of residents benefiting from the measure and accumulation of substantial noise reductions over many years, the benefits can be substantial. A noise reduction of one dBA has for long been given an economic unit value and we can thus obtain an accumulated value for the summed up noise benefits for all residents. However, corresponding economic unit values for the improvement in area amenity/aesthetics of introducing greenery in the form of a tree belt is missing. Without such values, standard economic analyses are only partial, implicitly disregarding the amenity/aesthetic aspects of green measures, effectively setting the value of such benefits to zero. To improve on this situation we have collaborated in the HOSANNA project to obtain initial and tentative unit value estimates based on a literature survey. Coupled with initial cost estimates for the planting and maintenance of the tree belt, we calculate the economic viability of using vegetation in situations where this could be an option. Since cost, benefit and effect estimates are associated with uncertainties we use Monte Carlo simulations to obtain an impression of how robust our estimates of Benefit-Cost Ratios and other result indicators are.

Tuesday 12:20-12:40, Hall Igls, Paper 1142 (invited)
Klæboe Ronny
Cost-Benefit Analysis of Tree Belt Configurations

Klæboe Ronny[1], Veisten Knut[1], Van Renterghem Timothy[2], Van Maercke Dirk[3], Leissing Thomas[3], Benkreira Hadj[4]

[1] Institute of Transport Economics, Norway, [2] Acoustics Research Group, INTEC, Ghent University, Belgium, [3] Centre Scientifique et Technique du Batmen (CSTB), France, [4] University of Bradford, UK

In some cases, when considering a set of noise-control measures, there is a possibility that adjustments of some elements might lead to reduction of the total cost and/or increase in the total benefit. Here we use economic analysis as an exploratory tool to test the economic rationale for selecting tree belt configurations. We assess the economic penalty of using a completely regular array of trees, the improvement of augmenting the acoustic effect of the tree belt with "artificial" trees in the form of standard impregnated tree poles, and novel devices "noise stoppers", made of recycled materials. Whereas the acoustic effect depends on the width of the tree belt plant density, tree stem thickness and planting configurations, the aesthetic impression depend most on the quality of the proximal tree rows facing residents. If we search for an optimal design we need to take all relevant effects into account. As the amount of materials, the amount of work, the prices of these, the acoustic effect and other effect estimates are associated with uncertainties as are their valuations, we use Monte Carlo simulations to obtain an impression of how robust our economic indicators results are.

SS66 Quiet Vehicles

Chair: Genuit Klaus

Tuesday 12:40-13:00, Hall Igls, Paper 0702 (invited)
Misdariis Nicolas
Sound signature of Quiet Vehicles: state of the art and experience feedbacks

Misdariis Nicolas, Cera Andrea
IRCAM, France

It seems now widely conceded that *Quiet Vehicles* are actually too quiet for leaving out the crucial question of their sound signature. When considering the increasing volume of works in that domain, it looks obvious that a dedicated sound design approach for these new means of transport becomes fully relevant regarding security (for people around) or ergonomics (for people inside). For quite a long time, and among other labs, the Sound Perception and Design (SPD) team at Ircam has focused a part of its works on that topic which represents an emblematic framework to operate knowledge, methodologies or tools developed in the field of Sonic Interaction Design. The paper aims at presenting, first, an overview of recent scientific studies in that field together with a review of current legislations or standards that are – or tend to be – effective in several countries. In a second part, we will try to adress this issue in the light of several works achieved within SPD team, especially some parts of a long run collaboration with a french car manufacturer, but also more recent investigations that contribute to the general question: what is the best sound for a quiet vehicle?

Tuesday 14:00-14:20, Hall Igls, Paper 0116 (invited)
Jen Ming Une
Investigating and controlling motor noise for an electrically power assisted bicycle

Jen Ming Une, Lu Ming-Hung
Industrial Technology Research Institute, Taiwan

Ride quality is one of significant features for electrified vehicles. Traction motors as the propelling power of electrified vehicles, however, may cause noise annoyance and degrade ride quality because of their improper mechatronic design. This study investigates the effects of structural and motor drive designs on the motor noise, and resolves the noise concerns of an axial-flux permanent magnetic motor packaged to an electrically power assisted bicycle. The developing pancake-shaped motor exhibits high operating noise with irregular abnormal noise occurrences. This paper first illustrates the methods for identifying noise sources under different scenarios, and then highlights crucial sensitivity investigations on the motor structure as well as on the motor drive. Data of noise, vibration, motor mechatronic design, motor drive design and operation conditions are correlated and explored. Time signature, spectrum, cepstrum of noise and vibration data were analyzed. By establishing an index $\dot{I}$s—rate of the summation of phase currents to represent the motor torque variations under constant speed operation, this study obtained an excellent correlation between the index and the abnormal noise occurrence. This study concludes the controller software's fault induced abrupt distortion of phase currents and caused the motor's irregular abnormal noise. Moreover, permeance variations due to the stator slotting effect were the origin of high motor operating noise. After comprehensive cause-effect analysis and the corresponding remedies, we obtained a satisfactory impression of motor noise; the maximum operating noise reduced from 65 dB to below 60 dB with no abnormal noise occurrence.

Tuesday 14:20-14:40, Hall Igls, Paper 0667 (invited)
Yasui Nozomiko
Effect of non-periodic fluctuation sound for detectability of approaching quiet vehicle

Yasui Nozomiko[1], Miura Masanobu[2]

[1] Department of Information Engineering, Matsue College of Technology, Japan
[2] Faculty of Science and Technology, Ryukoku University, Japan

Although the motors equipped on hybrid (HVs) or electric vehicles (EVs) are designed to provide calm environments to drivers, pedestrians have trouble recognizing their approach because they are too quiet. Warning sounds have been developed to solve this. However, it is still problematic for pedestrians. This paper proposes an approach to current warning sound attained by using irregular fluctuations for sounds to enhance their ability to be detected. Our previous study clarified the usefulness of irregular fluctuations for warning sounds, by observing that the exhaust sounds of gasoline engines had constant fluctuation ("1st fluctuation") and irregular fluctuation elicited with deviations for time and amplitude ("2nd fluctuation"), and these also contributed to their detectability. This paper describes the unclear points of previous, say, the independent effects of 1st and 2nd fluctuations on detectability and their combined effects.

Investigations were carried out by using synthesized motor sounds, called a "fluctuating motor sounds", which were designed to have 1st and 2nd fluctuations, and their effects on detectability by pedestrians were assessed. The results revealed that motor sounds with slow fluctuation could be detected better than those with fast sounds. Moreover, our results demonstrated that 2nd fluctuations influence detectability of approaching quiet vehicle. These results revealed that fluctuating motor sounds effectively enabled people to notice the approaching quiet vehicles.

Tuesday 14:40-15:00, Hall Igls, Paper 0688 (invited)
Yamauchi Katsuya
Effect of frequency shifting on acceleration impression for designing additional sound for quiet vehicles

Yamauchi Katsuya[1], Shiizu Takayuki[2], Tamura Fumio[2], Takeda Yuichiro[2]
[1] Faculty of Engineering, Nagasaki University, Japan, [2] Pioneer Corporation, Japan

Regulations regarding additional audible sounds for quiet vehicles have been developing in some governments. Some of the regulations might require the variation of the frequency content as a function of the vehicle speed to make pedestrians easily recognize the vehicle behavior such as acceleration. When the additional sound for quiet vehicles, which is independent from vehicle propulsion mechanism, is designed, it is needed to understand about the relationship between frequency shifting and acceleration impression. To understand the relationship, we designed a Scheffe's pair comparison test using audio-visual stimuli. The visual stimuli were a traveling vehicle on a road monotonically accelerated from stopping. One of them was recorded from the cabin as a view of a passenger and the other was recorded with a camera on the road as a view of a pedestrian. The audio stimuli were mixture of three 1/3-octave band noises, of which frequency shifting were independently controlled. The result showed that frequency shifting could affect to vehicle acceleration impression both for pedestrians and people in cabin. It was also shown that the impression could be affected by not only the ratio of shifting but also the shifting band frequency.

Tuesday 15:00-15:20, Hall Igls, Paper 0073 (invited)
Wall Emerson Robert
Blind pedestrians and the impact of quieter vehicles on mobility decisions

Wall Emerson Robert, Kim Dae Shik, Naghshineh Koorosh
Western Michigan University, USA

A series of studies was conducted in low and moderate ambient sound environments. Blind pedestrians performed common travel tasks with sound cues from internal combustion vehicles, hybrid vehicles without added sounds, and hybrid vehicles with added sounds. Tasks included detecting forward approaching vehicles and backing vehicles, determining the path of a vehicle at an intersection, deciding when to cross in a gap between vehicles, and taking parallel and perpendicular alignment from passing vehicles.

SS67 Psychoacoustics of environmental and mobile noise sources

Chair: Fiebig André, Preis Anna

Tuesday 15:20-15:40, Hall Igls, Paper 0731 (invited)
Sukowski Helga
Perceived quality of the interior sounds in electric and conventional motor vehicles

Sukowski Helga, Kühler Robert*, van de Par Steven, Weber Reinhard
Acoustics Group, University of Oldenburg, Germany
*Now at Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Sounds of electric vehicles are quite different from sounds of conventional motor vehicles. Therefore the trend towards an increasing number of electric vehicles implicates a change in the acoustical environment. This holds for the exterior acoustics of the car, mainly observable as a decrease in the radiated sound level, but this also holds for the interior sound of the car. In three consecutive empirical studies we investigated how people perceive and describe the sound quality of the interior sounds of an electric vehicle and a conventional car of a comparable category. The different studies included (1) an open questioning after test runs with both cars, and (2) an assessment task with a newly compiled adjective list (76 adjectives) in order to identify sound-relevant adjectives. Finally (3), a reduced adjective list (30 adjectives) was used to assess 14 interior sounds (7 from each car). Studies (2) and (3) were carried out as laboratory studies. An interesting result is the interaction between the factors "type of vehicle" and "driving velocity", which revealed that several clearly positive assessments for the electric vehicle sound, that were present at low speeds, e.g. concerning safeness and pleasantness, declined with the increase of driving velocity.

Tuesday 15:40-16:00, Hall Igls, Paper 0884 (invited)
Altinsoy Ercan
The detectability of conventional, hybrid and electric vehicle sounds by sighted, visually impaired and blind pedestrians

Altinsoy Ercan
Dresden University of Technology Chair of Communication Acoustics, Germany

The timely detection of the vehicles by pedestrians is a prerequisite for road safety. In this study, the traffic condition in which a vehicle approaching to the pedestrian from 50 meter distance with partial load acceleration was investigated. The binaurally recorded sounds of 14 internal combustion

engine cars, 4 hybrid cars, and 6 electric cars were presented to the visually impaired, blind and sighted participants. The criteria for the vehicle sound selection was to include broad spectral range with different temporal characteristics. The reaction times of 37 subjects were measured. In the reaction time experiment, the subjects were asked to imagine that they are standing on the curb waiting to cross a one-way street when there may be vehicle approaching from the left. The results show that pedestrians detect the sound of electric vehicles (without sound generator) much later than the sound of vehicles with internal combustion engines and relatively few signal elements are used to detect the sound of internal combustion engine vehicles.

Tuesday 16:00-16:20, Hall Igls, Paper 0956 (invited)
Fiebig André
Psychoacoustic Evaluation of Urban Noise

Fiebig André
HEAD acoustics GmbH, Germany

In the context of the COST network on soundscape of European cities and landscapes various in-situ acoustical and perceptual measurements were performed over three years in order to study perceptual phenomena in complex acoustic sceneries. In addition to the assessments of environmental noises in field experiments, the different acoustical stimuli were also subject to listening tests in laboratory. As expected, simple acoustic indicators cannot reflect the varying responses to the different multi-source scenarios with spatially distributed sound sources in field and laboratory context. It is widely known, that the analysis of psychoacoustic properties and further hearing-related parameters of noise can effectively help to understand human reactions to noise far beyond simple level considerations. Thus, the explanatory power and range of psychoacoustics regarding the collected data was investigated in detail. It is clear that some relevant cognitive aspects, like source identification, source connotation or attention processes, lies beyond psychoacoustics and cannot be explained by any acoustical parameter. Thus, the benefits as well as limitations of psychoacoustics with respect to environmental noise assessment are critically discussed.

Tuesday 16:20-16:40, Hall Igls, Paper 1178 (invited)
Lercher Peter
Psychoacoustic assessment of railway noise in sensitive areas and times: is a rail bonus still appropriate?

Lercher Peter[1], Kühner Dietrich[2], Lin Helen[1], Fiebig André[3]

[1] Division of Social Medicine, Medical University Innsbruck, Austria, [2] Independent researcher, Germany, [3] HEAD acoustics GmbH, Germany

Background: Railway noise is considered to exhibit less severe effects on health. However, railway noise exposure has changed substantially near the main corridors (frequency of occurrence, number of nightly freight trains). In sensitive areas standard noise analyses and indicators may give misleading results. Methods: A series of classical and binaural sound measurements were carried out in an alpine valley with complex topography and sensitive land use. Railway noise is the dominant source. Various acoustic and psychoacoustic analyses were applied across the valley towards the opposite slopes and compared with classical assessments. Results: Freight trains are about 7 dBA louder than passenger trains. Noise propagation towards the slopes is largely underestimated beyond 500m by classical means. Even at distances greater than 1000 m the peak noise exposure from the freight trains stands out 20 to 30 dBA during night. The noise is broadband (25 Hz to 2 kHz) contains strong low frequency components and some impulsive noise. The psychoacoustic loudness analysis results in an even stronger picture of the signal to noise ratio. Conclusion: In complex acoustic situations classical analyses can lead to a severe underestimation of the annoying and awakening potential of railway noise. The application of a rail bonus is inappropriate under these conditions.

Tuesday 16:40-17:00, Hall Igls, Paper 0685 (contributed)
Sakamoto Shinichi
Loudness evaluation of general environmental noise containing low frequency components

Sakamoto Shinichi[1], Yokoyama Sakae[1], Tsujimura Sohei[1], Tachibana Hideki[2]

[1] Institute of Industrial Science, The University of Tokyo, Japan
[2] Chiba Institute of Technology, Japan

The influence of low frequency sound in wind turbine noise has become a serious problem recently and various researches are being made in many

countries. Also in Japan, a synthetic study program titled "Research on the evaluation of human impact of low frequency noise from wind turbine generators" has been performed over the three years from the 2010 fiscal year, in which field measurements, social survey on the response of nearby residents and laboratory experiments on audibility of low frequency sounds were conducted. In parallel to these studies, field measurements on general environmental noises including transportation noises inside and outside of various vehicles were performed by paying attention to low frequency components. As a result, it has been found that low frequency components are included not only in WTN but also in general environmental sounds. The environmental sounds recorded on sites were reproduced by a test facility which can reproduce low frequency components including infrasound and loudness tests were performed. As a result, it has been found that the A-weighted sound pressure level is robustly applicable to the assessment of loudness for such kinds of environmental sounds.

Tuesday 17:00-17:20, Hall Igls, Paper 1094 (contributed)
Ohshima Toshiya
Evaluation of environmental sound quality considering meteorological conditions and masking effects of background noises

Ohshima Toshiya
RION Co. ltd, Japan

To appropriately evaluate the sound quality of a residential environment, residual sound and/or background noise should be taken into account in addition to distinct noise events. Since the auditory masking effect is unexpectedly large, it must not be ignored, especially in complicated sound situations. The relative sound intensities of both the distinct noise and residual sound will influence residents' resulting degree of annoyance. The relationship between these two factors changes over the year due to seasonal and meteorological conditions. The author conducted several week-long noise measurements in different seasons at several positions: one of them was beside a road and others were behind the houses. Temporal sequences of A-weighted sound pressure levels and loudness levels based on Zwicker’s method were calculated, and the differences between them were examined. Outdoor sound propagation predictions that took into account meteorological effects were also carried out using the parabolic equation method for a simple model case with a fixed point source and a line source that simulated road traffic noise. Several different vertical sound speed profiles were used in the calculations, which were determined to be representative profiles of different seasons based on measurements of meteorological data around Tokyo.

Tuesday 17:20-17:40, Hall Igls, Paper 0608 (contributed)
Schell-Majoor Lena
Application of psychoacoustic models for predicting detection thresholds of real signals in real backgrounds

Schell-Majoor Lena[1], Rennies Jan[1], Ewert Stephan D.[2], Kollmeier Birger[2]

[1] Fraunhofer IDMT, Project Group Hearing, Speech and Audio Technology, Germany, [2] Universität Oldenburg, Medizinische Physik, Germany

This study investigated detection thresholds of various real-world, technical signals in natural backgrounds measured in normal-hearing listeners. The data were compared to predictions of different configurations of the existing models. These models usually consist of two stages. First, the physical signal is transformed into a so-called internal representation containing perceptually relevant information only. Afterwards, a decision about the detectability is derived from a comparison of these internal representations. In previous studies, the models had been tested in psychoacoustic experiments with artificial stimuli and showed good relation to human performance, e.g., in spectro-temporal masking tasks. The goal of the present study was to assess the applicability of the models to real technical signals with complex physical properties. The experimental data revealed that detection thresholds of real signals depend on several cues, e.g., temporal structure and spectrum of the target as well as the masker spectrum. The good correspondence between some of the model predictions and experimental data indicates that the models may serve as a tool in practical applications, although some deviations require further investigation.

Tuesday 17:40-18:00, Hall Igls, Paper 0651 (contributed)
Kasess Christian
Psychoacoustic evaluation of different noise mitigation measures for steel bridges

Kasess Christian, Noll Anton, Waubke Holger
Acoustics Research Institute, Austrian Academy of Sciences, Austria

Steel bridges radiate noise at a high level making noise mitigation an important issue. Here, different mitigation measures for steel bridges were incrementally applied to two similar bridges and evaluated psychoacoustically. Starting from an initial state, pads between sleepers and bridge and synthetic sleepers were applied to bridge 1 and 2, respectively. After this step, rail dampers were mounted to bridge 1 and an absorbing system that acts as tiny noise barriers was mounted to the rails on bridge 2. Absorbing sheets aimed at reducing bridge vibrations were subsequently applied to bridge 2. Measurements were performed 7.5 m from the center and 1.2 m above the track. The highest observed decrease in A-weighted energy equivalent sound level L_{Aeq} was 1.5 dB after installing the padding. All other measures showed a decrease less than 1 dB and for the new sleepers even an increase of 1 dB was observed, accompanied by a change in spectral content showing increased low frequency contributions. Annoyance ratings were acquired in a laboratory experiment for the different stages with and without the observed changes in level. In particular, for the second bridge where changes of less than 1 dB were observed, subjective ratings showed a bimodal distribution that was less pronounced when levels were equalized. This highlights the importance of the frequency content for the individual annoyance in the case of small changes in sound pressure level.

SS46 Materials for Noise and Vibration Control

Chair: Arenas Jorge

Tuesday 08:20-08:40, Hall Maximilian, Paper 0185 (contributed)
Hasan Koruk
Vibro-acoustic responses of cylindrical shells with cardboard liners and determination of damping mechanism

Koruk Hasan [1,2], Dreyer Jason T.[1], Singh Rajendra [1]

[1]Acoustics and Dynamics Laboratory, NSF Smart Vehicle Concepts Center, Department of Mechanical and Aerospace Engineering, The Ohio State University, USA
[2]Istanbul Technical University, Mechanical Engineering Department, Turkey

Cardboard liners are often installed in automotive drive shafts to reduce radiated noise over a certain frequency range. However, the precise mechanisms that yield noise attenuation for some modes are not well understood. To overcome this void, a thin shell (under free boundaries) with different cardboard liner thicknesses is examined using analytical, computational and experimental methods. Acoustic and vibration type frequency response functions are measured in an anechoic room,and the natural frequencies and the loss factors of structures are determined using several frequency response based methods and measured data. The adverse effects caused by closely spaced modes during the identification of modal loss factors are minimized. Finally, the modal loss factors of cylindrical shells with cardboard liners are estimated using several methods, and the sources of damping mechanisms are identified. The proposed procedure can be effectively used to model damped cylindrical shells (with cardboard liners) to predict their modal behavior and radiated noise.

Tuesday 08:40-09:00, Hall Maximilian, Paper 0398 (invited)
Arenas Jorge P.
Acoustic characterization of loose-fill cellulose crumbs obtained from wood fibers for sound absorption

Arenas Jorge P.[1], Rebolledo Juan[2]

[1] Institute of Acoustics, University Austral of Chile, Chile
[2] Institute for Materials and Thermo-Mechanical Processes, University Austral of Chile, Chile

Cellulose loose-fill insulation has been commonly used as thermal and acoustical insulation in attic areas, under floors and wall cavities for several

years. It can be either hand-poured or pneumatically dry-injected to fill in gaps, obstacles and difficult spaces in building construction. This kind of insulation is lightweight, non-irritating and both biodegradable and recyclable making its use a sustainable product choice. Paper industry is widely using eucalyptus and conifer trees as raw material for producing cellulose which constitutes about 50% of the components of wood. Through an industrial process, called Kraft, the lignin is removed releasing cellulose as a paper pulp paste. After this process, the unbleached cellulose adopts a texture of small crumbs forming a porous medium. In this work, different samples of a layer of loose-fill cellulose crumbs insulation with different thickness were tested in order to measure its bulk sound absorbing properties through standardized methods. In addition, airflow resistivity was determined for dry and moist samples. An empirical model for fibrous materials in the frequency domain was used to compare the experimental results of acoustical performance. The model did not predict well the sound absorption behavior of the material, so a new model would be necessary for this purpose.

Tuesday 09:00-09:20, Hall Maximilian, Paper 1226 (contributed)
Roozen N.B.
Advanced dispersion measurement techniques for the characterization of the mechanical properties of poro-visco-elastic materials

Roozen N.B.[1,2], Verstraeten B.[1], Labelle L.[1], Glorieux C.[1], Leclaire P.[3]

[1] Katholieke Universiteit Leuven, Laboratory for Acoustics and Thermal Physics (ATF), Department of Physics and Astronomy, Belgium, [2] Katholieke Universiteit Leuven, Department of Mechanical Engineering, Belgium, [3] Département de Recherche en Ingénierie des Véhicules pour l'Environnement (DRIVE), Université de Bourgogne, France

Dispersion measurement techniques are normally used to determine the mechanical properties of poro-visco-elastic materials, such as their shear modulus. However, dispersion measurements of poro-visco-elastic materials are not easy and the experimentally accessible frequency range in which the modes of propagation are detectable is limited to the lower frequency range, typically up to about 1500 Hz. In this article an advanced measurement technique is discussed to perform the dispersion measurement, allowing to capture reliable measurement data up to higher frequencies and for higher order modes of propagation. A typical measurement result using the proposed approach is shown and the results are compared briefly with numerical simulations.

Tuesday 09:20-09:40, Hall Maximilian, Paper 0533 (invited)
Herrin David. W.
Estimation of Effective Parameters for Microperforated Panel Absorbers and Applications

Herrin D. W.[1], Liu J.[2], Hua X.[1]
[1] University of Kentucky, USA, [2] Deere and Company, USA

Microperforated panel absorbers are used in many noise control applications as an alternative to fibrous materials. Perforations were typically circular in shape in the past. Nowadays, slits are often sheared or cut into the material. Slits are non-circular and irregular shaped, and are difficult to model due to the fact that geometric parameters like slit size and porosity are difficult to measure. An inverse method using a nonlinear least squares data-fitting algorithm is utilized to estimate geometric parameters from measured absorption coefficient data. The circular perforation model proposed by Maa is used in the algorithm. The estimated geometric parameters are used to further calculate transfer impedance and transfer matrix with good agreement compared to measured data. The same algorithm is used to aid in understanding the effect of dust contamination on the performance of microperforated panel absorbers. In addition, the algorithm is used to examine the extent of manufacturing variations.

Tuesday 09:40-10:00, Hall Maximilian, Paper 0221 (contributed)
Williams Paul T.
Measurement of the bulk acoustic properties of rock wool at high temperatures

Williams Paul T.[1], Kirby Ray[2], Maleckib Colin[2], Hill James[2]
[1] School of Engineering and Design, Mechanical Engineering, Brunel University, UK, 2 AAF Ltd., UK

The acoustic absorption characteristics of fibrous materials have been the subject of many studies at room temperature and it is well known that the bulk acoustic properties may be measured using an impedance tube and expressed in the form of Delany and Bazley coefficients. However, many applications of fibrous materials take place at high temperatures, for example in gas turbines, and here little work has been done to investigate the effect of temperature on the bulk acoustic properties. Accordingly, the high temperature performance of rock wool is investigated here using a regular impedance tube modified to produce stable and uniform internal temperatures between 20°C and 500°C. Delany and Bazley coefficients are then derived from these measurements and it is shown that these coefficients

do not depend on temperature provided the temperature dependence of the flow resistivity and properties of air are accounted for. Therefore, it is shown that the bulk acoustic properties of rock wool can be characterised using Delany and Bazley's empirical formulae obtained at low temperatures and then extrapolated to higher temperatures using a straightforward modification of the material flow resistivity.

Tuesday 10:00-10:20, Hall Maximilian, Paper 0237 (invited)
Zhang Bo
Analysis of sound absorption properties of porous metals at high temperatures

Zhang Bo[1], Pi Jinbao[1], Chen Tianning[2]

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[2] School of mechanical engineering, Xi'an JiaoTong University, China

Porous metal is a type of multifunctional material that has been widely applied in some extreme environment s such as high temperatures, high sound pressure levels and airflow with high speed. Therefore, it is necessary performing theoretical and experimental acoustic investigations for porous metals under above-mentioned extreme conditions. In this work, the sound absorption properties of porous metals in different temperature fields – uniform temperature, constant temperature gradient and variable temperature fields - are mainly considered. A numerical algorithm and a semi-analytical approach are presented. And some comparisons of results are made also. Moreover, it is found that the numerical algorithm with minor modifications can be used for the acoustic computation of these materials at high sound pressure levels. Finally, the effects of different temperature conditions on the sound absorbing properties of porous metals are discussed and analyzed.

Tuesday 11:00-11:20, Hall Maximilian, Paper 0217 (invited)
Seybert Andrew F.
Controlling uncertainty of sound absorption measurements using the impedance tube method

Seybert Andrew F.[1], Hua X.[2], Herrin D. W.[2]
[1] Spectronics, Inc., USA, [2] University of Kentucky, USA

The measurement of sound absorption coefficient (SAC) of porous materials is covered by both American and international standards. However, by using the standards alone it is difficult to achieve consistently repeatable results given the large number of variables such as sample cutting and preparation, sample fit and position in the tube, and sample material variability. This paper will review the standards briefly and examine what is available in the literature to guide users in making consistently repeatable SAC measurements. The paper will also show some of the authors' results and interpret these results in light of the standards and technical literature on the subject.

Tuesday 11:20-11:40, Hall Maximilian, Paper 0951 (contributed)
Sato Taichi
Vibration and sound characteristics of vibration system with a damper containing thixotropic materials

Sato Taichi
Tokyo Denki University, Japan

The dynamic behavior of a damped vibration system containing thixotropic material was experimentally investigated. Thixotropic materials are substances that liquefy when stirred or shaken and return to a solid state when still. Vibration tests were performed using a vibratory system containing thixotropic material with rotating unbalanced masses. The force amplitude transmitted to the base was measured. The damped system containing thixotropic material exhibited good vibration characteristics. Furthermore, we constructed a device to evaluate vibration and sound in a thin plate structure with a damper containing thixotropic materials. The tests indicated that the damped system containing thixotropic materials had good vibration and sound characteristics.

Tuesday 11:40-12:00, Hall Maximilian, Paper 1261 (contributed)
Koruk Hasan
Modelling electromagnetic effect of the non-contact excitation system in Oberst beam method

Koruk Hasan, Sanliturk Kenan Y.
Istanbul Technical University, Mechanical Engineering Department, Turkey

The Oberst beam method is regarded as the conventional method for the identification of damping materials based on frequency response function

measurements on some typical beams. In this paper, adverse electromagnetic effects created by a non-contact exciter at the free ends of clamped beams in an Oberst test rig is modelled using analytical and numerical methods, and the errors in the identified material properties due to the adverse effects of electromagnetic field around the free end of the Oberst beam are presented. First, the natural frequencies of a few number of beams with different lengths are experimentally identified as a function of electromagnetic field around the free end of the Oberst beam. Then, the adverse electromagnetic effect is modelled as a stiffness modification at the tip of the beam. After that, the stiffness modification due to electromagnetic effect is identified using experimental results, and the errors in the material properties are determined as a function of stiffness effect of the electromagnetic field. Finally, the adverse effect of the electromagnetic field is modelled both as a distributed effect and a concentrated spring using finite element method and the validity of the assumptions made in the analytical model are assessed.

Tuesday 12:00-12:20, Hall Maximilian, Paper 0227 (contributed)
Popov Iurii
Numerical Simulation of Reduction of Low-Frequency Noise Passing Through the Structure with Anisotropic Distribution of Properties throughout Thickness

Popov Iurii
Russia

To generate an efficient barrier on the way of low-frequency noise propagation is a complicated engineering problem, especially if there are additional sizes, mass or structural parameters to consider. Such barrier can be a complicated layered structure made of various materials. The article describes the method of assessing acoustic parameters of a layered elastomeric structure. Numerical simulation of such structure allows more precise interpretation of obtained physical results, as well as efficiency assessment of separate elements of such structure. The article also provides calculation of a layered structure with anisotropic distribution of properties throughout thickness and assessment of its acoustic characteristics. Obtained results are verified by means of comparison against an analytical solution for an infinite layered medium. Analysis of numerical and analytical solution has shown a good correlation and potential of this approach for predicting results in development of noise management tools. These results can be used in both numerical simulationn of acoustic properties for rooms and the experimental studies regarding industrial structures.

Tuesday 12:20-12:40, Hall Maximilian, Paper 1258 (contributed)
Silva G. M.
Acoustical behavior of multi-layered structural systems

Silva G. M.[2], Magalhaes M.D.C.[1], Gomes C. V. S.[1], Gumieri A.G.[2]

[1] Dept. of Structural Engineering, Federal University of Minas Gerais, Brazil
[2] Dept. of Materials Engineering and Construction, Federal University of Minas Gerais, Brazil

This work presents a comparative study for sound absorption systems composed of sandwich panels made of coconut-fibres, foam and fabric. These systems have been used on a significant number of buildings in Brazil, mainly due to their ecological appeal, low-cost production, easy applicability and maintenance. Theoretical and experimental analyses were considered herein for the calculation of the sound absorption and other related acoustic properties of the multilayered systems. The experimental tests were performed using impedance tubes at frequencies varying from 400 Hz to 3000 Hz. The theoretical results were obtained using an empirical formula and the impedance method. The results of four acoustic systems are shown for different panel combinations. The most efficient systems were identified in terms of their sound absorption coefficients. The results were compared with those obtained via theoretical models, (macroscopic empirical models) such as the Delany-Bazley method [9].

Tuesday 12:40-13:00, Hall Maximilian, Paper 0450 (contributed)
Siviero Diego A.
Improving the sound transmission loss of a panel at low frequencies using a smart foam

Siviero Diego A., Arruda José R. F.
State University of Campinas (UNICAMP), Faculty of Mechanical Engineering (FEM), Brazil

Smart foams have been tested since they were developed in the early nineties aiming at improving the transmission loss of aeronautical panels. They consist of a piezoelectric actuator (responsible for the active control) embedded in a passive foam material. The active noise control acts mainly in low frequencies complementing the attenuation of the foam, which is effective in mid and high frequencies. Recently, smart foams have been investigated using an indirect sound transmission loss control approach. In this work, experimental studies show how the application of a smart foam prototype embedded in a multi-layer panel (composed of an aluminum plate, the smart-foam, an air gap and a honeycomb layer)

affects the sound transmission loss in low frequencies. The tests were performed with a plane and perpendicular wave incidence inside a plane wave tube with a quasi anechoic termination. The excitation is broad band random noise generated by a loudspeaker. The real-time indirect transmission loss control was performed using the classical single input/single output Filtered-X LMS algorithm. The error sensor was positioned in two different locations: inside the multi-layer panel and outside it, 25mm downstream. Results show that the smart foam can increase the sound transmission loss at low frequencies.

SS47 Machinery noise

Chair: Kurtz Patrick, Carniel Xavier

Tuesday 14:00-14:20, Hall Maximilian, Paper 0379 (invited)
Bös Joachim
Machine Acoustics at TU Darmstadt – History, present topics, and future developments

Bös Joachim[1], Storm Rainer[1], Hanselka Holger[2]

[1] System Reliability and Machine Acoustics SzM, TU Darmstadt, Germany
[2] Fraunhofer Institute for Structural Durability and System Reliability LBF, Germany

This paper will start with an overview of the historical development of the research and science of machine acoustics at Technische Universität Darmstadt, Germany, in the 1960s, 1970s, and 1980s. Back then the physical noise generation mechanisms of gears, gearings, and axial piston pumps were thoroughly investigated and analyzed for the first time, the "fundamental equation of machine acoustics" was developed, and measures for engineering noise control "at the source" were derived. In addition, the paper will present some recent examples and project results from current research projects. Finally, some trends for research activities in the future will be pointed out. These include the numerical simulation and experimental measurement of vibrational energy flow in solid structures, the increasing use of active methods, the combination of machine acoustics and psychoacoustics (What makes a machine noise more pleasant? How can a good and recognizable product sound or even a brand sound be generated? How can psychoacoustic metrics be incorporated into active control concepts? …), and the combination of methods for reliability assessment and machine acoustics (structure and damage monitoring, reproducibility of acoustic measurement results, quality control by means of acoustic emission measurements, etc.).

Tuesday 14:20-14:40, Hall Maximilian, Paper 0435 (contributed)
Baranski Filip
Noise reduction strategy for construction machines

Baranski Filip[1], Scholten Jan[2]
[1] KFB Polska Sp. z o.o., Poland, [2] IBAF GmbH, Germany

In spite of the manufacturers' extensive efforts to reduce noise emission of the construction machines especially those with intensive process noise, they have not always been successful. Thus, it occurred necessary to find a method allowing to develop a strategy to reduce noise of such machines taking into account noise generated by the machine and noise connected with the technological process. Effective noise reduction of construction machines very often becomes possible, exclusively, owing to detailed analysis both of noise generated by the machine itself and noise generated during the technological process. The method developed for identification and analysis of the above mentioned sources of noise enables to understand a vibroacoustic system of the machine and also a vibroacoustic system of the technological process and their interaction. This, in turn, permits to develop a strategy of noise reduction, taking into consideration parameters of a working machine and effectiveness of technological process. The article presents the newly created method of developing a strategy to reduce the noise of construction machines. To illustrate this approach the article gives exemplary descriptions of the noise reduction strategy of some types of construction machines. The presented method of developing a noise reduction strategy enables an effective noise reduction of construction machines, taking into account both the machine generated noise and that resulting from technological processes. The above mentioned method is applied to reduce industrial noise as well.

Tuesday 14:40-15:00, Hall Maximilian, Paper 0487 (contributed)
Peyroux Christophe
Noise path modelling approach for machinery noise prediction

Peyroux Christophe[1], El Massoudi Omar[1], Dalle Sébastien[1], Bollade Laurent[2]

[1] CETIM, Noise and vibrations department, France
[2] DYVA, Acoustics and vibrations consultant, France

The paper describes a methodology where a noise path modelling approach is applied to predict the noise in an excavator cabin. The noise path modelling aims to analyze the vibroacoustic behaviour of a machine based on its vibroacoustic scheme. The studied system is divided into components that represent the primary sources and the noise transmission paths. Several methods can be used to characterize each component: measurements, numerical calculation or analytical formulations. In the excavator study, the acoustic components are defined by their sound power and the airborne-noise transfer functions from the source to the cabin. The vibrations sources are defined by their injected forces into the structure and the structure-borne transfer functions to the cabin. The paper describes the model subsystems, the

chosen method for the characterization and the model validation by comparison with measurements in several operating conditions. The model aims to predict the sound pressure level in the cabin and to rank the sources contributions to the global noise. It can also be used to evaluate the influence of modifications on components and to compare several variants. The study was performed with the collaboration of the CETIM working group of earth moving machines manufacturers.

Tuesday 15:00-15:20, Hall Maximilian, Paper 0626 (contributed)
Carniel Xavier
Evaluation of process-noise using acoustic imaging

Carniel Xavier[1], Bollade Laurent[2], Chassaignon Christian[2], Pascal Jean-Claude[3]
[1] Cetim, France, [2] Dyva, France, [3] VVA, France

Standards provide methods to evaluate noise levels emitted by different types of machines and industrial sources. However, standardized assessments are not always representative of noise and annoyances generated by machines during "real life" processes. The difference is quiet obvious on machines used on construction sites for example. Determining how and when noise pollution is generated during normal working processes requires powerful tools. This paper presents an approach based on the combined use of large microphones antenna and beamforming algorithms in order to identify acoustic sources contributions. A spatial resolution enhancement technique is used to more accurately identify noise sources. These methods can be applied while observing the machine at work or during a standardized measurement to determine possible noise reduction solutions. Examples based on numerous acquisitions done on several earth moving machines are provided. Contributions of different sources (engine, backwards alarms…) can be analyzed from these data.

Tuesday 15:20-15:40, Hall Maximilian, Paper 0563 (contributed)
Sato Ken
Noise and Vibration Contribution Analysis on Hydraulic System Using SEA

Sato Ken[1], Yamazaki Toru[2], Kojima Eiichi[2]
[1] Graduate School of Kanagawa University, Japan, [2] Kanagawa University, Japan

This paper proposes a methodofthe noise and vibration contributionsina hydraulic systemfor experimental statistical energy analysis (SEA). Atargethydraulic system composed of an axial piston pump and a single rigid pipe is built to examine the feasibility of the proposed method, and three basic experiments are conducted to compare estimated contributions to measured values. First, an SEA model is constructed through an impulse hammeringtest, and the estimated vibration energy from the SEA model is compared to the measured energy. Next, the validity of the input power estimated by theproposedmethod is confirmed with experimental data and finite element methodeigenvalue analysis. The noise level is then predicted with estimated acoustic scaling factor values and vibration energy values measured during actual operation. Thevalidity of the predicted noise level is examined by comparing it with the measured noise level. Finally, the level that input power contributes to the noise is estimated with the proposed method, and theresults show thatthe energy transfer “from pipe to pump” is larger than the energy transfer “from pump to pipe” inseveral frequency bands.

Tuesday 15:40-16:00, Hall Maximilian, Paper 0750 (contributed)
Nam Dae-Ho
Identification on dynamic characteristics of core and windings for low noise transformer

Nam Dae-Ho[1], Kim Won-Hyun[1], Joo Won-Ho[1], Kim Jang-Kwan[2]

[1] Advanced Technology Institute, Hyundai Heavy Industries, Co. Ulsan, Korea
[2] Transformer Design Dep’t, Electro Electric Systems Division, Hyundai Heavy Industries, Korea

Main noise sources of transformer are core and windings. To predict and reduce the noise of transformer, it is necessary to know the dynamic characteristics of the core and windings. However it is difficult to find out the material properties because the core is made up of thousands of laminated silicon steel plates and windings consist of insulating paper, copper conductor and wood spacers. In this paper, analytical and experimental investigations were carried out to identify the dynamic characteristics of core and windings. Firstly, 3D-FE model of core and windings were made and their anisotropic material properties were tuned based on the modal tests. The obtained equivalent shear modulus of core and windings are much smaller than one-layered material but it has critical effect in dynamic characteristics. To verify the extracted material properties, forced vibration analysis was performed with electromagnetic excitations and dynamic response of the core and windings were measured by fiber-optic sensors, which can be applicable to high voltage and magnetic field environment. The peak frequency and amplitude of measured response shows good agreement with the analysis result. From the result, the extracted material properties for core and windings of transformer were verified to be meaningful.

Tuesday 16:00-16:20, Hall Maximilian, Paper 0259 (contributed)
Lindemann Jutta
Acoustic investigations on laser treating

Lindemann Jutta, Hübelt Jörn
Hochschule Mittweida, Germany

The use of laser treatment processes allow to achieve parts in 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 necessary. Therefore optical measurement methods have been established for the monitoring of the laser welding and cutting procedures. They are based, for example, on the detection of the process-dependent plasma. However, the reliability and validity of the error detection during the process can be increased by use of a combination of different sensors. Therefore, both optical and acoustic sensors, such as microphones and accelerometers, where used in the presented study.

Tuesday 16:20-16:40, Hall Maximilian, Paper 0861 (contributed)
Mehrgou Mehdi
On Sound Power Measurement of the Engine in Anechoic Room with Imperfections

Mehrgou Mehdi[1], Jönsson Ola[2], Feng Leping[3]

[1] AVL List GmbH., Austria, [2] Scania CV AB, Sweden, [3] MWL, KTH, Royal Institute of Technology, Sweden

Engine noise is one of the most critical noises in urban noises. NVH improvements are essential in order to fulfill various noise emission regulations such as ISO 362. Reducing engine noise has become a necessity for engine developers. Measurement plays an important role beside the simulations to improve the NVH behavior, because the engine is a rather complicated mechanical system with many components. ISO 3745 is an ideal method for sound power measurement for internal combustion engines since it provides a fast measurement through many different engine speeds.

However room as well as the measurement method, should comply with this standard. Because of the size and installation situation for a running engine there is limited space for measurement; and it is difficult to reach standards requirements especially for such a directive sound source. The difficulty to meet these requirements also applies to Scania's anechoic room. Here engine noise characteristics and the uncertainties in sound power measurement have been discussed based on both measurement and simulation. Recommendation has been made to decrease the uncertainty of sound power measurement.

Tuesday 16:40-17:00, Hall Maximilian, Paper 0535 (invited)
Nobile Matthew A.
Product noise declarations: Focusing on the mean instead of the statistical upper limit

Nobile Matthew A.
IBM Hudson Valley Acoustics Laboratory M/S P226, USA

The modern era of product noise declarations essentially began in 1985 with the publication of ISO 7574— Acoustics—Statistical methods for determining and verifying stated noise emission values of machinery and equipment. The overwhelming benefit was that for the first time the world had a uniform method of determining the noise emission value to be published for a product, as well as a clear procedure for how to verify the published values. The disadvantage, in this author's opinion, is the widespread confusion that has resulted from having statistical upper limits for noise emission values and complicated statistical procedures for determining the noise levels to declare to the public. This is especially troublesome when the output of all of our sound power level standards is a simple measured, or mean value. Moreover, we are certainly not helping prospective buyers who ask —What is the noise level of this product? Instead of giving them a simple answer, we say —Well, here is a value that will have a 95% probability of being verified using the procedures of ISO 7574 or ISO 4871, provided no more than 6.5% of the products, when new, have noise emission levels above this value. In this paper, the author suggests that we reconsider the way we tell the public what the noise levels of our products are.

Tuesday 17:00-17:20, Hall Maximilian, Paper 0555 (invited)
Nabuco Marco
Fifteen years of noise labeling in Brazil applied to household appliances

Nabuco Marco, Massarani Paulo, Villela Ricardo
Acoustics Testing Laboratory – Inmetro, Brazil

Since 1998, when the National Institute of Metrology, Quality and Technology - Inmetro started the tests to support the Brazilian Noise Labeling program, more than 3000 household appliances, including blenders, hairdryers and vacuum cleaners, were tested by accredited laboratories in the country. Next program steps include extending the program for white goods appliances (refrigerators, freezers, washing machines, air conditioners and the like) and, later for hobby electric tools and industrial machines. This paper presents a summary of the Brazilian Noise Labeling Program with a brief description of necessary steps to obtain the Noise Label, the actual laboratories facilities, and a critical qualitative and quantitative report, showing the data obtained according to the type of device, the resultant statistical distribution and a proposal to establish ranges of values to be informed to the consumer.

Tuesday 17:20-17:40, Hall Maximilian, Paper 0749 (contributed)
Kurtz Patrick
What can be done to improve the current poor noise emission declaration practice?

Kurtz Patrick
Federal Institute for Occupational Safety and Health, Germany

European noise abatement at workplaces and in the environment follows a concept which is based on a transparent market for the noise emission of machines and the requirement for employers to buy comparably quiet machines. In order to support this concept the EU Directives on machinery set up a system requiring machine manufacturers to declare the noise emission of their machines. In contrast the purchaser (employer) of machines has to observe the obligation of the EU Physical Agents Directive on Noise requiring to buy machines which are emitting the least possible noise. Although the use of noise emission declarations of machines should be nowadays current practice there were doubts about their quality. Therefore a joint European project on the quality of this information was carried through. In 2012 this "NOMAD" project between 14 Member States of the EU ended with a very unsatisfying result. The result was that 80 % of the declarations did not comply with legal obligations which

are set in the European Machinery Directive (MD) [1] covering about 83000 different kinds of machines and the so called "Outdoor"-Directive (OD) [2] addressing only about 50 different kinds of machines primarily used outdoors. These poor results of the NOMAD study require new ideas to foster the concept of making the market transparent and thus allowing purchasers to buy quieter machines. The paper will present a survey on the NOMAD project and give reasons why the noise emission declarations had to be negatively assessed. Finally it will provide some ideas to improve the unsatisfactory situation and will give examples how manufacturers could easily draft a noise emission declaration.

Tuesday 17:40-18:00, Hall Maximilian, Paper 0352 (invited)
Haynes Sarah
Making sense of machinery noise information

Haynes Sarah[1], Brereton Paul[1], Pitts Paul[2]
[1] Health & Safety Executive, UK, [2] Health and Safety Laboratory, UK

Machinery manufacturers, importers and suppliers of noise-emitting machinery for use at work in the European Union have duties to minimise noise from machinery. They are also required to provide information to warn where there are residual risks from noise exposure and how to reduce this. This noise emission information should allow purchasers and users of machinery to make informed choices regarding the safety of a potential purchase and to understand what measures will be necessary to mitigate the risk in real use. Most noise information is of poor quality and not regarded as an important risk area by manufacturers or of practical value by purchasers. The Health and Safety Executive (HSE) has developed a ‘Buy Quiet’ Data Checker to help purchasers to consider the credibility of noise data and enable them to compare the data for similar products in order to help them identify the quieter product. Our aim is to encourage more practical use of noise emission information and to stimulate dialogue between purchasers and manufacturers to help raise the profile of low-noise design.

SS72 Fan Noise

Chair: Gely Denis, Collin Dominique

Tuesday 08:20-08:40, Hall New Orleans, Paper 0498 (contributed)
Darvish Manoochehr
Numerical and experimental investigations on the noise of a centrifugal fan with forward-curved blades

Darvish Manoochehr, Frank Stefan
University of Applied Sciences HTW Berlin, Germany

This study is aimed to investigate the potential for the aeroacoustic simulations to predict the noise radiated from a radial fan with Forward Curved (FC) blades. Experimental measurements are carried out using the in-duct method in accordance with ISO 5136. Furthermore, LargeEddy, Detached Eddy and Reynolds Averaged Navier-Stokes simulations are performedto obtain the noise propagatedfrom the fan. The numerical resultsobtained from different Computational Aeroacoustic (CAA) methods (i.e. Ffowcs Williams-Hawkings, pressure monitors and the hybrid approach by coupling STAR-CCM+ with ACTRAN) are compared against the experimental results. Detailed descriptions of the performed simulations (e.g. boundary conditions, time-step and etc.) are given throughout the text. It is shown that all the presented methods are capable of predicting the noise of the fan. There isa close correlation between the experimental result and the results derived from Detached Eddy Simulations. Furthermore, it is shown how transient surface data helps tostudy the contribution of different parts in the noise of the fan, and thereby provides a good basis for optimization of component shapes.

Tuesday 08:40-09:00, Hall New Orleans, Paper 0722 (contributed)
Polacsek Cyril
Prediction of harmonic sound power generated by a modern turbofan with heterogeneous OGV and internal bifurcations

Polacsek Cyril, Barrier Raphaël, Bonneau Virginie
National Aerospace Research Agency (ONERA), France

The interaction of wakes generated by the fan with the Outlet Guide Vanes (OGV) occurring at blade passing frequencies is mainly responsible for aero-engines tonal noise emission at approach conditions. Rotor-stator interaction models assume axisymmetric rows and quasi-annular ducts. However, the

stator of new engines is characterized by non-identical vanes (so-called heterogeneous OGV) and integrates struts with two internal bifurcations up to the outlet. These new technologies invalidate the existing tools adopted by engine manufacturers at design stage. For this reason, hybrid methodologies based on a 3D unsteady RANS simulation considering the complete geometry of a modern Snecma engine model are investigated in this paper. A derivation of Ffowcs-Williams and Hawkings (FWH) integral formulation is proposed to take into account these technology effects. The impact of the heterogeneity on angular mode distribution (compared to an idealized homogeneous configuration) and the effect of internal bifurcations on downstream propagation are analyzed. The harmonic sound power predictions provided by RANS-FWH coupling are also compared to direct assessment of the acoustic power obtained by extracting the perturbation fields over prescribed cross-sections behind the OGV. A first attempt to relate some results to experimental data issued from a half-scaled turbofan test rig is suggested too.

Tuesday 09:00-09:20, Hall New Orleans, Paper 0673 (contributed)
Hopper Hugh
Effect of inlet flow distortion on the noise generated by a mixed flow compressor

Hopper Hugh, Stimpson Ryan, Heffer Jonathan
Dyson Ltd., UK

This paper studies a mixed flow compressor unit designed for use in the Dyson Air Multiplier^{TM} desk fan. It has been observed that distortion of the inlet flow can cause a reduction in the performance of the compressor as well as changes in broadband noise and tonal noise associated with the blade passing frequency. This phenomenon is well known in the literature and has been studied at all scales from gas turbines to cooling fans. This paper seeks to explore the flow features specific to the inlet geometry of the Dyson desk fan and link these to changes in the noise generated by the compressor. Isolating the flow features is achieved through a combination of computational fluid dynamics and hot-wire anemometry which are linked together with acoustic measurements. The ultimate goal is to identify critical parameters for designing inlet geometries which minimise size and noise. One particularly interesting result showed that slight changes in the manufacturing process of seemingly identical parts can cause flow features which have a marked effect on the acoustic properties of the compressor. The results and methods presented herein can be used to optimise the design of inlet geometries for performance and noise.

Tuesday 09:20-09:40, Hall New Orleans, Paper 0925 (contributed)
Reichenberger Johann
Fan broadband noise control by tuneable acoustic liner

Reichenberger Johann, Pongratz Reinhard, Schober Arnold
EADS Innovation Works, Germany

Efficient aircraft noise reduction is a major factor for continuing growth of civil aviation. In addition to low noise flight procedures it is essential to reduce the noise directly on the source. This paper presents an acoustic liner which reduces the broad band fan noise. One significant point of view is the possibility to tune the impedance matching between the acoustic liner and the sound field getting a optimized noise reduction for different operating conditions of the engine. The design of the liner and experimental studies on the EADS-own roto/stator test rig are shown.

Tuesday 09:40-10:00, Hall New Orleans, Paper 0687 (contributed)
Rynell Anders
Quiet and efficient cooling for IC-engine powered systems

Rynell Anders[1,2], Efraimsson Gunilla[1], Chevalier Mattias[2], Åbom Mats[3]

[1] Centre for ECO² vehicle design, KTH Aeronautical and Vehicle Engineering, Sweden, [2] Scania, Sweden, [3] Marcus Wallenberg Laboratory for Sound and Vibration Research (MWL), KTH, Sweden

The cooling module placed in heavy vehicles is a compact installation, consisting of several components that all affect the cooling air stream which results in complex flows. Even though the fan is considered the main source of sound, adjacent surfaces affect the flow and the scattering of the sound radiated from the fan and make it difficult to predict the acoustic source distribution and sound field inside and outside of the cooling system. This paper focus on the noise emissions caused by the flow associated with the cooling fan and the interaction with an upstream radiator. The long-term objective of the work is to obtain an efficient and accurate simulation tool for the design of silent and efficient cooling systems, where the present work will be a viable tool in the evaluation process. A modular test rig was built that consisted of a radiator, shroud, fan and hydraulic engine mounted in a wall, which was located between an anechoic room and a reverberation room in order to control the sound level of the incoming flow. Acoustic characteristics e.g. sound pressure-

and sound power levels, have been measured in both rooms and will later be used to validate future numerical simulations.

Tuesday 10:00-10:20, Hall New Orleans, Paper 0114 (contributed)
Wen Yi-Chuan
Noise and Vibration Analysis and Sound Quality Improvement of Residential Exhauster

Wen Yi-Chuan, Wang Wei-Hui
Center of Sound and Vibration Research, Department of Systems Engineering and Naval Architecture, National Taiwan Ocean University, China

The sound generated by a residential exhauster in kitchens is one of the noise sources to make people feel uncomfortable. The assessment of the sound quality of a specified exhauster is conducted to find out the cause of annoyance. In which, the noise sources such as the vortex flow in exhaust pipe, the vibrations of motor and enclosure casings, are diagnosed and identified. From the measurements the maximum vibrations occur at the pipe wall and the casing side shells induced by the flow vortices. Regarding the sound quality assessment, the head/torso simulator and the software dB-sonic are utilized. From the measurement and analysis results of the sound quality of the exhauster, it shows that the sharpness and the loudness are the predominant factors. Thus, both of which are the causes of annoyance of the exhauster. To improve the sound quality and to attenuate the loudness, the countermeasures adopted in this study have attained the improvements as that the noise level is reduced 12.9 dB, the loudness reduced 13.1 sone the vibration levels of the casing shell are reduced in a range of 1~5dB, and the annoyance index of sound quality is reduced from 13.19 to 8.16.

SS73 Ducts and Mufflers

Chair: Elnady Tamer, Denia Francisco D.

Tuesday 11:00-11:20, Hall New Orleans, Paper 0012 (contributed)
Li Shuaijun
Characteristics analysis of pressure wave propagation in liquid-filled pipes

Li Shuaijun, Liu Gongmin, Zhao Xiaochen
College of Power and Energy Engineering, Harbin Engeneering University, China

Considering the fluid pressure and Coriolis force, Centrifugal force and migration force caused by flow velocity, an improved 14-equation model is presented which describes the fluid-structure interaction behavior of thick-walled fluid-filled pipes. Taking into account longitudinal vibration, transverse vibration and torsional vibration, the transfer matrix method (TMM) has been used for numerical modeling of both hydraulic and structural equations. Then the model and algorithms were validated with numerical examples. Based on this model and algorithms, several pipeline schemes were calculated and analyzed with various fluid pressures, flow rates and thicknesses of pipe wall. Furthermore, the influence laws and characteristics of fluid parameters and properties of the structure on the pressure fluctuations and dynamic response of pipeline were discussed.

Tuesday 11:20-11:40, Hall New Orleans, Paper 0932 (contributed)
Glav Ragnar
Analysis of a cylindrical micro-perforated resistive silencer

Glav Ragnar[1], Färm Anna[2]
[1] Scania AB, Sweden, [2] KTH Royal Institute of Technology, Sweden

This paper presents an analytical wave decomposition model for predicting the transmission loss a cylindrical silencer with both annular and baffled micro-perforated screens. Numerical simulation shows the fundamental characteristics as well as the potential to achieve large attenuation using micro-perforations. The numerical model is verified by measurements using the 2-microphone technique and shown to be a useful tool in practical design. Clear from the analysis is the sensitivity of the micro-perforated silencer to changes in both porosity and overall layout.

Tuesday 11:40-12:00, Hall New Orleans, Paper 0256 (contributed)
Komi Erin
Measurement and simulation study of an exhaust system noise complaint

Komi Erin[1], Gao Zengxin[2], Hartikainen Jouni[3], Saine Kari[2], Jacqmot Jonathan[4], Robin Xavier[4]

[1] VTT Technical Research Centre of Finland, Finland, [2] Wärtsilä Finland Oy, Finland, [3] JTK Power Oy, Finland, 4 Free Field Technologies, Belgium

A noise complaint was issued during a 1000 hour endurance test for a Wärtsilä W32E engine with cylinder pressure 235 bar. Sound measurements were taken, and the cause of the complaint was determined to be the first stage exhaust silencer, which radiates noise in the 100 Hz third-octave band (i.e. engine order 7.5).Actran finite element software was used to create a vibro-acousticmodel of the exhaust silencer in order to investigate the noise problem identified as occurring at 94 Hz. The simulations indicated that a combination of factors resulted inthe noise problem; the engine load, which determines the temperature in the ductwork and silencer, the engine speed, which determines the engine order frequencies that are excited, and the length of the duct leading to the silencer, having a resonance at 94 Hz if engine load is at 100%. Several potential silencer modifications were simulated, and an extension of the silencer inlet was proposed. The silencer was thus modified, and the sound measurements were repeated. The result was a 10 dB decrease in total sound level measured around the silencer exterior.

Tuesday 12:00-12:20, Hall New Orleans, Paper 1217 (invited)
Wagih Mina
Analysis of duct networks at high frequencies using two-ports

Wagih Mina[1], Elnady Tamer[1], Åbom Mats[2]

[1] Group for Advanced Research in Dynamic Systems (ASU-GARDS), Ain Shams University, Egypt
[2] Marcus Wallenberg Laboratory for Sound and Vibration Research, The Royal Institute of Technology (KTH), Sweden

Duct Networks (e.g. HVAC) should be carefully designed to maintain certain pressure drop, flow rate and acceptable noise levels. To accurately analyze the acoustics in a duct network in the high frequency region, the following mechanisms need to be modeled: The sound power injected into the network by sound sources (e.g. Fans), the flow noise generated in different parts in the network (e.g. junctions), and the noise reduction across different parts of the

network. Traditionally only transmission of sound power with no reflection is considered in standards, e.g., ASHRAE or VDI, for analyzing noise in HVAC systems. In this paper, a more general approach is considered based on dividing the duct network into two-port elements where each element can be described by a 2x2 scattering matrix. The state variables are taken as acoustic power flow in the up/downstream directions. Junctions are described by multi-ports depending on the number of elements connected to the junction. A source vector is added to each element and junction to handle sound power injection by fans or other aeroacoustic sources. The advantage of this approach is that the same formalism (based on two-port network theory) can be used to analyze both low frequency range and flow distribution/pressure drop as well as the high frequency range. The two-port power based formulation was validated against a detailed HVAC example in VDI 2081: Part 2.

Tuesday 12:20-12:40, Hall New Orleans, Paper 0448 (invited)
Kirby Ray
The effect of temperature on the acoustic performance of splitter silencers

Kirby Ray[1], Williams Paul T.[1], Hill James[2]
[1] Brunel University, UK, [2] AAF Ltd., UK

In gas turbine exhaust systems dissipative silencers are normally used to attenuate broadband noise emanating from the turbine. These silencers often consist of parallel baffles packed with fibrous porous materials such as basalt wool. In gas turbine exhausts, temperatures can reach up to 700 °C and this can significantly affect silencer performance. Accordingly, the influence of elevated temperatures on silencer insertion loss is investigated here for one third octave bands up to a frequency of 8 kHz. Values for silencer insertion loss are generated using a theoretical model based on the finite element method and point collocation. Predictions draw on experimental data obtained for the bulk acoustic properties of basalt wool at temperatures of up to 500 °C. It is shown here that temperature significantly affects silencer performance and this effect should be compensated for when attempting to quantify silencer performance in high temperature applications.

Tuesday 12:40-13:00, Hall New Orleans, Paper 0085 (contributed)
Fang Zhi
Acoustic attenuation analysis of perforated tube dissipative silencers with offset extended inlet/outlet

Fang Zhi, Ji Zhenlin
College of Power and Energy Engineering, Harbin Engineering University, China

The two-dimensional finite element method is used to calculate the transversal modes of perforated tube dissipative silencer with offset extended inlet/outlet, and the numerical mode matching method is developed to determine the acoustic attenuation performance. The corresponding formulation is derived and the computational code is written. For a circular concentric configuration, the transmission loss results from the numerical mode matching method, the three-dimensional finite element method and experiment agree well, which validated the accuracy of numerical mode matching method in predicting the acoustic attenuation performance of perforated dissipative tube silencer. The numerical mode matching method is then used to investigate the effects of offset of perforated tube, density of porous material and extensions of inlet and outlet on the acoustic attenuation performance of the elliptical perforated tube dissipative silencer.

Tuesday 14:00-14:20, Hall New Orleans, Paper 1018 (invited)
Sánchez-Orgaz Eva M.
FE computation of sound attenuation in dissipative silencers with temperature gradients and non-uniform mean flow

Sánchez-Orgaz Eva M., Denia Francisco D., Martínez-Casas José, Fuenmayor F. Javier
Centro de Investigación de Tecnología de Vehículos, Universitat Politècnica de València Camino de Vera s/n, Spain

The finite element method is applied to the acoustic analysis of dissipative silencers including two effects simultaneously: (1) Temperature gradients in the central duct and outer absorbent material; (2) A perforated passage carrying non-uniform axial mean flow. The material of the outer chamber can be modelled by its equivalent acoustic properties. Temperature gradients introduce variations in these properties that can be evaluated through a heterogeneous resistivity. The wave equation for stationary medium is used with the equivalent density and speed of sound varying as functions of the spatial coordinates. Regarding the central air passage, a wave equation for non-uniform moving medium is required since the presence of

temperature variations introduce not only heterogeneous acoustic properties of the air but also a gradient in the mean flow velocity. The acoustic coupling between the central passage and the outer chamber is achieved by using the acoustic impedance of the perforated duct. This impedance depends on the heterogeneous properties of the absorbent material and the non-uniform mean flow, leading to a spatial variation of the acoustic coupling and also to additional convective terms in the governing equations. The results presented show the influence of the temperature gradient and the mean flow on the acoustic attenuation of automotive silencers.

Tuesday 14:20-14:40, Hall New Orleans, Paper 0921 (invited)
Okasha Ahmed
Acoustic response analysis of pipeline networks using two-ports

Okasha Ahmed[1], Elnady Tamer[1], Åbom Mats[2]

[1] Group for Advanced Research in Dynamic Systems (ASU-GARDS), Ain Shams University, Egypt
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Sound generation and propagation inside pipeline networks has been of major concern in different applications. There is a need to solve performance problems caused by reciprocating equipment or flow generated noise sources in piping and pipeline systems. If the source pulsations coincide with one of the acoustic resonances in the system, high dynamic pressure amplitudes can be generated causing shaking forces at the pipe ends which excite mechanical vibrations and mechanical stress which might lead to fatigue and failure. In this paper, the two -port technique is used to describe the pipeline network where the network can be divided into elements; each is described by a transfer matrix. The compressors are modeled as one-ports described by source strength and source impedance. A pilot plant equipped with a reciprocating compressor was built, and the pressure pulsations were measured in different positions inside the network. The source characteristics of the compressor were measured using the multi-load technique which is commonly used to characterize the acoustics of internal combustion engines. The dynamic pressure was calculated inside the two -port network and compared to the measurements.

Tuesday 14:40-15:00, Hall New Orleans, Paper 0529 (invited)
Herrin D. W.
Enhancing Muffler or Enclosure Performance by Adding Bypass Ducts

Herrin D. W., Zhang Y., Wu T. W.
University of Kentucky, USA

A bypass duct similar to a Herschel-Quincke tube can be used to increase the transmission loss of mufflers and insertion loss of enclosures at selected frequencies. In many cases, the duct can be short and thought of as a leak. It is shown that the optimal length and cross-sectional area can be determined by using a simple optimization technique known as the Vincent Circle. To prove the concept, a muffler was designed and optimized using transfer matrix theory. Then, the optimized muffler was constructed and the transmission loss was measured using the two-load method. The measured results compared well with predictions from transfer matrix theory for the muffler. A similar study was performed for a partial enclosure. A small bypass duct was introduced on an interior panel. It was demonstrated using boundary element analysis that a bypass duct can shift the trough of the insertion loss curve to another frequency without greatly changing the shape and size of the enclosure.

Tuesday 15:00-15:20, Hall New Orleans, Paper 0780 (invited)
Pedrosa Ana M.
A two source method with simultaneous excitation for the acoustic characterization of exhaust systems with mean flow

Pedrosa Ana M., Denia Francisco D., Besa Antonio J., Fuenmayor F. Javier
Centro de Investigación de Tecnología de Vehículos, Universitat Politècnica de València, Spain

This work presents an experimental technique that allows the acoustic characterization of exhaust system devices in the presence of mean flow. The technique is based on the two source method with simultaneous excitation, which has been successfully applied and validated by the authors in earlier studies with stationary medium. In the proposed method the two sources are excited simultaneously so only one test is required, thus reducing the test time to one half. This is an especial advantage in the mean flow case because environmental parameters such as in duct temperature and air velocity, which affect the acoustic characterization, can change with time. The measured fields are the acoustic pressures in four known locations, two in each side of

the device under analysis, and the electric signals sent to both acoustic sources. Combining properly the measured magnitudes it is possible, under certain conditions, to obtain individual transfer functions between each input, signals sent to loudspeaker, and the four outputs corresponding to the measured pressures. From these transfer functions, the acoustic characterization of the element under study can be obtained. The measurements of reactive and dissipative mufflers show good agreement with theoretical results for different values of mean flow.

Tuesday 15:40-16:00, Hall New Orleans, Paper 0345 (contributed)
Veloso Rafael
Linear acoustic multiport modeling of automotive intercoolers

Veloso Rafael, Elnemr Yasser
Virtual Vehicle Research Center, Austria

1D linear acoustic or gas-dynamics modeling of intake and exhaust systems is typically done during the early development stages of a vehicle in order to do quick sound design assessments. One of the components in the intake system of a turbocharged IC-engine is the automotive intercooler. The intercooler is positioned at the outlet of the compressor in order to cool the charged air before it enters the engine. Intercoolers are typically modeled as a 1D system comprised of an intake tank/duct, cooling tubes and an outlet tank/duct. A problem arises when the position of the inlet/outlet ducts are not axially symmetrical, which introduces three dimensional acoustic effects. This behavior is not included in typical 1D modeling. FEM could be used to describe this 3D effect but would need much longer time and a complete CAD model. In this study an acoustic multiport description of the intercooler model is presented. Such a description includes the influence of the asymmetric position of the inlet/outlet ducts on the acoustics. The multiport description is then reduced to an equivalent acoustic two-port model for the entire intercooler between its inlet/outlet ports. The frequency dependent transmission loss is calculated and compared to experimental results with good agreement.

Tuesday 16:00-16:20, Hall New Orleans, Paper 0593 (contributed)
Oh Seungjae
Influence of valve velocity on pressure wave in intake system of compressor

Oh Seungjae[1], Kim Jongnam[1], Kim Kihyun1, Ku Kunmo[2], Wang Semyung[1]

[1] School of Mechatronics, Gwangju Institute of Science and Technology, Republic of Korea
[2] KU Leuven, Department of Mechanical Engineering, Belgium

A supercharging effect in a compressor is defined by increasing the efficiency of suction using resonance phenomenon between acoustic mode of intake pipe and pressure pulsation caused by the intake valve. This research investigated supercharging effect with respect to intake valve motion with a specific intake pipe. First, a variety of intake valve motion were made considering suction and compression process. And the contribution of each frequency components to velocity of intake valve was identified through the Fast Fourier Transform. In addition, pressure was calculated by using relationship between input impedance of intake pipe and velocity components of valve. To identify the pressure at valve closing time, pressure spectrum was transformed into time domain by Inverse Fast Fourier Transform. As a result, we figured out that phase of each pressure component is the most important parameter. Therefore, when intake muffler is designed, phase of input impedance should be carefully considered. Instead of intake part of a compressor, speaker and pipe were used to experiment and validate results of analytical research.

Tuesday 16:20-16:40, Hall New Orleans, Paper 0071 (contributed)
Łapka Wojciech
Acoustic attenuation performance of selected helicoidal resonators lined with an absorbent materials of different thickness and density

Łapka Wojciech
Poznan University of Technology, Institute of Applied Mechanics, Poland

This paper describes the influence of helicoidal profile lined with an absorptive material on acoustic attenuation performance of selected helicoidal resonators. Investigated acoustic system consist of straight circular duct with helicoidal resonator inside. Two types of helicoidal resonators are investigated with number of turns n=0,671 (two resonances) and n=0,695 (one resonance) for the same ratio of helicoidal skip s to duct diameter d, s/d=1,976. The internal part of helicoidal profile is rigid, and it is covered on by layers with different thickness and density. Three types of

layers are investigated: one layer on the front side of helicoidal profile, one layer on the back side, and two layers with the same thickness and density of both sides of helicoidal profile. Four types of density were applied: 30kg/m^3, 50kg/m^3, 80kg/m^3, 100kg/m^3. By the use of a finite element method numerical acoustic calculations of the three dimensional models there were obtained transmission loss (TL) characteristics. Globally it can be observed that the thicker is the layer the TL is changing in such a way that for helicoidal resonator with two resonances, *n*=0,671, the second higher frequency resonance decreases, but the first resonance is dominating; for helicoidal resonator with one resonance, *n*=0,695, the resonance frequency and TL is getting lower.

Tuesday 16:40-17:00, Hall New Orleans, Paper 0413 (contributed)
Zhao Xiaochen
Theoretical Study of Drum Silencer in Circular Duct

Zhao Xiaochen, Liu Gongmin, Zhang Wenping, Li Shuaijun
College of Power and Energy Engineering, Harbin Engineering University, China

Low-frequency duct noise is difficult to deal with by passive methods. The drum silencer consists of a rectangular expansion chamber with two side-branch rectangular cavities covered by membranes under high tension. Theoretical study shows that the introduction of the drum silence into a typical air conveying system can achieve broadband quieting in the low-frequency region. This paper aims to investigate the performance of a drum silencer with annular chamber to be used in circular duct. Green’s function and Kirchhoff–Helmholtz integral are used to solve the sound radiation in the circular duct with an annular chamber, and then the modal vibration velocity amplitudes of the membrane are obtained. Having got the vibration velocity of the membrane, the pressure perturbation induced by the membrane oscillation and the transmission loss are found. Optimization is taken out in order to obtain the widest stopband. The transmission loss calculated by the analytical method agrees closely with the result of the finite element method (FEM) model simulation. The most desirable properties of the membrane are high tension and appropriate mass density, which can bring three adjacent peaks in transmission loss curve. Further modal analysis shows that these peaks are mainly contributed to by the first two modes vibration of the membrane, which is similar to the result of drum silencer in rectangular duct.

SS43 Sound Power

Chair: Keith Stephen

Tuesday 08:20-08:40, Hall Lugger, Paper 0811 (invited)
Dobson Andrew
Addressing the Complexities, Limitations and Benefits Involved in Conducting Near-Field Sound Power Measurements of Large Electrical Transformers

Dobson Andrew
HGC Engineering, Canada

The industry-standard method for quantifying the sound emission levels of electrical transformers is outlined in IEEE Standard C57.12.90, which details a procedure requiring sound pressure measurements at specified near-field distances and elevations surrounding a transformer. Despite widespread use of these measurement methods throughout the industry, recent field experience has shown that measurements of sound pressure levels conducted at these specified measurement distances can result in overestimated sound power levels, as determined by far-field sound measurements. Sound intensity measurements of transformers were also employed, using methods from ISO Standard 9614-1, which have also verified that the near-field sound pressure measurements can result in overestimated sound levels. This is thought to be a result of the acoustic reactivity in the near-field of the transformer tank. To improve the accuracy of acoustical measurements of transformers, ISO Standard 9614-2, along with elements from IEC Standards 60076-10 and 60076-10-1 have been employed, and have shown improved results. This paper presents a case study summarizing the complexities and limitations associated with near-field sound measurements of transformers, and outlines the benefits of sound intensity measurement methods and offset sound pressure measurement methods.

Tuesday 08:40-09:00, Hall Lugger, Paper 0162 (contributed)
Troge Jan
Simulation of the 3D Sound Propagation and Radiation of a Railway Air Conditioning Unit based on Transfer Matrix Techniques

Troge Jan[1], Starobinski Rudolf[2], Drossel Welf-Guntram[1], Kunze Holger[1], Knöfel Björn[1], Linke Moritz[1]

[1] Fraunhofer Institute for Machine Tools and Forming Technology, Germany
[2] Silencers. Consulting and engineering, Germany

The air conditioning unit (AC unit) is one of the major sound sources for exterior and interior noise of a railway vehicle. The design of such devices is a compromise between main functions like efficiency, fluid mechanics, thermodynamics and acoustics. Especially 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. For this purpose 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 an 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 and noise reduction.

Tuesday 09:00-09:20, Hall Lugger, Paper 1208 (contributed)
Laursen Jens Elgaard
Proficiency tests on noise from toys

Laursen Jens Elgaard
DELTA, Denmark

This paper describes Round Robin measurements on noise from toys involving 10 different laboratories in Europe and China. This proficiency test, conducted in 2010-2011, was arranged in collaboration between the Danish technical institute DELTA as peer review laboratory and SP Technical Research Institute of Sweden as project leader. The test involved 12 different toy specimens and a reference sound source to be measured according to a draft proposal of a revision of the acoustic parts of European standard EN 71 – Safety of toys part 1. In this paper the test application and some challenging issues are presented along with selected data from the test. It is generally difficult to take into account the fact that the test specimen becomes worn from use during the process of Round Robin measurements. The participants’ measurements on the reference sound

source can rule out some errors, but problems like operating and mounting the toy can also greatly influence the results.

Tuesday 09:20-09:40, Hall Lugger, Paper 0188 (invited)
Kimizuka Ikuo
Technical challenges for the development of the alternative qualification method of the inverse square law characteristics of hemi-anechoic room intended for sound power determinations

Kimizuka Ikuo[1], Suzuki Masaki[2], Shimoda Kohei[3], Tanaka Kouji[4]

[1] IBM Japan, Ltd., IBM Tokyo Laboratory, Strategy and Operations, Japan
[2] Lenovo Japan Ltd., Quality Development and Assurance, Japan
[3] Fuji Xerox Co., Ltd. International Certification Center, Japan
[4] CANON INC., Physical Properties Evaluation Center, Quality Management Headquarters, Japan

The precision method of sound power determination, ISO 3745 specifies, in its Annex A, the qualification method of the test environment. With some technical updates, the 3rd edition of ISO 3745 had been published in March of 2012. In the same month, the more generalized qualification method of free sound field, ISO 26101:2012 had also been published. Based on the method of ISO 26101, the Annex A of ISO 3745 is being revised. In the early stage of ISO 26101 development, it was based on provisions of Annex A of ISO 3745:2003, but, finally it became different in some important aspects; i.e., default test signal type to be pure-tone or discrete-frequencies, rather than broadband noise, and no considerations of acoustic centre offset for test sound source etc. Such a tendency looks very vital for ISO/IEC 17025 accredited test laboratories to comply with IT equipment noise test code, ISO 7779 which relies on ISO 3745 for test room qualification, especially for in-house laboratories of manufacturers applying to environmental labels, such as Blue Angel mark etc. To cope with such situations, JBMIA's sub-working group 3, "Considerations for adequacy of qualification method of HAC inverse-square law characteristics" has been organized, January of 2012. Based on the current views of the SWG3's technical investigations, this paper proposes alternative parameters for free sound field qualification testing.

Tuesday 09:40-10:00, Hall Lugger, Paper 0505 (invited)
Jonasson Hans G.
Some problems with measurement uncertainty and sound emission measurements

Jonasson Hans G.
SP Technical Research Institute of Sweden, Sweden

Round-robin measurements by 10 different laboratories in Europe and China have been carried out on a number of selected toys and a loudspeaker reference sound source. The measurements were carried out using ISO 11201. The measurement uncertainty has been evaluated using both the modeling approach according to the ISO GUM and statistical methods applied on the measurement result as indicated in different standards. Comparing the results of the different methods to estimate the measurement uncertainty gives rise to several fundamental questions which will be discussed in the paper. One of these questions is the definition of repeatability and another one the meaningfulness of different equations in the uncertainty chapters of the latest standards. The problems relate both to sound power and emission sound pressure level determinations.

Tuesday 10:00-10:20, Hall Lugger, Paper 0734 (invited)
Wittstock Volker
Establishing traceability for the quantity sound power

Wittstock Volker, Schmelzer Martin, Bethke Christian
Physikalisch-Technische Bundesanstalt Braunschweig, Germany

Sound power is a main quantity in acoustics. It is the basic descriptor for the sound emission of sound sources and furthermore the basis for all quantities in building acoustics. In spite of this importance, the metrological infrastructure for the quantity sound power is not well developed. Whereas in other areas, like ultrasound, there are standard devices for the realisation of power, such a device is not available in airborne sound. As a result of this, there is no traceability for the quantity sound power at present. In the frame of the European Metrology Research Programme it is now intended to implement a primary realisation of the unit watt in airborne sound which 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.

SS41 Acoustic Metrology

Chair: Fedtke Thomas, Figueroa Salvador

Tuesday 11:00-11:20, Hall Lugger, Paper 0167 (invited)
Olsen Sandermann Erling
Microphone acoustic impedance in reciprocity calibration of laboratory standard microphones

Olsen Sandermann Erling[1], Frederiksen Erling[2]
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Primary calibration of laboratory standard microphones with the reciprocity technique is standardized in international standard, IEC Publication 61094-2:2009. The standard describes how to calculate the acoustical transfer impedance between pairs of microphones mounted in standardized couplers. As stated in the standard, the acoustic impedances of the microphones form an important part of the acoustic transfer impedance of the system. However, the standard only describes how to determine a first approximation of the acoustic impedance expressed as a three-component lumped parameter model with mass, compliance and resistance in series. In this paper it is demonstrated that a better representation of the microphone acoustic impedance is immediately available and that the lumped parameter model is too simple. It is shown that the frequency dependence of the acoustic impedance of the microphones is closely related to the sensitivity of the microphones. Therefore, the frequency dependence can be determined with an iterative procedure, but the absolute level has to be determined separately. The influence on calibration uncertainty of using the improved impedance representation and the determination of the absolute level of the acoustic impedance of the microphones are discussed.

Tuesday 11:20-11:40, Hall Lugger, Paper 0628 (contributed)
Hsiao Jung-En
The works for microphone free-field sensitivity calibration by reciprocity method

Hsiao Jung-En, Kuo Shu-Fen, Liu Yu-Hsiang, Tu Tsung-Hsien
Industrial Technology Research Institute, Taiwan

In order to fulfill the needs of microphone free-filed sensitivity calibration for the customers and participation the key comparison activity for microphone free-field sensitivity, the acoustics standard laboratory of Center for Measurement Standards (CMS) of Industrial Technology Research Institute

(ITRI) in Taiwan has been working on the study of free-field sensitivity calibration technique in recent years. This paper shows how we design the microphone fixtures, sensitivity calculation program, and signal switch box. Furthermore, we present comparison result between free-field sensitivity and pressure sensitivity that already obtained by reciprocity method in coupler over 2.5 kHz to 16 kHz with LS2P microphones. Additionally, the estimation result for acoustic center of microphone is also presented in this paper.

Tuesday 11:40-12:00, Hall Lugger, Paper 1204 (contributed)
Barrera-Figueroa Salvador
Extending the frequency range of free-field reciprocity calibration of measurement microphones to frequencies up to 150 kHz

Barrera-Figueroa Salvador[1], Torras-Rosell Antoni[1], Jacobsen Finn[2]

[1] DFM A/S Danish National Metrology Institute Matematiktorvet, Denmark, [2] Acoustic Technolgy, Department of Electrical Engineering, Technical University of Denmark, Denmark

Measurement microphones are typically calibrated in a free field at frequencies up to 50 kHz. This is a sufficiently high frequency for the most sound measurement applications related with noise assessment. However, other applications such as the measurement of noise emitted by ultrasound cleaning machines and failure detection in aeronautic structures require that the sensitivity of the microphone is known at frequencies up to 150 kHz. Another area of particular interest is the investigation of the perception mechanisms of ultrasound. In any of these applications, it is of fundamental importance to establish a well-defined traceability chain to support the measurement results. In order to extend the frequency range of free-field calibration the measurement system and measurement methods must undergo a series of changes and adaptations including the type of excitation signal, techniques for eliminating unwanted reflections from walls, cross-talk, etc. This paper presents the results of an investigation of the calibration of measurement microphones at high frequencies. A strategy for the changes and adaptations to the existing measurement methodologies, and the determination of the microphone parameters is outlined and the results of its implementation are discussed.

Tuesday 12:00-12:20, Hall Lugger, Paper 0295 (contributed)
Takahashi Horonobu
Influence of preamplifier's shield configuration on free-field reciprocity calibration of WS3 microphones for airborne ultrasound

Takahashi Horonobu, Horiuchi Ryuzo
National Institute of Advanced Industrial Science and Technology, National Metrology Institute of Japan (AIST/NMIJ), Japan

The free-field sensitivity of a microphone depends on the geometrical configuration of the housing including preamplifier. The sensitivity also depends on stray capacitance inside the microphone and preamplifier. Thus IEC standards provide that the preamplifier shall be inserted into a long cylinder with same diameter as the microphone and shall satisfy requirements on the ground-shield configuration used for the mechanical attachment to the microphone. Practically, other shield configuration called "driven-shield" is often used for general acoustical measurements because it can obtain larger preamplifier output voltage than the ground-shield. Most of preamplifiers commercially available have the same outside diameter as WS1 or WS2 microphones. Thus these microphones can be directly connected to preamplifiers without any adaptor. However, WS3 microphone has to be connected to the preamplifier via microphone adaptor to compensate for the diameter difference. Under such conditions, the free-field sensitivity unexpectedly decreased as frequency became higher. In this paper, we assumed that this phenomenon is caused by the shield configuration of the preamplifier and investigated the reason theoretically by circuit simulator and experimentally by electrostatic actuator. As a result, it was revealed that this phenomenon is observed when the microphone adaptor is used and especially at high frequencies.

Tuesday 12:20-12:40, Hall Lugger, Paper 0689 (contributed)
Milhomem Thiago Antônio
Determination of the reciprocity factor for microphones primary calibration in a diffuse field

Milhomem Thiago Antônio, Martins Defilippo Soares Zemar, Portugal Pinto Carolyne
Inmetro – Laboratory of Electroacoustics, Brasil

This paper will present the first results of the first step of the implementation in Inmetro, national metrology institute in Brazil, of microphones primary calibration in a diffuse field. The first step is the determination of the

reciprocity factor while the second, the determination of the electrical transfer impedance. This paper will present the reciprocity factor, the procedures adopted for its determination and the results finds. In this work was used a small reverberation chamber. To determine the reverberation times was used swept sine as excitation signal and was measured the impulse response which has been processed to obtain the reverberation times. The measurements were made for different positions of sound source and for different positions of microphone. The chamber's volume was calculated from measurements of its dimensions and the density of air and the speed of sound in air were calculated from normalized equations and measurements of environmental conditions.

Tuesday 14:00-14:20, Hall Lugger, Paper 0552 (invited)
Nabuco Marco
Estimation of measurement uncertainty for air conduction audiometric testing

Nabuco Marco[1], Fontes Viviane[2], Soalheiro Marcia[3], Soares Zemar[4]

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Audiometric tests are widely used in Brazil to identify noise induced hearing losses, routine examination to support otolaryngology diagnoses and to design appropriate hearing aids. It can be very complicated to estimate uncertainties in such areas once it involves human sensitivity. In Brazil all audiometric tests shall follow the ISO 8253-1 requirements, which, in turn, refer to ISO Guide 98-3 for the expression of uncertainty in measurement. According ISO 8253-1 seven input quantities should be considered to estimate the uncertainty for hearing threshold level measurements. The contribution due some of those input quantities for total uncertainty was estimated from audiometric data obtained during an experimental investigation involving fifteen subjects, each of them tested six times during three days, in the morning and afternoon. A second trial of measurements was performed in live room with highly absorbent foam placed on all surfaces to reduce the reverberation and also background levels, which remained below ISO requirements. Again each of five subjects were tested six times for repeatability estimation. The last test checked the influence of operator/subject headphone fitting.

Tuesday 14:20-14:40, Hall Lugger, Paper 0797 (contributed)
Lavergne Thomas
Universal ear simulator: Specifications and artificial ear canal design

Lavergne Thomas[1], Rodrigues Dominique[1], Neimanns Vera[2], Sandermann Olsen Erling[3], Barham Richard[4]

[1] Laboratoire National de Métrologie et d'Essais (LNE), France, [2] Physikalisch-Technische Bundesanstalt (PTB), Germany, [3] Brüel and Kjær Sound & Vibration (BKSV), Denmark, [4] National Physical Laboratory (NPL), UK

Nowadays, newborn hearing screen programmes are used widely for early identification of hearing disorders enabling effectiveness of treatment to be enhanced. However, ear simulators underpinning traceability in such measurements are currently only suitable for adults. One objective of the EMRP EARS Project is to design a universal ear simulator that can be adapted to adults, children and newborns. The purpose of the presented work is to specify the ear simulator requirements. These arises from key physiological parameters relating to ears and hearing gathered from literature, for newborns, children and adults. In fact specifications for five target age groups have been established. The need for a universal occluded ear simulator for the calibration of insert earphones and probes has also been identified. This confirms expectations of hearing specialists consulted by means of a questionnaire. The specifications include geometric details of the ear canal for each age group. The basis of the proposed design for the artificial ear canal is to use a duct of geometry close to the real ear geometry in order to reproduce the transfer acoustic impedance of the ear canal as accurately and simply as possible. Details of this are discussed. Further study will deals with designing additional components to match the input impedance of the ear canal.

Tuesday 14:40-15:00, Hall Lugger, Paper 0794 (contributed)
Rodrigues Dominique
Methodology of designing an ear simulator

Rodrigues Dominique[1], Lavergne Thomas[1], Fedke Thomas[2], Sandermann Olsen Erling[3], Barham Richard[4], Durocher Jean-Noël[1]

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Several artificial ears have been developed over the last 80 years. However, to our knowledge, no existing document theorizes the entire methodology of its design. In the literature, the key parameter usually considered for its design is the input acoustic impedance of the ear canal. In a Brüel & Kjær document (1976), the significance of parameters such as the acoustic transfer impedance as well as the acoustic impedance of the sound source are first-time discussed, however without providing demonstration. Based on this discussion, a modelling of the ear canal coupled with a sound source is used to emphasize the key parameters of the ear simulator design, in order to provide a design methodology of an artificial ear. Using this modelling and the typical dispersion of the geometrical dimensions of the adult ear canals, a calculation by a Monte Carlo method is provided. This calculation leads to an estimation of the typical errors that occurs when using audiological screening device, such as an audiometer, which has been previously calibrated with the concerned ear simulator. Finally, a methodology of designing an ear simulator resulting from this study is provided. (This work is part of the EMRP Project HLT01 EARS)

Tuesday 15:00-15:20, Hall Lugger, Paper 1105 (invited)
Hof Christian
Traceability in bone conduction audiometry

Hof Christian
Federal Institute of Metrology, Switzerland

The hearing ability of persons can be objectively tested by means of audiometry. Thereby the persons' response to sounds of known levels is compared with tabulated values from otologically normal persons. To generate such known sounds an audiometer equipped with calibrated headphones or a calibrated free field facility is needed. As a result, a hearing loss may be assessed and quantified. In order to identify the medical condition causing a hearing loss, complementary measurements are needed. Bone conduction allows one to stimulate the inner ear directly. If carried out at defined levels, audiologists can discriminate between conductive and sensorineural hearing losses. Calibrations of bone conductors are crucial for these measurements to provide meaningful results. They have to be performed under equivalent mechanical loads as presented by typical human heads. This is achieved with artificial mastoids, the properties of whose have been specified in a standard (IEC 60318-6:2007) for several decades (since 1971). Unfortunately, the specification of the standard includes implicitly the physical properties of a testing device (impedance head) which is no longer commercially available. This situation is conceptually disturbing and will lead to problems for conformance testing in the future.

Tuesday 15:40-16:00, Hall Lugger, Paper 0376 (invited)
Soares Zemar
Influence of the Sound Sources in the calibration of Sound Level Meters

Soares Zemar[1], Bondarenco Zajarkievaiech Jorge Enrique[2]

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[2] Total Safety Ltda. - CALILAB (Laboratório de Calibração e Ensaios), Brazil

Sound Level Meters calibration in free field traditionally requires the use of anechoic chamber and excitation of the sound source (loudspeaker) with pure tone. This work will present the different uncertainties of calibration related to different sound sources, where the shape/geometry of these sound sources diverges both dimensionally and in its configuration. The measurements were performed using swept sine, time-selective technique (TST) and Fast Fourier Transform (FFT) to obtain the frequency response of the Sound Level Meter (SLM) in simulated free-field. The main component evaluated to estimate the expanded uncertainty was the *rms Deviation* that aims to quantify the deviation from the inverse distance law (1/r) for sound pressure. This article will also show that it is possible to obtain the frequency response of Sound Level Meters at low frequencies using the time-selective technique.

Tuesday 16:00-16:20, Hall Lugger, Paper 0704 (invited)
Bjor Ole-Herman
Calibration of microphones by comparisons

Bjor Ole-Herman
Norsonic AS, Norway

Pressure sensitive microphones may be tested and calibrated by measuring the response when the microphones are exposed to a known sound pressure either in a closed coupler or in an open field, – or alternatively to a virtual pressure created by electrostatic forces if the diaphragm is a conductor. The paper describes calibration of WS2 microphones for obtaining the free-field response. A fast exponential sweep, covering the frequency range of interest, is used for the excitation. A virtual free-field condition is created by signal

processing of the received response. In addition to removal of reflections, the signal processing also greatly reduces the effects of distortion in the excitation signal. The standard deviations in repeated measurements are calculated to show repeatability.

Tuesday 16:20-16:40, Hall Lugger, Paper 0416 (contributed)
Metzger Jochen
Simultaneous calibration of all three acoustic particle velocity components of a pressure-velocity probe

Metzger Jochen, Kaltenbacher Manfred
Vienna University of Technology Wiedner, Austria

The precise calibration of acoustic particle velocity sensors in pressure-velocity (p-v) probes is still a great challenge and not fully solved, since no standardized reference sensor exists. Current available techniques does not allow for simultaneous calibration of all three components of the particle velocity sensor. Furthermore, most of the available calibration procedures require anechoic conditions and guarantee the calibration just for a restricted frequency range. Therefore, we propose an advanced calibration technique for such p-v probes, which has the following properties: (1) simultaneous calibration of all three components of the particle velocity sensor; (2) does not need any anechoic conditions; (3) is not restricted to a specific frequency range. Thereby, the p-v probe is exposed to a sound field generated by a vibrating piston. The surface velocity of the piston itself is characterized over the whole frequency range by a laser vibrometer. This technique allows us to simultaneously calibrate all three components of the particle velocity sensor, if the azimuth and elevation angles are known. The advanced calibration technique for a three dimensional p-v probe is evaluated by showing first results and comparisons with the nominal correction curves specified by the manufacturer.

Tuesday 16:40-17:00, Hall Lugger, Paper 0166 (contributed)
Tsuei Kuang-Yih
Research on calibration technology for reference sound source and its application

Tsuei Kuang-Yih, Kuo Shu-Fen, Lu Yih-Ming, Liu Yu-Hsiang, Hsiao Jung-En
Center for Measurement Standards, Industrial Technology Research Institute 321, Taiwan

Reference sound source has the features of producing a stable output of sound power with wideband frequency. Because this sound source mainly determines the noise emissions of physically stationary sound source or can estimate the correction factor for an acoustic environment, the accuracy of its output power is very significant. This paper describes how to estimate the environment conditions of a calibration area, following ISO 6926 standard, to establish the calibration technology for the sound power level of the reference sound source with measurement frequency range from 100 Hz to 20 kHz. The effects of the environmental correction factors under different chambers and measurement surfaces are also discussed. Through this processes of establishing the calibration technology for a reference sound source, the national traceability can be offered.

Tuesday 17:00-17:20, Hall Lugger, Paper 1251 (contributed)
Cho Wan-Ho
Report on the calibration results of pressure sensitivity of WS2P microphones measured at the uncontrolled environmental conditions

Cho Wan-Ho, Suh Jae-Gap, Kwon Hyu-Sang, Suh Sang-Joon
Korea Research Institute of Standards and Science, Korea

The effect of environmental condition on the pressure sensitivity of WS2P microphones cannot be avoided, therefore compensation by the statistically estimated parameters measured under controlled environmental conditions has to be applied to make it the result at the standard environmental conditions. In this study, it is reported that the sensitivity of condenser microphones calibrated during several years by the comparison method based on the IEC 61094-5 under the laboratory environmental conditions. With the results, the relation between the sensitivity and the environmental conditions was investigated and it compared with the compensation parameters suggested in IEC 61094-2. Generally, the effect of relative humidity on the microphone sensitivity was relatively small, in comparison with the other environmental effects, static pressure and temperature. However, some measurement data show that the relatively high correlation between the sensitivity of microphones and the relative humidity after applying the compensation for standard temperature and static pressure condition. This result shows that the relative humidity can be an important environmental condition according to microphone type.

SS38 Sound Visualization and Aurealization

Chair: Rindel Jens, Ich Jeong Guon

Tuesday 08:20-08:40, Hall Aalborg, Paper 0076 (contributed)
Xiang Shang
Inverse patch transfer functions based nearfield acoustic holography with dual layer pressure measurements

Xiang Shang, Jiang Wei-Kang, Wu Tianxing
Institute of Vibration, Shock & Noise, School of Mechanical Engineering, Shanghai Jiao Tong University, China

The dual layer pressure measurements and the Green's function with evanescent wave expansion were suggested in the inverse patch transfer functions (iPTF) based nearfield acoustical holography (NAH), by which neither an anechoic chamber nor a sound field separation technique was necessary. An enclosing measurement surface containing no internal source was predefined in order to remove the influences from reflective waves or other sources outside the cavity. With the Euler's equation and finite difference approximation, normal velocities and pressure on the boundary can be evaluated by dual layer pressure measurements without using pressure-velocity (p-u) probes. This paper first gave the theoretical derivation of the iPTF method and then discussed the selection of Green's function expansions, which would affect the reconstruction error significantly. Experiments were performed to verify the method. The normal velocities of two baffled loudspeakers generating 500-Hz sinusoidal signals were reconstructed by simulation and experiment respectively in the presence of coherent sources. The precise location of sources and small reconstruction error indicated that the presented method is applicable to NAH reconstruction in the presence of reflection and other noise sources.

Tuesday 08:40-09:00, Hall Aalborg, Paper 0339 (contributed)
Tiana-Roig Elisabet
Towards an enhanced performance of uniform circular arrays at low frequencies

Tiana-Roig Elisabet[1], Torras-Rosell Antoni[2], Fernandez-Grande Efren[1], Jeong Cheol-Ho[1], Agerkvist Finn T.[1]

[1] Acoustic Technology, Dep. Electrical Engineering, Technical University of Denmark, Denmark
[2] DFM, Danish National Metrology Institute, Denmark

Beamforming using uniform circular arrays of microphones can be used, e.g., for localization of environmental noise sources and for conferencing. The performance depends strongly on the characteristics of the array, for instance the number of transducers, the radius and whether the microphones are mounted on a scatterer such as a rigid cylinder or a sphere. The beamforming output improves with increasing frequency, up to a certain frequency where spatial aliasing occurs. At low frequencies the performance is limited by the radius of the array; in other words, given a certain number of microphones, an array with a larger radius will perform better than a smaller array. The aim of this study is to improve the performance of the array at low frequencies without modifying its physical characteristics. This is done by predicting the sound pressure at a virtual and larger concentric array. The propagation of the acoustic information captured by the microphones to the virtual array is based on acoustic holography. The predicted pressure is then used as input of the beamforming procedure. The combination of holography and beamforming for enhancing the beamforming output at low frequencies is examined with computer simulations and experimental results.

Tuesday 09:00-09:20, Hall Aalborg, Paper 0612 (invited)
Ih Jeong-Guon
Acoustic source localization by using twisted double-module 3D intensity array

Ih Jeong-Guon, Woo Jung-Han, Cho Sung-Kyu
Center for Noise and Vibration Control (NoViC), Department of Mechanical Engineering Korea Advanced Institute of Science and Technology, Korea

Number of microphones and spacing are most important factors to determine the precision of source localization using the microphone. Conventional broadside and end-fire arrays are well established, but the technique is somewhat disadvantageous in system size and number of sensors. In this work, a twisted double-module 3D intensity array system is suggested to overcome the aforementioned limit. A 3D intensity vector indicating the bearing angle is estimated using a set of four microphones arranged in a tetrahedron. Because a microphone in the apex is used in common for two modules in tetrahedral configuration, number of microphones and size are reduced. This double module system, sharing the same geometric center, provides more intensity vectors compared to a single 3D probe. The array produces the overdetermined data due to 12 different vectors in seeking the source direction. The 3D intensity vector at the center is calculated by the Taylor series expansion. For an array having

45 mm in spacing, experiments are conducted for the performance of angle detection by varying the bearing angle. It is observed that the average error of all bearing angles in azimuth and elevation directions are less than 2° with the proposed array system.

Tuesday 09:20-09:40, Hall Aalborg, Paper 0700 (contributed)
Torras-Rosell Antoni
Reconstruction methods for sound visualization based on acousto-optic tomography

Torras-Rosell Antoni[1], Lylloff Oliver[2], Barrera-Figueroa Salvador[1], Jacobsen Finn[2]

[1] DFM, Danish National Metrology Institute, Denmark
2 Acoustic Technology, Dep. of Electrical Engineering, Technical University of Denmark, Denmark

The visualization of acoustic fields using acousto-optic tomography has recently proved to yield satisfactory results in the audible frequency range. The current implementation of this visualization technique uses a laser Doppler vibrometer (LDV) to measure the acousto-optic effect, that is, the interaction between sound and light, over an aperture where the acoustic field is to be investigated. By identifying the relationship between the apparent velocity of the LDV and the Radon transform of the acoustic field, it is possible to reconstruct the sound pressure distribution of the scanned area using tomographic techniques. The filtered back projection (FBP) method is the most popular reconstruction algorithm used for tomography in many fields of science. The present study takes the performance of the FBP method in sound visualization as a reference and investigates the use of alternative methods commonly used in inverse problems, e.g., the singular value decomposition and the conjugate gradient methods. A generic formulation for describing the acousto-optic measurement as an inverse problem is thus derived, and the performance of the numerical methods is assessed by means of simulations and experimental results.

Tuesday 09:40-10:00, Hall Aalborg, Paper 0888 (invited)
Rindel Jens Holger
The use of colors, animations and auralizations in room acoustics

Rindel Jens Holger, Christensen Claus Lynge
Odeon A/S, Scion DTU, Denmark

The use of computer models for acoustical design of auditoria takes advantage of visualization and auralization for several purposes, some of which will be presented. The sound absorption characteristics of materials can be visualized by the use of colors of surfaces in a 3D room model. Calculation results displayed as color maps in a grid can give a quick overview of complicated conditions of sound distribution, including the display of acoustical parameters for noise level, sound strength, clarity, echo etc. The dynamic picture of a wave front with thousands of balls emitted from a source and reflected in a room has proven to be a useful tool to understand complicated conditions of sound reflection. Using auralization dynamic phenomena like reverberance, echo, and flutter echo can be auralized by listening to a hand clap. Coloration is another phenomenon that may be auralized by listening to white noise. The multisource auralization of a symphony orchestra where each single instrument has been modeled and auralized is a new technique which has opened for a detailed evaluation of the balance and blend due to reflecting surfaces near the orchestra.

Tuesday 10:00-10:20, Hall Aalborg, Paper 0515 (invited)
Peter Martin
Visualization of low frequency sound fields in rooms

Peter Martin
applied acoustics GmbH, Switzerland

In room acoustic design and analysis the low frequency behavior is an important quality criterion. Especially in small rooms, where the Schroeder frequency lies high above the limits of electroacoustic reproduction systems, the discrete eigenfrequencies of the room are crucial for the frequency response at a listener position. For about five years a software tool has successfully been used in the design process and for the analysis of studios and other rooms for high quality reproduction and recording of sound material. The approach focuses on the practicability of the modeling and the visualization of room modes. Therefore the method uses simplified boundary conditions, which also allows for a high uncertainty of input data and a largely varying level of detail in the planning process. An overview of the method and its implementation is given. The limitations of the tool and accuracy issues due to the necessary simplifying assumptions are being referred to. Measurements carried out for a recent project are evaluated in that regard, attempting a better estimation of these limitations. Exemplary samples of the application for the design of new studios and the analysis of problematic existent facilities are described.

SS39 Active Noise and Vibration Control

Chair: Lu Jing, Akhtar Muhammad Tahir

Tuesday 11:00-11:20, Hall Aalborg, Paper 0918 (contributed)
Vau Bernard
Improved multichannel attenuation of time varying narrow band noise using Youla-Kucera parameterized filters – Algorithms and Applications

Vau Bernard
IXBLUE S.A.S, France

Noise reduction in a vehicle compartment is a major issue that is increasingly achieved by active control techniques. In many applications, narrow bands disturbances are present (i.e. car booming noise, aircraft turboprop noise). This paper presents a novel multichannel feedback algorithm for attenuation of a narrow band noise that includes a linear time invariant (LTI) central controller interconnected with a Youla-Kucera infinite impulse response filter. Youla-Kucera filter gains are scheduled depending on noise frequency (that is supposed to be provided).Level of rejection and frequency wideness is easily tunable, and algorithm robustness with respect to uncertainty on the model of transfer functions between loudspeakers and error microphones can be easily assessed during a design stage. This is an important advantage compared to FXLMS or adaptive notch filter algorithms. Experimental tests performed on multichannel systems with two loudspeakers and two error microphones (in a configuration close to that of vehicle compartment) give excellent rejection performances for either fixed or varying noise frequency. Furthermore the robustness with respect to model uncertainty and low complexity of this approach makes this control law a good candidate for industrial implementation.

Tuesday 11:20-11:40, Hall Aalborg, Paper 0278 (invited)
Nishimura Masaharu
ANC with multi-channel wave synthesis method (Phase 2: Experiments in real sound field)

Nishimura Masaharu[1], Maeda Shotaro[1], Sakurama Kazunori[1], Shigeki Kenji[2]

[1] Tottori University, Japan
[2] Loarant Co. Ltd., Japan

It is strongly required to reduce noise at moving persons' ears in a noisy room by some active noise control (ANC) techniques. In the case of using fixed secondary sources, an ordinary feed forward ANC is difficult to apply for this purpose because it needs the online system identification of the error paths. On the other hand, Wave Synthesis (WS) method is useful because it doesn't need the above system identification, even though it is only applicable for periodic noise. In our previous paper, Multi-channel Wave Synthesis Method has been proposed and its usefulness has been proved by some simulations and simple experiments using electrical circuits. In this paper, a dual channel WS algorithm was installed to a DSP controller and its noise reducing performance was examined experimentally in a real sound field. The system could reduce periodic noise remarkably even if the error points were moving in certain conditions. However it became unstable in other conditions. The difference between these conditions is discussed in this paper.

Tuesday 11:40-12:00, Hall Aalborg, Paper 0641 (invited)
Murao Tatsuyae
Basic study on active acoustic shielding: phase 5 improving decentralized control algorithm to enlarge AAS window

Murao Tatsuyae, Nishimura Masaharu, Sakurama Kazunori
Department of Mechanical Engineering, Tottori University, Japan

In this paper, we propose a new control algorithm for Active Acoustic Shielding (AAS)-window to enlarge the window size. AAS is a system that can attenuate the sound passing though an open window. The existing type of AAS window has noise reducing performance of the frequency region between 500Hz and 2 kHz. In our previous works, the AAS window with 4 AAS cells was fabricated and proved to be effective for not only single stable noise source but multiple and moving noise ones. The AAS system is composed of many AAS cells set in an array. Each AAS cell consists of approximately colocated microphone and speaker, and it is individually controlled by a single-channel feedforward method. However, a size of existing type AAS window is 250mm square. Therefore, it is necessary to develop a new control algorism to be useful for a large size window and large number of AAS cells. In this paper, we propose M(1-1)-L' FX-LMS algorism(M: number of AAS systems, L': number of error signals used for controlling one AAS cell). This algorithm is a kind of FX-LMS algorithm, each AAS cell is controlled individually by it's own reference microphone and neighboring error sensors. In this paper, 6 AAS cells is set on rectangular

window (125 x 750mm square) and controlled by 6(1-1)-3' FX-LMS. As a result, this system was proved to be useful to control AAS cells and obtained equivalent noise reduction to previous work over a wide area in the room.

Tuesday 12:00-12:20, Hall Aalborg, Paper 0274 (invited)
Berkhoff Arthur
Tracking and convergence of multi-channel Kalman filters for active noise control

Berkhoff Arthur, van Ophem Sjoerd
TNO Technical Sciences, Acoustics and Sonar, University of Twente, Faculty EEMCS, The Netherlands

The feed-forward broadband active noise control problem can be formulated as a state estimation problem to achieve a faster rate of convergence than the filtered reference least mean squares algorithm and possibly also a better tracking performance. A multiple input/multiple output Kalman algorithm is used to perform this state estimation. To make the algorithm more suitable for real-time applications the Kalman filter is written in a fast array form and the secondary path state matrices are implemented in output normal form. The implementation was tested in simulations and in real-time experiments. It was found that for a constant primary path the Kalman filter has a fast rate of convergence and is able to track changes in the spectrum. For a forgetting factor equal to unity the system is robust, but the filter is unable to track rapid changes in the primary path. It is shown that a forgetting factor lower than unity gives a significantly improved tracking performance. Numerical issues of the fast array form of the algorithm for such forgetting factors are discussed and possible solutions are presented.

Tuesday 12:20-12:40, Hall Aalborg, Paper 0275 (invited)
Berkhoff Arthur
Flat sources for active acoustic shielding based on distributed control of a vibrating plate coupled with a thin cavity

Berkhoff Arthur[1,2], Ho Jen-Hsuan[2]

[1] TNO Technical Sciences, Acoustics and Sonar, University of Twente, Faculty EEMCS, The Netherlands, [2] University of Twente, Faculty EEMCS, The Netherlands

Air cavities between plates are often used to improve noise insulation by passive means, especially at high frequencies. Such configurations may suffer

from resonances, such as due to the mass-air-mass resonance. Lightweight structures, which tend to be undamped, may suffer from structural resonances as well. Active methods have been suggested for improved noise insulation of plates, using piezoelectric patch actuators or inertial mass actuators. Other active methods for improved noise insulation can be based on acoustic control of the sound field in the cavity, using acoustic sources and acoustic sensors. Methods based on feedforward control of the sound radiated from such panels with air cavity usually suffer from an irregular frequency response of the actuators on the radiating panel and insufficient acoustic control authority at low frequencies. This paper presents a method to realize the combination of the air cavity and a radiating surface with a well controlled vibration distribution over the radiating surface. A specific distributed controller results in a smooth and well defined frequency response over a broad frequency range, enabling effective feedforward control of the radiated sound. Experimental results agree with numerical predictions.

Tuesday 12:40-13:00, Hall Aalborg, Paper 1305 (invited)
Zou Yue-Xian
An Efficient Adaptive LMS Virtual Microphone Method for Remote Active Noise Control

Zou Yue-Xian, Yu Y. S.
ELIP/ADSPLAB, School of Electronic Computer Engineering Peking University, China

One of the key techniques of the virtual microphone methods for the remote active noise control (ANC) is to efficiently estimate the optimal mapping vector between the arranged physical microphones (PMs) and the virtual microphone (VM). In this paper, an efficient approach is proposed to estimate the mapping vector between the PMs and the VM at the fixed location in an online manner and the noise control at the virtual microphone is achieved by using the FXLMS algorithm accordingly. Comparing with the existing offline mapping vector estimation approach, the proposed mapping vector estimation method is able to adapt itself to the misplacement of the PMs and variations of the primary sound. This on-line approach is more suitable for the practical remote ANC applications. Simulation results show that the proposed approach can achieve about 3dB improvement compared with that of the offline approach when the location misplacement of the physical microphones are considered.

Tuesday 14:00-14:20, Hall Aalborg, Paper 0292 (invited)
Lu Jing
Analysis of delayless frequency domain adaptive filter for active noise control in noncausal circumstances

Lu Jing, Mao Xin, Zou Haishan, Chen Kai
Institute of Acoustics, MOE Key Lab of Modern Acoustics Nanjing University, China

The frequency domain adaptive filter is superior over the time domain algorithm in computational burden since FFT can be used to calculate the filter output and the frequency domain update terms. For active noise control systems, the delayless frequency domain adaptive filter is preferred due to the critical causal constraint. However, in some application scenarios, even if the latency of the control hardware is kept at minimum, the noncausality of the whole control system is still inevitable. In this paper, the performance of the delayless frequency domain adaptive filter in active noise control system is investigated especially in noncausal circumstances. The analysis result is also validated by some simulations using measured acoustic transfer functions.

Tuesday 14:20-14:40, Hall Aalborg, Paper 0996 (contributed)
Fujii Kensaku
A Method for automatically estimating coefficients of feedback control filter under active noise control

Fujii Kensaku[1], Sakai Tetsuya[1], Iwamatsu Yusuke[1], Muneyasu Mitsuji[2], Morimoto Masakazu[1]
[1] University of Hyogo, Japan, [2] Kansai University, Japan

In this paper, we propose a method for repeatedly updating the coefficients of the feedback control filter used for canceling a feedback path from a loudspeaker to a noise detection microphone. The coefficients are usually estimated by feeding a sequence of extra noise to the loudspeaker. The proposed method can automatically estimate the coefficients without feeding the extra noise. We have already presented a method, called *simultaneous equations method*, based on a different principle from the filtered-x algorithm. The simultaneous equations method automatically estimates the coefficients of the noise control filter cancelling a target noise, called primary noise, without pre-identifying a secondary path from the loudspeaker to an error microphone. The simultaneous equations method can also derive the modified secondary path involving the feedback path and the primary path from the noise detection microphone to the error microphone. The

proposed method estimates, utilizing the modified secondary path, the coefficients of the feedback control filter. In this paper, we show the updating process of the coefficients of the feedback control filter, and verify, using the impulse responses of practical acoustic paths, that the proposed method can estimate the feedback path and can cancel the primary noise without any pre-operations.

Tuesday 14:40-15:00, Hall Aalborg, Paper 1165 (invited)
Jiricek Ondrej
Broadband active structural acoustic control with moment actuator

Jiříček Ondřej, Jandak Vojtěch, Brothánek Marek
Czech Technical University in Prague, FEE, Dept. of Physics, Czech Republic

Sufficient transmission loss of lightweight structures is always a challenge, especially at low frequencies. The paper deals with application of the moment actuator developed at CTU specifically for active structural acoustic control (ASAC) to the double-layer structure consisting of two metal sheets separated by an air gap. The efficiency of the actuators and the entire system were experimentally tested using various noise signals, particularly low-frequency broadband noise. A comparison of results obtained from application of actuators to the incident plate and to the radiating plate of the double layer structure is presented. The 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.

Tuesday 15:00-15:20, Hall Aalborg, Paper 0065 (contributed)
Ma X.L.
Active vibration control of a floating raft isolation system supported by a flexible cylindrical shell structure

Ma X.L., Jin G.Y., Liu Z.G., Zhang S.J.
College of Power and Energy Engineering, Harbin Engineering University, China

As far as the study of vibration isolation system is concerned, most of the previous works are confined to rigid foundations or flexible foundations using beam or plates. However, the study on vibration isolation system supported by a flexible cylindrical shell structure is more of practical significance in some engineering applications, such as submarines. In this paper, active vibration control of a floating raft isolation system coupled with a flexible

cylindrical shell as the foundation structure is studied analytically. A theoretical model of the coupled system is developed and three types of active control strategies including power flow minimization, square acceleration minimization and structural kinetic energy minimization strategy are considered. The optimum control force corresponding to each control strategy is obtained by linear quadratic optimal method. Numerical simulations are conducted and results are presented in detail. Active control performance with different control configurations is analyzed numerically and evaluated in terms of the total kinetic energy of the supporting shell. The effect of the number of actuators when they are used at up-layer and low-layer respectively under different control strategies are compared and discussed. The present results provide some fundamental insight into the effects of control strategies and system configurations on active control performance so that an effective guidance for system design and vibration control can be derived.

Tuesday 15:20-15:40, Hall Aalborg, Paper 0474 (contributed)
Mosquera-Sánchez Jaime A.
A multi-objective optimization procedure for guiding the active sound quality control of multi-harmonic disturbances in cavities

Mosquera-Sánchez Jaime A.[1], Villalba Jesús D.[2], de Oliveira Leopoldo P. R.[1]

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[2] Department of Civil Engineering, Faculty of Engineering, Javerian University, Colombia

The refinement of the sound quality of the engine disturbance perceived in vehicle cavities can be accomplished by means of active control algorithms, oriented by psychoacoustic metrics. Loudness, Roughness and Tonality, as the most regarded metrics in designing sound quality targets for low frequency disturbances, are commonly investigated on an individual basis, which leads to tackle one or some of them, while – possibly - degrading the others. This paper contributes to the design and implementation stages of the sound quality for low-frequency, multi-harmonic disturbances by presenting a multi-objective optimization procedure. The optimization tools correspond to the NSGA-II and SPEA-II algorithms, which have been extensively used in the engineering community for solving problems with conflictive objectives, as is the Loudness/Roughness/Tonality case and its combinations by pairs. Both the NSGA-II's and SPEA-II's operators and parameters are selected from the specialized literature. Computer simulations of the SF-cFxLMS control algorithm implemented over a synthesized internal combustion engine

disturbance show the feasibility of attaining the obtained Pareto frontier solutions, thus demonstrating a complete method for controlled designing and implementing of sound fields in cavities.

Tuesday 15:40-16:00, Hall Aalborg, Paper 0573 (contributed)
Anai Ken
Suitable control position against road traffic noise for active control technique in residential ventilation openings

Anai Ken, Suetsugu Kazutaka, Tsubaki Shintaro
Dep. of Civil Engineering, Faculty of Engineering, Kyushu Institute of Technology, Japan

In this study, active noise control (ANC) is applied to reduce middle-frequency and low-frequency noise entering through residential openings to indoor side. The past experimental results in pilot residences show that ANC effectiveness against the road traffic noise is greater than 7 dB on average at the indoor side. These results demonstrate that humans can recognize the ANC effectiveness by hearing. But it is better for putting this technique to practical use that the ANC performance is more improved for the residences located along trunk roads. In this paper, therefore, a decision method of suitable control position for the situations that controlled targets are road traffic noise is investigated. It is showed in this paper that large effectiveness appears when a control microphone is placed at the point where the sound pressure is large in the opening. This paper also shows that the suitable point is decided theoretically with clarifying previously sound field characteristics of the opening and frequency characteristics of the target noise. It is shown as one of conclusions that the suitable control position is decided with adopting the frequency characteristics of power level of road traffic noise, which is shown in the ASJ (Acoustical Society of Japan) RTN-Model 2008.

Tuesday 16:00-16:20, Hall Aalborg, Paper 0136 (invited)
Zou Haishan
A study of a hybrid pressure-release sound absorbing structure with feedback active noise control system

Zou Haishan, Qiu Xiaojun, Lu Jing, Li Ningrong
Key Laboratory of Modern Acoustics (MoE), Institute of Acoustics, Nanjing University, China

A kind of hybrid pressure-release sound absorption structure is proposed. With this structure, a passive absorption structure including a porous layer and an air layer provides sound absorption at middle and high frequencies, and the low frequency performance of the structure is compensated by a feedback active noise control (ANC) system. The high absorption performance over the whole frequency range may not be obtained with this structure, since the performance in middle and high frequencies may deteriorate due to the waterbed effect of the feedback ANC system. The factors affecting the performance of this structure are analyzed by experiments in a duct, and the difference of the absorption performance in various frequency ranges is discussed.

Tuesday 16:20-16:40, Hall Aalborg, Paper 1048 (contributed)
Hausberg Fabian
Improving the convergence behavior of active engine mounts in vehicles with cylinder-on-demand engines

Hausberg Fabian[1,4], Vollmann Stefan[1], Pfeffer Peter[2], Hecker Simon[3], Plöchl Manfred[4], Kolkhorst Torsten[1]

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[3] Univ. of Applied Sciences, Electr. Eng. and Information Technology, Germany
[4] Vienna Univ. of Technology, Inst. of Mechanics and Mechatronics, Austria

Active engine mounts provide an effective solution to further improve the acoustic and vibrational comfort of passenger cars. The most common strategies to control active engine mounts are adaptive feedforward algorithms such as the filtered-x least-mean-squares (FXLMS) algorithm due to its computational simplicity and ease of implementation. However, such algorithm needs a significant convergence time until full cancellation of the disturbing engine vibration is achieved. This becomes a disadvantage in applications such as cylinder-on-demand (COD) engines, where cylinders and active engine mounts are frequently switched on and off. After briefly introducing a computationally efficient variant of the Narrowband-FXLMS algorithm, this paper proposes a new method to overcome this drawback. The adaptive feedforward algorithm is extended with a look-up table which uses additional engine information to adapt its values to the vibrational behavior of the engine. Since the look-up table is trained online, it is capable to track changes and no prior parameterization is necessary. Finally the new method is experimentally validated in a vehicle with a V8-COD-engine where a significant reduction of the convergence time is observed.

Tuesday 16:40-17:00, Hall Aalborg, Paper 0928 (contributed)
Yang Tiejun
Experimental investigation of active vibration isolation for a diesel engine generator in a harbor tug

Yang Tiejun, Du Jingtao, Zhu Minggang, Liu Xueguang, Liu Zhigang
Institute of Vibration and Noise Control Harbin Engineering University, China

An active vibration isolation system is developed for a diesel engine generator in a floating harbor tug. This system consists of six inertial actuators and a DSP processor. A six-input and six-output adaptive control strategy is applied and the reference input signal comes from an optical tachometer on the shaft of the diesel. Six accelerometers are located on the top of isolators to act as error sensors. A hydrophone is dropped in the sea water to measure the underwater radiation caused by the diesel generator. The active vibration isolation experiment is conducted in the tug boat when only the diesel engine generator is working. The experimental results demonstrate that good reductions are obtained both for vibrations of error sensor's locations and outputs of the hydrophone which is dropped in the water under the hull. Some discussion and conclusions are given at last.

Tuesday 17:00-17:20, Hall Aalborg, Paper 0674 (invited)
Vrbata Jiri
Development of a hardware-in-the-loop test facility for signal processing units with adaptive control algorithms for an automotive application

Vrbata Jiri, Millitzer Jonathan, Mayer Dirk, Röglin Tobias, Bartel Torsten
Fraunhofer Institute for Structural Durability and System Reliability LBF, Germany

A major part 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 supports the engine against rotational movement caused by the angular acceleration of the crank shaft. In a laboratory setup, the torque arm is placed between a shaker and the car's subframe, fixed on a span. The shaker emulates a controlled engine run-up. An inertial mass actuator based on piezoelectric ceramics is attached to the subframe nearby the torque arm aiming to reduce the transmitted vibrations. By means of a multi-order adaptive narrowband controller the performance of the inertial mass actuator in reducing vibration induced into the car body is investigated. The system behavior of the test bed is measured and implemented in a hardware-in-the-loop test facility, which is intended for

use as a test and development environment for signal processing units with adaptive control algorithms for the purpose of active vibration control. The developed hardware-in-the-loop test facility is subjected to a functional test, by comparing its controllability with the one of the real test bed.

Tuesday 17:20-17:40, Hall Aalborg, Paper 0559 (contributed)
Guldenschuh Markus
Identification of secondary-path irregularities for active-noise-control headphones

Guldenschuh Markus[1], de Callafon Raymond[2], Sontacchi Alois[1]

[1] Institute of Electronic Music and Acoustics, University of Music and Performing Arts Graz, Austria
[2] Mechanical and Aerospace Engineering, University of California, USA

Headphones with feedback Active-Noise-Control show a good performance, but bear the danger of instabilities. These instabilities are likely to occur if the headphone is lifted because the transfer function from the loudspeaker to the error-microphone inside the headphone changes abruptly. These changes are most prominent in the low-frequency response. Therefore an18 Hz sinusoid is constantly played-backto detect these changes. The 18 Hz sinusoid cannot be heard by humans and does not influence the noise control. The noise-control is hence unconstrained as long as the headphone sits regularly tight. Once the headphone is lifted, the decrease of the 18 Hz tone can be detected and active-noise control is smoothly turned off. Simulations show that the lifting of the headphone can be detected early enough to prevent instabilities.

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Bös Joachim
LOEWE-Zentrum AdRIA: Latest results of an interdisciplinary research project on active vibration and noise control

Bös Joachim[1], Bein Thilo[2], Hanselka Holger[2]

[1] System Reliability and Machine Acoustics SzM, TU Darmstadt, Germany
[2] Fraunhofer Institute for Structural Durability and System Reliability LBF, Germany

The LOEWE-Zentrum AdRIA (**Ad**aptronics – **R**esearch, **I**nnovation, **A**pplication) 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. Three so-called application scenarios (namely, "adaptive car", "quiet office", and "adaptive tuned vibration absorber") implement and test new methods and tech- nologies that are developed within the nine so-called technology areas (e.g., materials, simulation, sensors and actuators, control strategies, embedded systems, manufacturing). The main purpose of this research project is to increase the marketability of devices for active noise and vibration control by means of a balanced mixture of basic research, applied research, and industrial applications. This paper will give an overview of some recent results and some latest developments of this research project.

TIMETABLE WEDNESDAY

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Chair: McBride David, Fuente Adrian

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SS55 Noise and health related quality of life

Chair: Shepherd Daniel, van Kamp Irene

Wednesday 08:20-08:40, Hall Tirol, Paper 0391 (contributed)
Shepherd Daniel
Sound mind in a sound body: health in the noise context

Shepherd Daniel
AUT University, New Zealand

The World Health Organization (WHO), during its formation in 1948, defined health as “A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”. This definition departed from the prevailing biomedical viewpoints of the time, and in adopting a biopsychosocial approach, health came to mean not only disease, disability, or terminal illness, but also well-being, quality of life, and amenity. At the personal level good health can be facilitated not only by the pursuit of healthy lifestyles (e.g., exercise and diet), but also societally by the provision of restful and restorative environments (e.g., green or quiet areas). A prominent factor determining the restfulness of a living space is the level of privacy and intrusion by pollutants, including smell, air quality, and noise. In assessing the impacts of noise it is important to not only consider the potential of noise to induce poor health, but also its potential to compromise good health. The WHO (2009; 2011) directs that health related quality of life (HRQOL) be used to estimate the impact of noise on health. Such an approach, however, is considered “soft” by many governing bodies, who instead demand that evidence of “serious adverse health effects” be demonstrated in order for noise to be considered in planning or mitigation cases. To this end, “hard” measures involving medical appraisals are often stipulated, constituting a regression to biomedical approaches. This paper discusses current approaches to health, including health-related quality of life, in the noise context.

Wednesday 08:40-09:00, Hall Tirol, Paper 0575 (contributed)
Welch David
The relationship between noise annoyance, amenity and health-related quality of life

Welch David[1], Shepherd Daniel[2], McBride David[3], Dirks Kim[1]

[1] University of Auckland, New Zealand, [2] Auckland University of Technology, New Zealand,
[3] University of Otago, New Zealand

There appears to be a restorative influence of the environment, including enhanced recovery from physiological stress, improvement of health and well-being, and decreased negative affect. Individuals seek out quiet areas with natural surroundings; considered by most to be high amenity zones. Such areas should therefore promote health, but would other aspects of the personal environment also contribute? We tested whether amenity and noise annoyance contributed independently to health in a sample of 789 New Zealanders. Health was estimated using the short version of the World Health Organisation's quality of life tool (WHOQOL). Neighbourhood amenity was operationalised using a combination of questionnaire items about the local environment. Personal environmental amenity: such as feeling safe, having access to information, and having opportunity for leisure was measured by the WHOQOL Environmental Domain. Noise annoyance was measured by items used in our previous research. We measured the association between neighbourhood amenity, noise annoyance and health-related quality of life (HRQOL), and then reanalysed those relationships while controlling for personal environmental amenity. Noise annoyance and neighbourhood amenity were both moderate to weak predictors of all HRQOL Domains (Physical, Psychological, Social and Environmental), and the effects of noise annoyance and neighbourhood amenity were largely independent of each other. Both effects were wholly mediated by personal environmental amenity, suggesting that while these external environmental elements may have some role in personal amenity, other factors are also influential. In summary, personal amenity appeared to explain much of the relationship between noise annoyance and HRQOL but neighbourhood amenity did not.

Wednesday 09:00-09:20, Hall Tirol, Paper 0557 (contributed)
McBride David
A longtitudinal study of the impact of wind turbine proximity on health related quality of life

McBride David[1], Shepherd Daniel[2], Welch David[3], Dirks Kim N.[3]

[1] Department of Preventive and Social Medicine, University of Otago, New Zealand, [2] Department of Psychology, School of Public Health, Auckland University of Technology, New Zealand, [3] School of Population Health, The University of Auckland, New Zealand

Background: Wind turbine noise is known to cause annoyance and sleep disturbance, which are primary health effects. An additional risk factor is the trait of noise sensitivity, which describes individuals who are more likely to

pay attention to sound, evaluate sound negatively and have stronger emotional reactions to noise. The result is chronic stress, the effects of which could be monitored through detecting stress related outcomes such as hypertension in exposed individuals. An alternative approach is to monitor health related quality of life (HRQOL). This study examines whether there is a change in this metric over time in a turbine exposed community. Methods: This is a 2 year follow up of a base-line survey carried out on individuals living within two kilometres of industrial wind turbines compared with a matched control group[1]. We have repeated the self administered questionnaire survey in which self-reported HRQOL was measured using the abbreviated version of the WHOQOL-BREF. Results: The base-line survey found that residents living within 2 km of a turbine installation experienced significantly lower overall quality of life, physical quality of life, and environmental quality of life than a control group. The turbine group showed no change in WHOQOL or amenity scores with time, however compared to the 2012 control group, the turbine group had lower physical domain scores, and rated their overall health as being poorer. The results do not therefore support any improvement in this global health metric with time.

Wednesday 09:20-09:40, Hall Tirol, Paper 0905 (contributed)
Dirks Kim N.
Annoyance to traffic noise and annoyance to air pollution: an orthogonal or co-varying relationship in noise-sensitive individuals?

Dirks Kim N.[1], Shepherd Daniel[2], Welch David[1], McBride David[3]

[1] School of Population Health, The University of Auckland, New Zealand, [2] Department of Psychology, School of Public Health, Auckland University of Technology, New Zealand, [3] Department of Preventive and Social Medicine, University of Otago, New Zealand

Noise-sensitive individuals can be described by two key characteristics. Firstly, they are more likely to pay attention to sound and evaluate it negatively (e.g. as threatening or annoying). Secondly, they have stronger emotional reactions to noise, and consequently, greater difficulty habituating. It has been noted that noise sensitivity correlates with negative effect, a dispositional tendency to negatively evaluate situations and the self. Individuals high in such traits are more likely to report negative features for their environment, and those reporting high levels of noise sensitivity may report greater sensitivity to other sensory stimuli such as smell and scent, bright light and pain. Research investigating the relationship between noise sensitivity and chemical sensitivity, however, failed to uphold the expected relationship between the two classes of stimuli if a common underlying trait such as negative effect is assumed to cause them. Here we report data which examines the relationship between noise sensitivity and annoyance to noise and air pollution. Our results suggest that noise exposure itself drives annoyances ratings in noise sensitive individuals, and not some other non-noise related factor such as personality.

SS63 Health care acoustics

Chair: Persson-Waye Kerstin

Wednesday 10:00-10:20, Hall Tirol, Paper 0497 (contributed)
Khoo Boo Cheong
On High Intensity Focused Ultrasound (HIFU) for biomedical and dentistry applications

Khoo Boo Cheong[1], Ohl Siew-Wan[2], Klaseboer Evert[2]

[1] Department of Mechanical Engineering, Faculty of Engineering, National University of Singapore, Singapore, [2] Institute of High Performance Computing, Singapore

We study the physical phenomena and the application of HIFU (High Intensity Focused Ultrasound) using simulation and experiment. The experiment was done with a bowl-shaped focused ultrasound system. High speed videos of the generation of cavitation bubbles at the focal point of the HIFU are captured. We observed interesting bubble cloud structures, bubble movements and stationary bubble oscillations. The system is then employed for dentistry applications. Firstly we use the HIFU to drive the antibacterial nanoparticles into the dentinal tubules for disinfection in root canal treatment. Initial results show that the delivery of these nanoparticle deep into the dentinal channels which are a few microns in size. Next we the cultivate E. Faecalis biofilm, a common bacteria colony found in the mouth and teeth, on petri dish and in human tooth. Then we subject them for removal under strong HIFU for a period of time. We obtain positive results in the biofilm removal with the increasing HIFU sonification time. Separately, we simulate the interaction of a bubble with pulsed ultrasound and in an ultrasound field near bio-materials such as fat, muscle and bone. The simulation shows extreme growth and collapse of the bubble under certain conditions. It is found that the formation and direction of the water jet during bubble collapse is highly dependent on the properties of the bio-materials nearby. These studies provide a foundation for better understanding of HIFU and its uses in medical treatment.

Wednesday 11:00-11:20, Hall Tirol, Paper 0895 (invited)
Xie Hui
A comparative study on the hospital acoustic environment in the UK and China

Xie Hui[1], Deng Zhixiao[1], Kang Jian[2]

[1] Faculty of Architecture and Urban Planning, Chongqing University, China
[2] School of Architecture, University of Sheffield, UK

Various noises play an important role in the healthcare environment. This paper aims to compare the acoustic environment in typical general hospitals in the UK and China, through a series of acoustic measurements. The Critical Care Department of Northern General Hospital, UK and 6 different departments (ICU, Obstetrics, Cardiology, Oncology, Orthopaedics and Gynaecology) of Yibin2nd People's Hospital, China were chosen. It has been shown that the RT ranged from 0.25s to 0.83s in the 13 wards of Chinese hospital, whereas less varied RT was obtained in the UK's ICU ward. The longest RT in the Chinese hospital was measured in the single-bed ICU ward, due to its large areas of glass window. The measurements in both UK's and Chinese hospitals revealed the sound level in the wards were in excess of WHO guided level by at least 20dBA. In the Chinese hospital, the SPL of all the studied wards ranged from 57 dBA to 64 dBA, with the quietest in the Gynaecology and the noisiest in the Cardiology.

Wednesday 11:20-11:40, Hall Tirol, Paper 0896 (contributed)
Deng Zhixiao
Evaluation of medical staff and patients on the sound environment in a Chinese hospital based on a questionnaire survey

Deng Zhixiao[1], Xie Hui[1], Kang Jian[2]

[1] Faculty of Architecture and Urban Planning, Chongqing University, China
[2] School of Architecture, University of Sheffield, UK

Noise pollution in hospitals is becoming an increasingly serious concern across the world. Based on a questionnaire survey, the sound environment in 6 departments in a general hospital in China has been investigated from the perspectives of both medical staff and patients. In total, 434 valid questionnaires were collected, including 243 patients and 191 staff. It is shown that equipment alarms are recognised as the most annoying noise in critical care wards, whereas talking is more significant in general wards. Agreed by both patients and staff, acoustic environment is considered as the most important physical environmental factor, compared with temperature, humidity, lighting and air quality. Noises have already affected patients' sleep and staff working efficiency. In particular 43.6% of the patients experienced sleep interruption by noises. It has been shown nurses and doctors are more concerned with noises than patients. There are also significant differences between staff and patients, with regard to the strategies for the improvement of sound environment. Staff in general wards believe reducing the talking level from patients' families might be more effective, while patients recommend more single-bed wards to be designed. Moreover, acoustic treatments and reduction of noise from medical equipment are suggested by ICU staff.

Wednesday 11:40-12:00, Hall Tirol, Paper 0219 (contributed)
Park Munhum
Source-specific analysis of the noise in an intensive care unit

Park Munhum[1], Kohlrausch Armin[1,2], de Bruijn Werner[1], de Jager Peter[3], Simons Koen[3]

[1] Philips Research Laboratories, The Netherlands, [2] Technische Universiteit Eindhoven, The Netherlands, [3] Department of Intensive Care Medicine, The Netherlands

High noise levels in hospitals are often linked to various negative effects on patient outcome and work performance of clinical staff. Despite growing research attention on the adverse acoustic conditions in healthcare environments, few studies offer on-site surveys collected for a relatively long period with a clear description of the measurement protocol, and furthermore, the sources of noise in hospitals are not well documented in the literature. In the current study, the soundscape of an ICU (intensive care unit) room was analysed based on a ~3-day calibrated audio recording, from which acoustic parameters were obtained off-line. In addition, a selected 24-hour recording was annotated, which enabled a source-specific analysis, excluding the patient-generated/-involved contributions. The results showed that the acoustic energy of the noise in this ICU room was attributed to speech and other activities by staff (57%), alarms (30%) and the operational noise of medical devices (13%). In addition, the analysis of the number of loudness peaks showed similar but more uneven proportions: staff (94%), alarm (5%) and device noise (1%). The current study suggests that, to a considerable extent, the noise in ICUs may be attributed to potentially modifiable factors, e.g., staff's speech and activities.

Wednesday 12:00-12:20, Hall Tirol, Paper 0501 (contributed)
van den Bosch Kirsten A.
The role of sound and audible safety in special needs care

van den Bosch Kirsten A.[1], Andringa Tjeerd C.[2], Vlaskamp Carla[1]

[1] Special Needs Education and Youth Care, University of Groningen, The Netherlands
[2] Artificial Intelligence and Cognitive Engineering (ALICE), University of Groningen, The Netherlands

Soundscape research applicable to residential facilities for people with Profound Intellectual and Multiple Disabilities (PIMD) is scarce. The aim of this study is to determine the role of sound for persons with PIMD, because we expect it provides insight into role of audition. We hypothesize that sound is important in developing a sense of a safe place: when the sonic environment does not provide positive indicators of safety, individuals within this environment will not feel safe. Feelings of unsafety and insecurity are likely to play a major role in the onset of problem behavior and thus reduce the quality of life for people with PIMD. To test the validity of this claim, we organized focus groups for PIMD professionals, where we examined whether their latent knowledge corresponded to our theoretical framework. In total 34 professionals attended. Results showed a strong consistency between the knowledge and experience of the professionals and our theoretical framework, indicating that, for people with PIMD, the auditory environment is crucial in determining the answer to the questions "Am I in a safe place?" and "What is happening here?". In addition we conclude that the (re)introduction of positive indicators of safety and soundmarks associated with daily structure, in the environment of people with PIMD, are likely to improve their quality of life.

SS64 Noise policy and economic evalution of noise effects

Chair: van den Berg Martin, Ögren Mikael

Wednesday 12:20-12:40, Hall Tirol, Paper 0881 (invited)
van den Berg Martin
Rise and fall of noise abatement policy in the Netherlands

van den Berg Martin
Ministry of Infrastructure and Environment Den Haag, The Netherlands

It was Pieter Winsemius [1] in his book on environmental management who proposed the life cycle of environment issues. After a phase of exploration in which the problem would be defined and recognized, political focus would rise through the phase of searching for solutions, policy formation, regulation and taking up measures. After that the problem would be under control, and loose political attention when entering the phase of maintenance and control. The phases are well recognizable (with the benefit of hindsight) in the development of noise policy in the Netherlands. The past few years political attention for noise in the political arena was steadily diminishing, and it looks like it will come to a complete halt the next years. But is the problem completely under control? If noise problems cannot be completely solved in a modern society, is there a bottom that can be reached?

Wednesday 12:40-13:00, Hall Tirol, Paper 0263 (invited)
Boegli Hans
Future developments that influence noise abatement policies

Boegli Hans, Walker Urs, Stamatiadis Chrisoula, Fischer Fredy
Federal Office for the Environment FOEN, Switzerland

The Swiss Federal Office for the Environment conducted a study on the anticipated future trends that are of significance in terms of noise abatement. The aim of the study was to provide impulses for the development of future noise abatement strategy. The study identified technological, social, economic and political developments of relevance to noise abatement and described and analysed these megatrends with the aid of the DPSIR model. Attention was exclusively focused on analysing and describing the probable trends over the 40-year timeline. This implies that findings cannot be deduced in a strictly direct manner. In view of this, the conclusions to be drawn from the analyses described are formulated in form of 11 assumptions or hypotheses that are intended to serve as the basis for discussion and provoke

responses and measures. For example Social consensus regarding the concept of noise and quietness will vanish, the need for quiet zones in the close vicinity of home and workplace will rise sharply and - as a result of increasing interaction and mobility - reducing mobility-related noise will continue to be a central aspect of noise abatement policy.

Wednesday 14:00-14:20, Hall Tirol, Paper 0729 (contributed)
Pelša Inga
Issues and perspectives of railway noise management instrument appliance

Pelša Inga[1], Krūkle Zanda[1], Baranovskis Andrejs[2], Žagars Andrejs[3]

[1] Project Management Department of State JSC, Latvia, [2] Riga Technical University, Latvia, [3] Composite Constructions Ltd., Latvia

Railway is considered as important environmental noise source causing significant socio-economic impacts in urban areas and therefore requires efficient noise management solutions. Theoretically, there is set of instruments that can be used for railway noise management; however the suitability of their application is sometimes limited or ambiguous, and may cause imperfections. This research aims to analyze railway noise management in Latvia, identifying imperfections and providing proposals for further improvement. Latvia as a research subject is chosen for several reasons: noise management in Latvia is still developing; the technical parameters of the railway differ from the ones in most EU countries; cargo shipments are transnational and mostly provided by operators from non-EU countries. This limits the possible adaptation of best practice management from other EU member states and determines the need to find specific solutions. The research through analysis of literature and practical studies made on Latvian railways scrutinizes the problems and gives suggestions on the appliance of planning, technical, administrative, economic, and communication instruments in Latvia and countries with similar railway system or issues. The research is made within the LIFE+ project "Innovative solutions for railway noise management" (LIFE11 ENV/LV/376 ISRNM) and is important for its success.

Wednesday 14:20-14:40, Hall Tirol, Paper 0933 (invited)
Andersson Henrik
Pricing of noise externalities

Andersson Henrik[1], Ögren Mikael[2]

[1] Toulouse School of Economics (UT1C, CNRS, LERNA), France, [2] The Sahlgrenska Academy at the University of Gothenburg,Occupational and Environmental Medicine, Sweden

The marginal cost of railway noise can be estimated using the standardized and well established methods for predicting noise levels from railway traffic together with valuations of noise exposure based on hedonic regression. Previous research in this area has been limited to very simplified approaches or estimates for small areas. The research presented here apply the method for the complete railway network in Sweden using data on traffic flows (including speed limits), population distribution and acoustic emission data for individual train types at different speeds. The results for a reference 500 meter long freight train is on average 3.6 SEK/km, but show large variations over the network explained mainly by the large variations in population density close to the track. It is necessary to include similar variations in a charging system in order to gain the full benefits of internalizing the noise cost.

Wednesday 14:40-15:00, Hall Tirol, Paper 0100 (invited)
Thanos Sotirios
Non-linearities, stigma and self-selection influencing the values of noise nuisance

Thanos Sotirios[1], Bristow Abigail L.[2], Wardman Mark R.[3]

[1] Institute for Housing, Urban & Real Estate Research, Heriot-Watt University, UK
[2] Transport Studies Group, Dep. of Civil and Building Engineering, Loughborough University, UK
[3] Institute for Transport Studies, University of Leeds, UK

The value of noise is often estimated as a constant percentage of house price depreciation per decibel of noise. We examine this assumption and determine to what extent self-selection influences noise values from spatial Hedonic Pricing (HP) and Stated Choice (SC) approaches, exploring key aspects of noise valuation, such as non-linearities, thresholds and stigma. The HP models show non-linear house price depreciation per decibel of aircraft noise, increasing from 0.40% per decibel at 45 decibel to 2.38% at 75 decibel. HP models applied after the total removal of aviation noise show one specific area, with significantly higher long-term exposure to aircraft noise, to be subject to

noise “stigma” or unalleviated noise depreciation. SC noise values in the same “noisy” area are considerably lower than neighbouring areas, attributed to self-selection and the resulting higher noise tolerance of local residents. The HP results show that the housing market does not reflect this increased noise tolerance of the residents. However, the nonlinearity of the HP noise values reflects the self-selection effects for observations with high aviation noise, and self-selection can also remain as a localised stigma after the removal of the effect. These findings have implications for stated preference applications and the representation of noise costs in policy.

Wednesday 15:00-15:20, Hall Tirol, Paper 0962 (invited)
George Frank
Public Health and Economic Burden of Environmental Noise

George Frank, Héroux Marie-Eve, Fong Kelvin
World Health Organization, Regional Office for Europe, European Centre for Environment and Health, Germany

The health impacts of environmental noise (EN) are a growing concern among both the general public and policy-makers in Europe. In 2011, the World Health Organization (WHO) Regional Office for Europe and the Joint Research Centre (JRC) of the European Commission, published the report “Burden of Disease from Environmental Noise”, which quantified the healthy years of life lost in Europe due to EN. The burden of disease combines in one measure the time lived with disability and the time lost due to premature mortality in the general population. Sufficient information is available to quantify the burden of disease from EN for effects such as ischemic heart disease, cognitive impairment of children, sleep disturbance, tinnitus and annoyance. These results indicate that at least one million healthy years of life are lost every year from traffic-related noise in the western part of Europe. Based on the estimates, expressed in terms of disability-adjusted life-years (DALYs), economic methods such as stated preferences by a “willingness to pay” (WTP) study could be used to provide estimates of welfare economic costs of the health effects related to environmental noise. In the absence of any research or survey - known to WHO – which has applied such an economic estimation methodology specifically for the burden of EN we propose as an estimate of the magnitude of the economic burden the application of a generic and hence debatable Value of a Statistical Life Year (VSLY) as used in other studies by the EC, OECD and others. Being aware of the shortcomings and restrictions of

this approach we recommend and support future research in monetizing the health effects of the burden of environmental noise.

Wednesday 15:20-15:40, Hall Tirol, Paper 0214 (invited)
Urban Jan
Linking traffic noise, noise annoyance and life satisfaction

Urban Jan, Máca Vojtěch
Charles University in Prague, Environment Center, Czech Republic

This study explores the link between traffic noise and overall life satisfaction. While the negative relationship between residential satisfaction and traffic noise is relatively well established, much less is known about the effect of traffic noise on overall life satisfaction. We hypothesize that the relationship between traffic noise levels and life satisfaction is mediated by noise sensitivity, noise annoyance and residential satisfaction so that the direct relationship between noise exposure and life satisfaction may be actually attenuated. The empirical model is tested using structural equation modeling that allows for inclusion of latent variables that are measured by observed ordinal indicators. Our study exploits data on a sample of respondents living in areas with high road-traffic noise and another sample of respondents living in areas exposed to high levels of rail-traffic noise. We find that traffic noise has a negative effect on residential satisfaction, but no significant direct or indirect effects on overall life satisfaction. Noise annoyance due to road and rail traffic noise has strong negative effect on residential satisfaction rather than on overall life satisfaction. These results are very similar for the road and railway traffic contexts and regardless of whether the model assumes the top-down or bottom-up direction of the causation between life satisfaction and residential satisfaction. Extended analysis of personal and home characteristics does not reveal explanation of the missing link or evidence that disadvantaged and noise-sensitive people are left behind in noise areas.

Wednesday 15:40-16:00, Hall Tirol, Paper 0867 (contributed)
Wolfert Henk
Motor Vehicle Noise a mirage that should be considered as unparalleled

Wolfert Henk
DCMR EPA, The Netherlands

Noise generated by motor vehicles is the main course of the noise burden in Europe. To reduce the noise measures are needed at multiple level. By the European Commission action was taken by means of issuing the revision of directive 70/175/EEC. In this directive the noise of four wheeled motor vehicles is addressed. The latest modification of this directive has been in 1995, almost 20 years ago. However, this modification has not lead to lower noise by vehicles. Main reason would be the test method that was quite different to real driving conditions. The revision of the directive, as meant in the Commissions' proposal of 9 December 2011 (COM)2011/856, was scrutinised by Working Group Noise EUROCITIES. After finalising the proposal of the Commission the dossier has been proceeded to the European Parliament. The Committee for Environment, Public Health and Food Safety (ENVI) was responsible for reporting on this dossier. Other committees have been involved as well, like the parliamentary committees on Transport & Tourism (TRAN) and Internal Market and Consumer Protection (IMCO). In this paper an overview of the process and some general and specific remarks from the cities perspectives.

SS10 Railway induced Vibrations and Vibration induced Airborne Noise

Chair: Egger Adrian, Unterberger Wolfgang

Wednesday 08:20-08:40, Hall Innsbruck, Paper 0795 (invited)
Steinhauser Peter
Railway induced vibrations and structure borne noise – requirements for abatement

Steinhauser Peter
Steinhauser Consulting Engineers ZT-GmbH, Austria

Vibrations belong to the most disturbing environmental burdens of railways. While prediction and abatement of noise are well established techniques, vibration abatement is causing problems. This is due to the multiple feedback system between train, track, geodynamics of the underground and the dynamic behaviour of buildings. Effective measures for vibration abatement can be taken only at the track (ballast mats, floating slabs etc.). Therefore reliable vibration forecasts are necessary before building the track, especially for shallow sections of new railway tunnels in residential areas. Structure borne noise is thereby often the major source of annoyance. But characteristics of train vibration, as well as of the local geodynamics and the dynamic behaviour of buildings, own extreme bandwidths. These spreads are demonstrated by means of data from almost hundred railway projects. As a consequence experimental in-situ investigations are indispensible for trustworthy forecasts. A multi-staged investigation scheme has proven to be the best, starting with seismic investigations and the evaluation of dynamic building-behaviour in the planning phase. As soon as the basic tunnel is driven a heavy seismohydraulic vibrator can synthesize emissions with frequency sweeps of equivalent force and spectrum. This enables to encompass the transfer functions to neighbouring buildings for vibrations and structure-borne noise and the determination of appropriate eigenfrequencies for mitigation measures.

Wednesday 08:40-09:00, Hall Innsbruck, Paper 0998 (invited)
Ralbovsky Marian
Predicting vibration immission using Train Simulation: A combination of experimental and numerical solutions to assess railway-induced vibrations prior to construction

Ralbovsky Marian, Alten Karoline
AIT Austrian Institute of Technology GmbH, Austria

Rail-bound traffic is the most prominent source of traffic-induced vibration in buildings and can become particularly challenging in densely populated areas. While vibrations represent a problem for critical infrastructure such as medical facilities or sensitive equipment and machinery, ground-borne noise can pose an additional nuisance in residential areas. Threshold values for either parameter can be found in several national and international norms which recommend limit values for human exposure to noise and vibration in buildings. ISO 14837-1:2005 describes the types of approaches available for predicting these immissions and classifies them as either parametric (algebraic or numerical) or empirical, or a combination of both. The patented *Train Simulation* method is one of the latter (semi-empirical) approaches and relies on a combination of experimental in-situ measurements to determine a transfer spectrum, along with a numerical calculation of vibration transfer in the time domain; the response to train emission signals is added up at the immission point to predict the incident vibration. Since normative methods for evaluation of vibration exposure make use of time-domain signals, the predictions can be directly used for such evaluations.

Wednesday 09:00-09:20, Hall Innsbruck, Paper 0303 (invited)
Heiland Dieter
Insertion loss of vibration mitigation systems - methods of free field measurements with soil correction

Heiland Dieter, Mistler Michael
Ingenieurbüro Dr. Heiland, Germany

The insertion loss describes the effectiveness of a vibration mitigation system as e.g. mass-spring systems, ballast mats or under sleeper pads. Measurements in free field can be done either as right/left or before/after method. In both cases two different situations are compared with the aim to get most comparable values for the vibration improvement at the relevant measuring points. Different soil conditions, geometric differences of compared sections, train variation and many other variations often make the comparison difficult, even nearly impossible. The different boundary conditions become more noticeable for smaller mitigation effects (e.g. under sleeper pads) than for high effective systems like mass-spring systems. A fundamental improvement of the results is obtained by taking into account the correct soil mobility at both measuring sections and the correct emission spectrum of the vibration source. The authors show insertion loss evaluations with and without soil correction for different mitigation systems. For soil

correction the neighbored track or artificial excitation (impacts or shaker) can be used. Experiences of the presented method, advantages and disadvantages are shown with the help of practical examples. The shown methods will also be part of the new DIN45673-3-Spec “Experimental evaluation of insertion loss of mounted track systems”.

Wednesday 09:20-09:40, Hall Innsbruck, Paper 0664 (contributed)
Coquel **Guillaume**
Comparison of impact hammer and maximum length sequence method to measure vibration transfer functions in soils

Coquel Guillaume, Kengni-Kengang Arnold
Régie Autonome des Transports Parisiens, France

Before construction of new train, subway, tramway lines near existing buildings or in case of new buildings construction near existing lines, operators and local authorities have to predict vibration levels generated in buildings. Therefore, vibrations levels have to be evaluated at every step of propagation path. For evaluation of soil vibration transfer functions, different methods based on impulsive sources or on electrodynamics shakers can be used. The goal of this paper is to test the validity of Maximum Length Sequence (MLS) method to evaluate vibration level differences between different accelerometers by comparison with impact hammer method, and identify key parameters that improves results. Main aspects of signal processing associated with both MLS and impact hammer method, type of device used to produce vibration and main characteristics of Impulse Response (IR) are presented. A comparison of mitigation measured by MLS method (for fixed parameters) and impact hammer method is given. After that, a parametric study is performed on each MLS key parameter. Finally, a variation of soil properties after twenty days is given.

Wednesday 09:40-10:00, Hall Innsbruck, Paper 0231 (contributed)
Hirao Yoshihiro
Measurements of building vibration amplifications for ground-borne vibrations using the horizontal exciting system

Hirao Yoshihiro[1], Ohta Kenji[2], Kunimatsu Sunao[3], Kitamura Yasutoshi[4]

[1] Kobayasi Institute of Physical Research, Japan, [2] OYO Seismic Instrumentation Corporation, Japan, [3] National Institute of Advanced Industrial Science and Technology, Japan, [4] Construction Engineering Research Institute Foundation, Japan

Residents of buildings experience discomfort or annoyance from ground-borne vibration sources such as rail transit systems, road traffic, construction sites, and industrial plants. The building vibrations may cause discomfort such as sleep disturbance because the vibrations experienced are often greater than the ground vibrations near the building. Such vibration amplification in each building is induced by typical structural resonances in the horizontal direction. It is possible that the structural resonances of the buildings are affected by the frequency characteristics or magnitudes of the ground-borne vibrations onto the substructure of buildings. We developed a “reference horizontal exciting system” to investigate the structural resonances of buildings under certain ground-borne vibration conditions. The system consists of two unbalance weights, three transmission gear wheels, a pulse-motor, and a pulse-motor controller. The unbalance weights are horizontally rotated in sync by the transmission gear wheels and the pulse-motor. The system generates a unidirectional and horizontal force that is exactly timed for a sinusoidal signal. The buildings were excited in a horizontal movement by our system through the ground near the substructure of the buildings. The horizontal structural resonances of the two-story wooden and steel constructed house were investigated by vibration measurements using by the system. The resonance curves on the second floor of each house were calculated. Moreover, it is shown that the second floor of the wooden house was rocked in a rotatory motion by using the Lissajous curves of displacements at the three measurement points on the horizontal plane on the second floor.

Wednesday 10:00-10:20, Hall Innsbruck, Paper 0129 (contributed)
Fernández Espejo **Teresa**
Measurement procedures for vibration propagation from railway tracks

Fernández Espejo Teresa[1], Olafsen Sigmund[2], Brekke Arild[3]

[1] Brekke & Strand Akustikk AS, Norway, [2] Brekke & Strand Akustikk AS, Sweden, [3] Brekke & Strand Akustikk AS

Oslo is one of the fastest growing cities in Europe and with the people expected to relocate to the capital there will be an increased demand for new transportation systems. Rail-bound traffic (e.g. railways, metros and tram lines) is considered the solution to solve future transport issues. This paper presents a study aimed at improving the prediction of railway noise and vibration in earlier stages of future projects. The idea is to measure and calibrate induced vibrations with artificial sources in areas where new railway systems are planned and then compare them to vibration measurements on existing tracks. This study shows the results of numerous measurements using two artificial sources (a 200 kg sandbag and a 200 kg sand filled oil barrel) dropped from a height of 2 meters and the conclusions derived from this experiment.

Wednesday 11:00-11:20, Hall Innsbruck, Paper 1038 (invited)
Müller Gerhard
Prediction and assessment of re-radiated sound

Müller Gerhard
Chair for Structural Mechanics, Technische Universität München, Germany

Currently various methods are applied for predicting, measuring and assessing re-radiated sound linked to structural vibrations. They range from simple engineering approaches to the application of numerical methods with high detailing. The level of uncertainties in the prediction of the emissions depends on the characteristics of the excitation and on the transmission from the sources to the sound field inside of structures. Apart from the delimitation of the excitation and transmission, the quality of prediction depends on the required resolution with respect to frequency and space. The limitations of typical predictions are discussed. At existing sources, e.g. railway-lines, the excitation is usually described at the basis of measurements. For new sources and structures the prediction of structural vibrations in a first step typically starts with rough assessments. With increasing knowledge about the structural characteristics - obtained during the planning and construction process - the prediction can be delimited with higher precision. Measurements and predictions of re-radiated sound have to cope with the spectral characteristics of the signals and the resulting spatial distribution. Due to superposed direct sound, techniques are applied to measure re-radiated sound indirectly via vibrations. For the assessment differing guidelines in Germany, Austria, and Switzerland exist. The paper refers to work, carried out for the design of the guideline VDI 2038 [1].

Wednesday 11:20-11:40, Hall Innsbruck, Paper 0063 (invited)
Österreicher M.
On the calculation of the re-radiated sound pressure level from vibration measurements according to ONR 199005

Österreicher M., Ibáñez L.
iC consulenten ZT GmbH, Austria

Due to the increase of urban public transport infrastructure on the one hand and the intention to have residential buildings with a good connection to the public transport network vibrations and re-radiated noise become increasingly important. Especially for new buildings re-radiated noise is an important topic because the noise insulation of modern windows leads to a significantly decrease of the interior base noise level in rooms.The measurement of the re-radiated noise with sound pressure level meters is, because of the rather low levels complicated, and needs special equipment like low noise microphones. The present work shows a method according to ONR 199005 to calculate the re-radiated noise from vibration measurements. Within the objective work measurements were carried where both, direct measurements of the sound level and vibration measurements were done. The main goal of the present work is to estimate the accuracy of this method based on the measurement. Furthermore a goal of this work is to study to evaluate the reasons for errors between the measured and the calculated re-radiated noise.

Wednesday 11:40-12:00, Hall Innsbruck, Paper 0874 (invited)
Billeter Peter
Development and assessment of a new approach to determine structure-borne sound in rooms

Billeter Peter[1], Egger Adrian[2], Müller Roger[3]

[1] IUB Engineering Ltd., Switzerland, [2] Basler+Hofmann Ltd., Switzerland, [3] SBB Swiss Federal Railways, Switzerland

The contribution presents a method to determine the level of structure-borne sound radiation in buildings. The method was developed within the context of the preparation of an ordinance on vibration and noise control as required by the Swiss Environmental Protection Act. Based on the assumption that the noise level in living rooms in buildings can be computed by semi-empirical formulae from vibration measurements on the room floor, a calculation method using both analytical formulae and empirical coefficients was developed. The theoretical framework of the method and its practical application are explained. The suggested procedures for data acquisition and data processing as well as the computation rules to determine the level of structure-borne sound are shown. The method was validated by the comparison of in-situ measurements of structure-borne sound in rooms to the computed sound level for the equivalent room conditions. The reliability of the new method is discussed and compared to direct measurements of structure-borne sound.

Wednesday 12:00-12:20, Hall Innsbruck, Paper 1037 (invited)
von Diest Konstantin
High Speed Grinding – railway noise reduction through regular rail grinding without traffic interruptions

von Diest Konstantin, Püschel Aiko
Vossloh High Speed Grinding GmbH, Germany

Vossloh High Speed Grinding GmbH (VHSG) has developed a unique rail grinding method tailored for regular preventive maintenance of rails. Most recently, VHSG has concentrated to extend the use of “High Speed Grinding” (HSG) to reduce the waviness of rails resulting in lower noise emissions from railway traffic. One of the important sources for railway noise is the condition of the rails. An increased waviness (corrugation or slip waves) of the rail surface leads to significantly higher noise emissions of passing trains. VHSG has now tested and proven in various occasions that HSG reduces the waviness significantly and furthermore slows down its future growth. Conclusions drawn from the tests include that “the HSG method is generally suitable to produce a noise level on a track in conformity with TSI Noise” and “HSG can be used for acoustic restoration as well as for acoustic prevention operations”. For both main passenger and freight lines as well as for commuter lines, metro and tram networks different acoustic grinding solutions exist.

Wednesday 12:20-12:40, Hall Innsbruck, Paper 1043 (contributed)
Lackner Andreas
Projection and verification of solid-borne noise based on measurements using the example of the recently built “Katzenbergtunnel”

Lackner Andreas, Herrmann Wolfgang
Obermeyer Planen + Beraten GmbH, Germany

Due to the plan approval order of the year 2002 for the construction of the “Katzenbergtunnel” in south-west Germany, a vibration forecast had to be done to protect the buildings above. This was performed based on measurements of the transfer function from the basements to the floors of the buildings combined with vibration data gained from other tunnels. The results showed that suitable protection measures would have to be applied for the prevention of annoying vibrations in the buildings. After the construction of the tunnel transmission measurements of vibrations generated by a vibration roller were performed to analyze the transfer

function “tunnel to the buildings basements”. The obtained data was used as an input for a prognosis model considering the amount of train rides to calculate the vibration levels and the vibration induced airborne noise. Based on the results minimum requirements for a protection system were elaborated and a mass-and-spring system got the vote. After the installation of the system in the tunnel, the actual mass-and-spring system characteristics had to be verified by measurements during train-test-runs. Finally, control measurements in random houses above the track were made after the tunnels start up giving the opportunity for verification of the forecasts.

Wednesday 12:40-13:00, Hall Innsbruck, Paper 0692 (contributed)
Steinhauser Wolfgang
Vibration and ground borne noise forecasts for Lainzer Tunnel and Wienerwaldtunnel

Steinhauser Wolfgang
STCE – Steinhauser Consulting Engineers ZT-GmbH, Austria

Noise and vibration are considered to be the most disturbing environmental problems of railways. While the forecast of noise is a well proved method, vibration prediction is more complicated to deal with. This is caused by the complex transmission behaviour of the underground and the different feedback characteristic of each building. Lainzer Tunnel and Wienerwaldtunnel are both part of the new high-speed railway track from Vienna to St.Pölten. A considerable amount of their segments is located under the township of Vienna. Due to this position close to a large residential area, ground motion mitigation and ground borne noise reduction make high demands on the superstructure and emphasize therefore the necessity of accurate predictions. In an extensive investigation the vibration and ground borne noise levels have been artificially created with help of a vibration generator, which is able to produce the whole frequency band of train emissions and therefore allows equivalent simulation. Thus the design parameters – like insertion loss of the elastic elements – can be calculated. During acceptance and high speed measurements up to 330 km/h, it was possible to quantify the effects of the systems. The results of these measurements will be shown later on. Although the construction of the track had been heavily counteracted by local residents, no complaints have been made since the operation of both tunnel systems started. As far as control surveys have been realisable, they demonstrated that all systems work as planned.

SS07 Noise from Hybrid and Electric Road Vehicles

Chair: García Juan Jesus, Genuit Klaus

Wednesday 08:20-08:40, Hall Brüssel, Paper 0080 (contributed)
Møller Iversen Lykke
Noise from electric vehicles – 'state-of-the-art' literature survey

Møller Iversen Lykke, Marbjerg Gerd, Bendtsen Hans
Danish Road Directorate, Denmark

As a part of the COMPETT project about electric vehicles and the promotion of the use of these, an international 'state of the art' literature survey on noise has been done. It investigated how much is already known about the noise from electric vehicles and discovered where more research is needed. The findings in the literature survey show that there is a potential for noise reduction by replacement of ICE vehicles with electric vehicles, but the findings also show that there is a great deal of uncertainty about how large this potential is. The reductions of noise found in the references differ greatly and seem to depend very much on how the comparison between noise from ICE vehicles and electric vehicles is done. Most references do however find that it is only at low speeds that a noise reduction can be expected. This report is concluded with recommendations for how future measurements of noise from electric vehicles could be performed and what aspects of this noise need further investigations. In the next step in the noise investigations in the COMPETT project measurements of the noise from electric vehicles will be carried out.

Wednesday 08:40-09:00, Hall Brüssel, Paper 0663 (contributed)
Denjean Sébastien
Are electric and hybrid vehicles too quiet for drivers?

Denjean Sébastien[1,2], Velay Jean-Luc[3], Kronland-Martinet Richard[2], Roussarie Vincent[1], Sciabica Jean-François[1,3], Ystad Sølvi[2]

[1] PSA Peugeot Citroën, Scientific and Future Technologies Directorate, France, [2] LMA, CNRS, UPR 7051, Aix-Marseille Université, France, [3] LNC, CNRS, UMR 7291, Aix-Marseille Université, France

The development of quiet electric motorizations has led to a radical change in the acoustic feedback that the driver perceives in the passenger compartment. Although one might think that this noiselessness might improve the comfort, internal combustion engine noise is a major source of

information for the driver. Even more, its loss could alter the driver's motion perception which is inherently multisensory and based on the combination of visual, vestibular and acoustic information. To evaluate the influence of sound on motion perception, two experiments were conducted in a driving simulator. Participants were asked to accelerate or decelerate to a given target speed in the absence of a speedometer with three sound conditions: internal combustion engine, electric motorization or no sound. The results confirmed that acoustic feedback can influence motion perception, and showed that the engine noise plays a leading role in speed estimation. Without engine noise and even more without any sound, it was more difficult for the participants to precisely estimate the target speed and to keep it constant. Consequently, drivers might be forced to pay more attention to speed regulation in quiet vehicles, which might lead to an increase in their cognitive load and consequently affect their driving performance.

Wednesday 09:00-09:20, Hall Brüssel, Paper 0725 (invited)
Pallas Marie-Agnès
Noise emission and noise sources of a hybrid bus

Pallas Marie-Agnès, Chatagnon Roger, Lelong Joël
IFSTTAR, LAE (Environmental Acoustics Laboratory), Université de Lyon, CeLyA, France

Awkward environmental conditions induced by dense traffic in urban areas lead many cities to expand sustainable public transportation services. In addition to contributing to the reduction of air pollution and energy consumption, the selection of hybrid buses against conventional buses may also impact on noise emission. The French research project ElLiSup has been developing a plug-in series hybrid bus, operating either in hybrid or electric mode. The noise emission of the vehicle has been assessed and compared with an equivalent Internal Combustion Engine (ICE) bus. Global and third-octave noise analysis has been performed, relying on the classical Controlled Pass-by (CPB) procedure, and on a microphone array beamforming technique for investigating the noise sources. Pass-bys at constant speed, with acceleration and braking have been considered. The hybrid bus provides significant noise reduction at constant low speed due to lower powertrain contribution, both in hybrid or electric mode. This advantage decreases with increasing speed, as rolling noise becomes prevailing. However, in some acceleration or even braking situations the increase of the motor's contribution in frequency ranges of high human ear sensitivity may put the hybrid bus at a disadvantage, even in electric mode.

Wednesday 09:20-09:40, Hall Brüssel, Paper 0150 (invited)
Lennström David
Prominence of tones in electric vehicle interior noise

Lennström David[1], Lindbom Thomas[1], Nykänen Arne[2]
[1] Volvo Car Corporation, Sweden, [2] Luleå University of Technology, Sweden

The rapid increase of various types of electric vehicles introduced creates new challenges also in respect to noise control and sound quality. With the absence of acoustic emissions from an operating internal combustion engine, the presence of high pitched tonal components from the electric traction motor can be pronounced in many driving conditions. In order to fulfill the customer's expectations of interior acoustic comfort, further knowledge needs to be gained about the perception of tonal components appearing in a mix of random noise from wind and tires. This paper presents a study on the relationship between the psychoacoustic metric *prominence ratio (PR)* and the threshold of detecting the tones and also the perceived annoyance for both constant speed and acceleration in a pure electric vehicle. The listening test results reveal that below 800 Hz, a higher PR value is required for audibility compared to tones above 2.5 kHz. For all driving conditions, the perceived annoyance was relatively low with small differences between the frequency ranges for the low audibility stimuli (PR≤2 dB). With higher audibility (PR≥3 dB), the perceived annoyance was significantly increased for frequencies above 5 kHz compared to frequencies below 800 Hz for the constant speed cases. The acceleration cases yielded similar conclusions. The findings are intended to support in the requirement specification process for sounds in electric vehicles.

Wednesday 09:40-10:00, Hall Brüssel, Paper 0973 (contributed)
Sekine Michiaki
Basic investigation to determine international standardization requirements of the sound in Audible Vehicle Alerting System for quiet electric vehicles

Sekine Michiaki, Sakamoto Ichiro, Morita Kazumoto, Tsutsumi Reiko
National Traffic Safety and Environment Laboratory, Japan

It is well known that hybrid and electric vehicles are almost silent during low speed running. The international standardization work on the artificial warning sound for pedestrians has been progressing. We conducted a basic hearing experiment to propose a condition of sound that is easy to detect. Narrow width band noises were made using pink noise filtered through a 1/3

octave band pass filter. One of the high noises (from 1.6kHz to 6.3kHz) was coupled with one of the low noises (from 200Hz to 800Hz), then total 49 test sounds were created. Each test sound was overlapped on the ambient noise proposed by NHTSA. Participants were asked to detect a test sound in the ambient noise. The minimum sound pressure level was investigated. The test sounds including over the 2kHz band noise were detectable even in the low intensity. It was revealed that the sounds including the components from 2kHz to 2.5kHz are easy to detect. Then, following assessments were conducted; how the acoustic waves are transmitted when these sounds were emitted from a vehicle and what is the furthest away these sounds people can hear. When the measurement was conducted at the vicinity of the vehicle, it was founded that the sounds in the high frequency range significantly decayed with the increasing distance from the vehicle compared to the sounds in the low frequency range even the levels of both ranges were same.

Wednesday 10:00-10:20, Hall Brüssel, Paper 0824 (invited)
Biermann J.-W.
Synthetic sound generation for electric vehicles

Biermann J.-W., Fortino A., Hillers T.
Institute of automotive engineering (ika) RWTH Aachen University, Germany

Unlike conventional road vehicles with acoustically optimized combustion engines, electric vehicles are missing a significant load and speed dependency regarding their noise emission. The possibility of quiet transportation entails risks for surrounding pedestrians, because in the lower speed range the noise from electrified vehicles is at a low sound pressure level and masked by the urban background noise. Therefore the legislation is currently working on guidelines for designing exterior noise that represents a vehicle. In addition, the interior noise has to be taken into account as well to satisfy the customer demand for an appealing driving experience. With this background, the realization of a synthetic sound generation system has been researched at the institute of automotive engineering (ika), RWTH Aachen University, Germany. Besides the realization of executable software to enable real-time capable CAN communication and sound calculation, an implementation on an in-vehicle control unit has been realized. Finally, the interior and exterior noises have been analyzed with regard to the audibility and sound quality by operating the sound system in an electric vehicle. The methodology of the synthetic sound generation and key results are represented in this paper.

SS08 Road Traffic Noise Characterization

Chair: Goubert Luc, Anfosso Fabienne

Wednesday 11:00-11:20, Hall Brüssel, Paper 0190 (invited)
Bergiers Anneleen
Pilot study of the acoustic quality of thin noise reducing asphalt layers

Bergiers Anneleen[1], Vanhooreweder Barbara[2], Vercauteren Tatjana[3], Vuye Cedric[3]

[1] Belgian Road Research Centre (BRRC), Belgium, [2] Flemish Agency for Roads and Traffic, Belgium, [3] Artesis University College, Belgium

Within the context of the European Noise Directive action plans are established. One of those actions is to deepen the knowledge about noise friendly road surfaces. Noise reducing road surfaces are seen as a cost-efficient measure for traffic noise abatement. Therefore some test sections were installed in May 2012 in Belgium. The test sections consist of hot laid, bituminous top layers with a thickness of maximum 30 mm and a maximum content of accessible voids of 18 %. Two reference surfaces were installed on the same location, namely stone mastic asphalt SMA-C and double layer porous asphalt. The acoustic quality of the thin asphalt layers is followed up in time. Statistical Pass-By (SPB) and Close-ProXimity (CPX) measurements are performed according to ISO 11819 within certain time intervals after construction to follow up the evolution. In this paper the measurement results of the first monitoring year are discussed. Texture measurements performed with a laser profilometer according to ISO 13473 are linked to the noise measurement results.

Wednesday 11:20-11:40, Hall Brüssel, Paper 0149 (invited)
Andersen Bent
Noise from heavy vehicles on thin noise reducing surfaces
Comparison of pass-by noise levels measured during 2003 – 2012

Andersen Bent, Bendtsen Hans
Danish Road Directorate, Vejdirektoratet, Denmark

Since 2003 Danish Road Directorate has developed and improved noise reducing thin wearing courses in cooperation with road administrations and asphalt contractors. Full scale test sections have been constructed and monitored regularly e.g. by statistical pass-by measurements. In this study results from 4 highways and 3 urban roads with totally 45 different wearing courses have been compiled. All test sites include a dense asphalt concrete with 11 mm maximum aggregate size as a reference – the noise reducing test surfaces have an open surface texture, high air void percentage (6 – 17 %), and small maximum aggregate size (4 – 8 mm). Results have been published for passenger cars; however, often the number of heavy vehicle pass-bys has been insufficient for analysis. Noise reduction, ageing effects, and sensitivity to the fine texture of the road surface are smaller for heavy vehicles than for cars. In this study individual pass-by results for heavy vehicles are compared for nearly 1500 pass-bys on urban roads (at approximately 50 km/h) and more than 8000 pass-bys on highways and motorways (at approximately 80 km/h). The pass-by noise levels are analyzed for groups of similar wearing courses, and as a function of pavements age.

Wednesday 11:40-12:00, Hall Brüssel, Paper 0851 (invited)
Donavan Paul
Design and evaluation of quieter highway rumble strips

Donavan Paul[1], Rymer Bruce[2]
[1] Illingworth & Rodkin, Inc., USA, [2] California Department of Transportation, USA

A proposed design to reduce the exterior noise produced by rumble strips was developed with the intent to decrease the overall A-weighted exterior sound level while still maintaining adequate disturbance inside the vehicle. The quieter rumble strips or “mumble” strips were installed by the California Department of Transportation (Caltrans) and evaluated for exterior noise and interior disturbance along with conventional warning devices including ground rumble strips and dot pavement markers. Four test vehicles were used in the evaluation and measurements of exterior pass-by noise, exterior on-board noise, interior noise, and vibration level at seat track and steering column locations were made. The results of these measurements indicated that the overall A-weighted exterior noise levels produced by conventional strips were reduced by over 6 dB with the mumble strips as determined for three different types of passenger vehicles. For the fourth vehicle, a medium duty, six-yard dump truck, the reduction with the mumble strips was less, but slightly more than 3 dB compared to the ground rumble strips. In general, the interior disturbance levels for the mumble strips were comparable to those for the ground rumble strips. The design of the mumble strips and the results of the evaluation are reported in this paper.

Wednesday 12:00-12:20, Hall Brüssel, Paper 0524 (contributed)
Sabato Adolfo
Evaluation of acoustic climate produced by the installation of speed bumps and rumble strips in the urban fabric

Sabato Adolfo[1], Sabato Alessandro[1], Reda Alfredo[2]

[1] DIMEG – Dipartimento di Ingegneria Meccanica Energetica e Gestionale, Università della Calabria Laboratory of TCA, Italy, [2] Self-employed environmental engineer, Italy

On the roads of many cities several retarding devices - as speed bumps - are placed to slow vehicles. Furthermore, close to obstacles and crossroads rumble strips are installed to keep the attention of drivers. Speed bumps usually are 5 to 15 cm high and 30 to 300 cm long; the biggest ones are called anti-speed bumps. These so called “raised areas” are made to protect crosswalks from high speed and they are built increasing the traffic floor with connection ramps (with a slope, usually, of 10%). Instead, rumble strips are 0.3 cm high bands of an elastoplastic laminate. Their mutual distance depends on the attention level to activate. To determine the effects on the acoustic climate of the areas where these systems are placed, measurements during the passage of different kind of vehicles (weight and speed) have been made. Transit characteristics over bumps and strips have been identified through analysis of different acoustic descriptors; highlighting differences with those transits at same the speed in other parts of the studied infrastructure where there are no retarding devices. Analysis of main acoustic descriptors (L_{AE}, spectral composition, impulsive events, etc.), allow obtaining interesting consideration on the effects these devices have on the acoustic climate of the studied areas.

Wednesday 12:20-12:40, Hall Brüssel, Paper 1312 (contributed)
Moon Hak-Ryong
Characteristic of Road Traffic Noise according to Road Geometric Structure using PASS BY Method

Moon Hak-Ryong, Han Dae-Cheol, Kang Won-Pyoung
Advanced Transport Research Division, Korea Institute of Construction Technology, Korea

The road traffic noise generally occurs due to engine sound of vehicle, tire friction sound, exhaust sound and so on. There are several variables of the road traffic noise modeling such as traffic rate, speed of vehicle, the condition of road surface, and slope. However, there has been a little research regarding

road slope. The purpose of this research is to study the influence of road traffic noise by grade through the analysis of the field road traffic noise. This research measured road traffic noise by the PASS BY method at three field sections in Korea. Noise was collected at the flat land, uphill section, and downhill section. The microphone was installed at 1.2m and 5m height. Also, total sound pressure and sound pressure level by the 1/3 octave band frequency was calculated through the raw field data. The results were compared in accordance with the road geometric structure. This research shows that sound pressure level of uphill section was higher than those of other sections at 1m of microphone height in low frequency. Also, the flat land, uphill, and downhill section had similar results at 5m of microphone height.

Wednesday 14:00-14:20, Hall Brüssel, Paper 0055 (invited)
Bravo Teresa
Modelling the near field to far field propagation of noise radiated by vehicles

Bravo Teresa, Ibarra David, Cobo Pedro
Centro de Acústica Aplicada y Evaluación No Destructiva (CAEND), Spain

Traffic noise models are used to predict transmitted noise levels that are taken into account, for instance, in noise mapping and legislation. These models are coupled with a propagation method to calculate the radiated noise to the receiver positions. However, although it has been shown that the traffic noise annoyance is highly correlated with the Maximum Noise Levels produced by noisy drivers, the predictions are made considering an overall assessment, without making the distinction between quiet and noisy drivers. In this work, an on-board acquisition system has been designed for the detection of the vehicles responsible of maximum radiation levels. It is composed of two near-field microphones for the on-line acquisition of the rolling noise and the power-train noise. We have developed a methodology for the noise propagation to the far-field positions combining analytical descriptions, for the consideration of the absorbing properties of the propagating floors, and experimental measurements to characterise the properties of the engine hood. The extrapolated noise levels are then calculated considering the geometrical spreading term, the absorption by the air and the ground interaction. The predictions are compared with experimental pass-by measurements performed with different vehicles at different velocities.

Wednesday 14:20-14:40, Hall Brüssel, Paper 0618 (contributed)
Mietlicki Fanny
Noise generated by the Paris ring-road: state of knowledge and issues

Mietlicki Fanny, Ribeiro Carlos, Sineau Matthieu
Bruitparif, Noise Observatory, France

The Paris ring-road carries one quarter of all Paris traffic and represents an important link between Paris and the surrounding towns. With over 100,000 people living along its 35 km, the ring-road is also one of the noisiest roads in Paris according to the noise maps produced by the city of Paris within the framework of the implementation of European directive 2002/49/EC. In order to better understand the reality of these nuisances and to complete the strategic maps of noise, Bruitparif carried out a large measurement campaign over one month in 2009. This campaign allowed the description of variations in noise over time, the improvement of knowledge on the relationship between noise and traffic conditions, and a focus on sudden noise events (car horns, and particularly noisy two-wheeled motor vehicles). Further studies were conducted in 2010/2011 in order to quantify the population exposed to noise above the threshold values along the ring-road and to study the potential impact of some solutions. The monitoring went on with the setting up of permanent measurement stations to follow the evolution of noise levels over time. The main results of these studies will be presented and discussed.

Wednesday 14:40-15:00, Hall Brüssel, Paper 1151 (contributed)
Zhang Xin
A site measurement case study on the small-amplitude vibration EIA of highway bridge/viaduct traffic

Zhang Xin[1], Zhang Jiping[1], Zhang Weidie[2], Shen Saiyan[1]

[1] Zhejiang Research and Design Institute of Environmental Protection, China
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In China, it is clearly described in the law and regulations for road traffic noise management, that the noise environmental impact assessment (EIA) and mitigation are the first of all when an expressway, highway, or urban main road will be constructed, rebuilt, or expanded. However, it is generally ignore the small-amplitude vibration environmental impact from road bridge or viaduct traffic unless there appear special cases, such as large-amplitude sympathetic vibration, etc, so there is absent vibration EIA and

control. This paper monitored the noise and vibration environmental impact at a residential building which is located very close to a highway bridge, although the approach viaduct body and guard-fence even manually setting up a noise barrier can create sound shadow zone to mitigate road traffic noise, the small-amplitude vibration transmission may become a main source and should be attention. Therefore, the vibration EIA will be necessarily included into EIA regulations for the bridge or viaduct passing sensitive buildings within too close distance. The future works are suggested to construct easy model for the small-amplitude vibration transmission control theoretically or regressively, and to determine the threshold distance value how far away from a building to approach bridge for the vibration EIA.

SS25 Room Acoustics

Chair: Guigou-Carter Cathy, Patricio Jorge

Wednesday 08:20-08:40, Hall Freiburg, Paper 1067 (contributed)
Bradette Alain
Practical and accurate room acoustical measurements in large indoor multipurpose halls and measures to optimize acoustics

Bradette Alain[1], Lorenz-Kierakiewitz, Klaus-Hendrik[2]

[1] Peutz & Associés SARL, France, [2] Peutz Consult GmbH, Germany

This paper presents practical ways to perform accurate room acoustical measurements, particularly of echoes in large indoor multipurpose halls, and describes provisions to obtain good acoustics. It is based on recent experience acquired at the "Palais des Sports Paris-Bercy", POPB, and similar European stadiums. POPB is one of Europe's major indoor stadiums with a seating capacity of about 17 000 persons. After 30 years of use, a major renovation takes place. This multipurpose hall is home to a wide range of activities such as music concerts, sports events (tennis, motocross, ice skating, basketball, etc.), and political rallies. The paper focuses on the acoustical characteristics of the main hall of the POPB. Different acoustical measurements (reverberation time, background noise level, quasi-impulse responses with a highly directional speaker) have been performed in order to investigate the existing characteristics. Solutions to improve acoustics in the design phase are presented. The acoustical characteristics encountered at POPB being typical of large indoor multipurpose halls, the measurement method and the acoustical treatments can be applied in similar halls.

Wednesday 08:40-09:00, Hall Freiburg, Paper 0866 (contributed)
Che Din Nazli
Measurement of the acoustical performance of traditional vernacular mosques in Malaysia

Che Din Nazli[1], Abd Jalil Nurul Amira[1], Ahmad Yahaya[1], Othman Rosniza[2], Otsuru Toru[3]

[1] Department of Architecture, Faculty of Built Environment, University of Malaya, Malaysia
[2] Centre for Foundation Studies, International Islamic University Malaysia, Malaysia
[3] Department of Architecture and Mechatronics, Faculty of Engineering, Oita University, Japan

Mosques are worship places used for activities performed by Muslim e.g. prayer, speech and Quran recitations. All activities in the mosques are important acoustical interests for satisfactory speech intelligibility i.e. verbal communication. Unfortunately, recent architectural styles or restoration works were given very little attention about acoustical considerations. In this research, the acoustical performance of five selected traditional vernacular mosques in Malaysia, built between 1728 – 1830, have been investigated as a preliminary study. The acoustic parameters such as reverberation time (RT), clarity (C50) and speech transmission index (STI) were measured. Measurement of the influence of the operating facilities in the mosques on their acoustic quality was also carried out. The PC-based measuring system (dBBati32) with sound level meter (01dB Solo Metravib) as analyzer was utilized. Data collected reveals initial findings that the operating facilities in the mosques resulting higher rating of noise criteria which is reducing the performance of speech intelligibility.

Wednesday 09:00-09:20, Hall Freiburg, Paper 0639 (contributed)
Sato Shin
Spatial information of sound fields scattered by periodic-type diffusers behind a stage

Sato Shin, Takahashi Daiji
Kyoto University, Graduate School of Eng., Japan

Temporal information of reflections due to diffusers with periodic roughness has been discussed in many reports; however, spatial information is hardly investigated. It is commonly accepted that early lateral reflections highly contribute to spaciousness of sound fields. Furthermore, this contribution is independent of other reflections and of the presence of reverberation. The present study mainly focuses on such spatial information of the sound fields caused by periodic-type diffusers. Calculations are carried out for a corrugated wall behind a stage with a pair of lateral walls using a boundary integral equation method (BIEM) and a “closely located four point microphone method.” Discussions are given to both the frequency characteristics and the spatial information regarding the early lateral energy fraction in comparison with a flat wall. From limited results of this study, it might be concluded that the diffuser behind a stage doesn’t effectively contribute toward spatial impression as expressed in the early lateral energy fraction.

Wednesday 09:20-09:40, Hall Freiburg, Paper 0994 (contributed)
Bo Elena
Acoustic simulations for the modern use of ancient theatres

Bo Elena[1], Rychtárikova Monika[2], Garcia David Pelegrin[3], Glorieux C.[3], Astolfi Arianna[4]

[1] Politecnico di Torino, Italy, [2] STU Bratislava, Department KPS, Slovakia, [3] KU Leuven, Laboratory of Acoustics and Thermal Physics, Belgium, [4] Politecnico di Torino, Department of Energy, Italy

The modern use of ancient theatres for spectacles and performances is often compromised by a damaged situation of the theatre itself. This damage is caused by natural erosion, constant visits of tourists at the archaeological site and by inappropriate usage of the structure (as modern theatre). In this article, we report on an analysis of how the acoustical situation of an ancient theatre changes with the introduction of a scenery. A parametric case study was performed by means of room acoustic prediction software Odeon version 10.1® for the Greek theatre of Syracuse. The used spatial acoustic model is based on the scenery realised by OMA in 2012 for the *48th Edition of Classical Plays at Syracuse's Theatre*. Eight simulated alternatives, based on different properties of sound sources, its position on the stage and the material of the *cavea* (where the audience sits), were investigated. Special focus was given to the comparison of different alternatives (in the original situation without damages due to erosion) of the acoustical parameters EDT, T30, SPL (G value), C80, C50 and STI. In order to verify the acoustic situation of the theatre today during a play, different architectural alternatives were simulated, with or without the scenery, while taking into account the presence of background noise, as well as the directivity of a talker and the frequency spectrum of the human voice.

Wednesday 09:40-10:00, Hall Freiburg, Paper 0140 (contributed)
Rosenhouse Giora
Acoustical comfort and speech privacy in the design of flexible open-plan offices

Rosenhouse Giora
Swantech – Sound Wave Analysis and Technologies Ltd. (Retired Prof., Faculty of Civil Engng, Technion), Israel

When an area for a new open-plan office is allocated, the initial architectural design in many cases is subject to unpredictable changes during use by the owner or other involved people. The acoustic design has to have robust

characteristics under such circumstances. This means that even under significant changes in the open-plan office, the basic acoustic criteria for a good open-plan office will not be changed, unless a new acoustical design is required. Basic acoustical design principles and new quantitative evaluation formulae for the acoustic design of open-plan offices, first presented by the author in Inter-noise 2012, for the room constant, SNR and the critical radius are applied to match the acoustics to the flexible open-plan office needs. Special attention is paid to the hearing comfort of hearing impaired people. The acoustic design model and method minimize the differences in acoustic comfort due to changed room parameters in such a way that the acoustical quality of the space is sustained as much as possible. The model also defines changes that yield the best results. A short review of the formulation and solved examples that illustrate the acoustic design possibilities conclude the paper.

Wednesday 10:00-10:20, Hall Freiburg, Paper 0810 (contributed)
Abd Jalil Nurul Amira
Acoustical investigation of open-plan offices in green buildings in Malaysia

Abd Jalil Nurul Amira, Che Din Nazli, Keumala Nila
Department of Architecture, Faculty of Built Environment, University of Malaya, Malaysia

Open-plan office has become the most popular type of office layout. Organizations were inclined to employ open-plan office layout for its economic, flexibility and ideological reasons. Green building tends to utilize this concept of office layout for its ability to assist in maximization of daylight usage and natural ventilation. However reduced barriers in open-plan office resulted in poor acoustical performance. Thus, the objective of this study is to investigate and evaluate the level of acoustical performance of open-plan offices in green buildings in Malaysia. Investigation were limited to selected assessment parameters of background noise (BN) level, noise criteria (NC), reverberation time (RT) and speech transmission index (STI). The BN levels for all measured open-plan offices were found to be acceptable around 35 dB(A) while the NC ratings found the spaces to be somewhat quiet. RTs were varied from satisfactory 0.7s to an unacceptable 1.5s. STIs were found to be ample within good and fair speech intelligibility. However, it still provides equally ample speech distraction towards the occupants of the spaces.

SS17 Prediction Methods for Building and Room Acoustics

Chair: Davy John Laurence, Borello Gerard

Wednesday 11:00-11:20, Hall Freiburg, Paper 1066 (contributed)
Borello Gérard
Modeling timber-framed multi-layered panels by combining transfer matrix approach with SEA and FEM

Borello Gérard
InterAC, France

In timber-framed light-weighted construction, the acoustic Transmission Loss (TL) of multi-layered panels is strongly dependent on mechanical links between the various layers. The panel acoustic performance is then limited above a few hundred Hz. Due to the variety of construction principles, there is no simple rule to predict this vibrational path. For predicting TL, a specific technique is implemented in SEA+ software. The acoustic path is modeled using the Transfer Matrix Method (TMM) in which the various layers (wood, porous material, air gap) are assembled with continuity of pressure and velocity. The mechanical path is modeled using Statistical Energy Analysis (SEA) and combined with Finite Element Method (FEM) when necessary due to geometrical complexity. Virtual SEA method is here applied to convert FEM dynamical information to SEA. TMM and SEA modeling are then combined to merge both mechanical and acoustic transmitted powers while taking into account TMM added mass and damping on SEA subsystems and spatial windowing to correct TMM approach in the low and mid frequency domains. Effectiveness of the method is demonstrated by comparing measured TL of various timber-framed panels to SEA+ modeling results.

Wednesday 11:20-11:40, Hall Freiburg, Paper 1157 (contributed)
Reynders Edwin
Sound insulation prediction of complex building elements using a hybrid finite element - statistical energy analysis approach

Reynders Edwin[1,2], Langley Robin S.[2]

[1] KU Leuven, Department of Civil Engineering, Belgium
[2] University of Cambridge, Department of Engineering, UK

Predicting the airborne sound insulation of a complex building element generally requires a detailed model of that element, as simplified analytical models such as an equivalent orthotropic plate are only accurate for the first

few natural frequencies. A commonly adopted strategy therefore consists of constructing a detailed finite element model and computing the expected value of the sound reduction index by numerically integrating the plane-wave transmission over all angles of incidence. This is not only computationally costly, but all information on the uncertainty of the predicted values due to the statistical nature of the diffuse field assumption for the rooms is also lost. In this work, an alternative method is therefore proposed, where a finite element model of a building element is coupled to statistical energy analysis models of the rooms. Both the mean and variance of the sound reduction index are computed, so that the uncertainty of the predicted values due to the generalized diffuse field assumption can be assessed. The method is then applied to the sound reduction index prediction of a rib-stiffened plate and a thicker masonry wall and validated against measured data. It is found that the proposed approach can capture both the complex dynamics of the walls and the uncertainty of the generalized diffuse field assumption of the rooms.

Wednesday 11:40-12:00, Hall Freiburg, Paper 0785 (contributed)
Díaz-Cereceda Cristina
Pushing SEA beyond its limits: a model for real building structures

Díaz-Cereceda Cristina, Poblet-Puig Jordi, Rodríguez-Ferran Antonio
Laboratori de Càlcul Numèric. UPC - Barcelona TECH, Spain

The main challenge for models of building acoustics is being able to consider all the geometrical and physical details of real structures with a reasonable computational cost for high frequencies. The SEA (Statistical Energy Analysis) framework is suitable for these frequencies, but presents some difficulties for dealing with complex structural configurations. For instance, modelling absorbing materials with SEA is an open issue, since they are neither reverberant subsystems nor conservative couplings. In this work, a model to account for absorbing materials with a SEA-like approach is performed. It is obtained by analogy with an electrical circuit. This approach is combined with numerical simulations in order tosolve vibroacoustic problems in real structural configurations (including complex geometries or dissipative connections) throughout the entire frequency range required by regulations. The proposed technique is applied to modelling the sound insulation of double walls. These walls consist of two leaves of plasterboard connected through metallic studs and filled with a layer of absorbing material. The combination of numerical simulations and SEA arises as a good technique for modelling the acoustic behaviour of real life structures with an affordable computational cost.

Wednesday 12:00-12:20, Hall Freiburg, Paper 0522 (contributed)
Masovic Drasko
An insight into EN 12354 sound insulation calculation results dispersion due to variations of building element performance quantities

Masovic Drasko, Mijic Miomir, Sumarac Pavlovic Dragana
School of Electrical Engineering, Serbia

EN 12354-1 and EN 12354-2 European standards describe models for the prediction of airborne and impact sound insulation in buildings, based on various building element performance quantities as the input parameters. Therefore, the level of agreement between the models' input values and real in situ values in buildings directly influences the estimation accuracy. Moreover, many of the relevant quantities still lack of measurement data or even reliable measurement procedures, especially in the field, so empirical data and formulas have to be used, which give rise to the further uncertainty of predictions. This paper shows results of calculations according to EN 12354, with variable scenarios and values of input parameters. As a starting point for the input quantities, some measurement data found in the existing literature were also used. The results provide an insight into the dispersion of sound insulation calculation results due to the influence of input values variations.

Wednesday 12:20-12:40, Hall Freiburg, Paper 1245 (contributed)
Santoni Andrea
Case studies on the application of EN 12354-5 in Italy

Santoni Andrea, Fausti Patrizio
Engineering Department in Ferrara, Italy

The prediction models of the sounds levels due to service equipment in buildings, given by EN 12354-5:2009, need a variety of input data to characterize sources and structures. The early applications of these models highlighted some of the difficulties in obtaining several input data, to characterize structure-borne sound sources and their interaction with building supporting elements, as happened for the early applications of the first part of series EN 12354. The basic idea of this study derived from to the possibility to apply one of the measurement methods of the characteristic structural sound power given by EN 12354-5 to characterize a structure-borne sound source and its interaction with building supporting elements to obtain the necessary input data for using the prediction model.

Wednesday 12:40-13:00, Hall Freiburg, Paper 0744 (contributed)
Reynders Edwin
Uncertainty quantification of the sound transmission loss of building components at the design stage

Reynders Edwin
KU Leuven, Department of Civil Engineering, Belgium

The sound transmission of a building component does not only depend on its material properties, but also on the facility in which it is tested and on the test procedure, especially at low frequencies. This introduces uncertainty in a design situation where the test facility and measurement procedure are still unknown, i.e., when predicting the variability of the transmission loss across different facilities and procedures is of interest. In this work, a robust probabilistic framework is developed for quantifying the combined effect of the uncertain parameters involved in sound insulation prediction problems. The main idea is to construct the probability distribution of these parameters from the available information using the maximum entropy principle. The probability distribution of the predicted sound transmission loss, which is subsequently obtained through Monte Carlo simulation, is then fully compatible with the available information but otherwise maximally uncertain. The method is applied for quantifying the uncertainty of the transmission loss of single and double walls at the design stage, where the available information on the uncertain parameters is limited to e.g. standardized requirements and nominal damping values.

Wednesday 14:00-14:20, Hall Freiburg, Paper 0570 (contributed)
Okuzono Takeshi
Relationship between dispersion error and accuracy of room acoustics parameter in time-domain finite-element room acoustics simulation

Okuzono Takeshi[1], Otsuru Toru[2], Tomiku Reiji[2], Okamoto Noriko[3]

[1] Faculty of Engineering, Oita University, Japan, [2] Department of Architecture and Mechatronics, Architecture Course, Faculty of Engineering, Oita University, Japan, [3] Department of Architecture, Ariake National College of Technology, Japan

The time-domain finite-element method (TD-FEM) is a powerful wave-based numerical method for room acoustics simulation. However, it is well known that this method incurs an inherent error, called dispersion error, due to both spatial and time discretizations. To obtain a reliable result, discretization of both space and time, which maintain the dispersion

error within acceptable level, is required, although the level for room acoustics applications such as calculating of the room acoustical parameters still remains unclear. Further, sufficiently fine spatial and time discretizations for reducing the error make the computation expensive. For efficient use of the method in practical applications, the balance between accuracy and computational cost needs to be considered. For the purpose, this paper presents the relationships between the dispersion errors and accuracy of room acoustical parameters in TD-FE analysis with fourth-order accuracy. Five room acoustical parameters of a sound field in a rectangular room with volume of 62 m^3 were computed at frequencies from 250 Hz to 1 kHz, using TD-FEM with FE meshes of different spatial resolutions and with different time resolutions. Also, the dispersion errors in each analysis were theoretically estimated by dispersion error analysis in three dimensions. Results showed that the use of FE meshes having dispersion error below 0.52 % is recommended to yield the reasonable results at given frequency range.

Wednesday 14:20-14:40, Hall Freiburg, Paper 0728 (contributed)
Marbjerg Gerd
Development of a pressure based room acoustic model using impedance descriptions of surfaces

Marbjerg Gerd[1,2], Brunskog Jonas[2], Jeong Cheol-Ho[2], Nilsson Erling[3]

[1] Saint-Gobain Ecophon, Denmark, [2] Acoustic Technology, Technical University of Denmark, Denmark, [3] Saint-Gobain Ecophon, Sweden

If a simulation tool is to be used for the optimization of absorbent ceilings, it is important that the simulation tool includes a good description of the surface. This study therefore aims at developing a model which can describe surfaces by their impedance values and not just by their statistical absorption coefficient, thus retaining the phase and the angle dependence. The approach of the proposed model will be to calculate the pressure impulse response using a combination of the image source method and acoustic radiosity. The image source method will account for the specular reflections and acoustic radiosity will account for the diffuse reflections. This paper presents the motivation for the new model in the form of results in literature, which show the importance of retaining the angle dependence and phase information in reflections along with simple examples of angle dependent reflection from a porous absorber.

Wednesday 14:40-15:00, Hall Freiburg, Paper 0392 (contributed)
Asakura Takumi
Finite-difference time-domain analysis of structure-borne sound using a plate/beam model

Asakura Takumi[1], Ishizuka Takashi[1], Miyajima Tohru[1], Toyoda Masahiro[2], Sakamoto Shinichi[3]

[1] Institute of Technology, SHIMIZU Corporation, Japan, [2] Kansai University, Japan, [3] Institute of Industrial Science, The University of Tokyo, Japan

Finite-difference time-domain method for prediction of structure-borne sound in architecture is proposed in this paper. Under the present circumstances of the PC performance, prediction for a large-scale problem is difficult yet. To solve such a problem, we model the target architecture as compositions of plate elements or beam elements to reduce the dimension of the simulated field to 1 or 2 dimensions in comparison to the situation that the object is discretized by 3-dimensional solid elements, and it results in a memory-saving, and faster calculation. In this report, the basic theory of the FDTD analysis for a model with plate or beam elements is described, and results of a case study for box-type and frame-type structure models are discussed.

Wednesday 15:00-15:20, Hall Freiburg, Paper 0597 (contributed)
Yasuda Yosuke
Difference between locally-reactive and extended-reactive boundary conditions in a non-diffuse sound field with unevenly-distributed sound absorbers

Yasuda Yosuke, Kadota Masaru, Sekine Hidehisa
Department of Architecture, Faculty of Engineering, Japan

In wave-based numerical analyses, locally-reactive boundary conditions are often adopted, whereas their applicable range is not sufficiently clarified. The difference between locally-reactive and extended-reactive conditions may be clearly observed in a non-diffuse sound field with unevenly-distributed sound absorbers, because the incident angle of many sound waves in such a field is far from the normal of the boundary surfaces. In the present paper, the difference between both of the conditions in a rectangular room with unevenly-distributed sound absorbers is investigated in detail by a wave-based numerical analysis using the fast multipole BEM (FMBEM). A porous-type sound absorber on a rigid wall is assumed for absorptive surfaces. For locally-reactive cases, real- and complex-number surface impedances are adopted, in the latter of which the phase is considered. Extended-reactive

cases are analyzed using the domain decomposition method. Main conclusions are summarized as follows: (i) Many results with complex-number impedances have the same tendency as those with extended-reactive conditions, even in a non-diffuse sound field. (ii) one can judge whether an extended-reactive surface can be treated with a complex-number impedance, from the theoretical dependence of the absorption coefficient on the incident angle and relationship between the absorber thickness and the analysis wavelength.

SS31 Barriers

Chair: Clairbois Jean-Pierre, Garai Massimo

Wednesday 08:20-08:40, Hall Strassburg 1, Paper 0855 (invited)
Clairbois Jean-Pierre
EN standards for road traffic Noise Reducing Devices and railway Noise Barriers: state of the art

Clairbois Jean-Pierre[1], Garai Massimo[2]

[1] A-tech/Acoustic technologies, Belgium
[2] Department of Industrial Engineering (DIN), University of Bologna, Italy

Started in the early 90's, a first set of European (EN) Standards has been drafted by the CEN/TC226/WG6 working group of experts: this set of standards includes, under a global product standard (EN14388), references to acoustic and non-acoustic supporting standards. In more than 20 years, many parts of this set have been revised, thanks to new assessment and /or measurement methods, the most important challenge being to establish measurement methods that are completely in line with the effective intended use of the devices, i.e. outside buildings, either in free-field conditions or in more complex situations with multiple reflections. On the other hand, another working group has been started as the CEN/TC256/SC1/WG40, on a similar base, but adapted to the specific intended use along railways. This paper will present the state of those two set of standards as of today, and in which direction they will be revised in the coming future, thanks to the outcome of new researches as QUIESST, amongst others. The final objective of those standards is to improve the use of efficient and sustainable noise reducing devices along the highway and railway networks.

Wednesday 08:40-09:00, Hall Strassburg 1, Paper 0378 (invited)
de Roo Foort
Assessment of reflectivity of noise barriers in the far field – QUIESST method compared to traditional approach

de Roo Foort
TNO Technical Sciences, The Netherlands

The sound reflectivity of noise barriers elements is one of the major acoustic product characteristics. Traditionally this property was tested in reverberation rooms according to EN 1793-1 and the results were used to

predict the effect of sound reflections in the far field. As in many cases these results cannot be used directly to assess the far field influence of reflections, two methods to modify the test results (truncation and correction for finite sample size) may be used for practical applications. More recently outdoor in-situ sound reflectivity tests were developed as an alternative for the laboratory tests (CEN/TS 1793-5). After the first development phase in the EU project Adrienne (1995 -1997) the in-situ test method for reflectivity was improved in the EU-FP7 project QUIESST (2009-2012). In this project the near field test was complemented with an engineering computation method to predict the far field effect of reflections. This combined assessment methodology is discussed in this paper and its results are presented and compared to the traditional approach.

Wednesday 09:00-09:20, Hall Strassburg 1, Paper 0094 (invited)
Garai Massimo
On the declaration of the measurement uncertainty of airborne sound insulation of noise barriers

Garai Massimo, Guidorzi Paolo
University of Bologna – DIN, Italy

The declaration of the results of a measurement cannot be considered complete if not accompanied by a clear and realistic declaration of the measurement uncertainty. Airborne sound insulation of noise barriers makes no exception. It is measured in the laboratory under a diffuse sound field (EN 1793-2) and in situ (EN 1793-6) in a direct sound field. The uncertainty in laboratory conditions can be assessed referring to ISO DIS 12999-1; the uncertainty in field conditions can be assessed referring to the outcomes of the QUIESST project. This paper shows how these findings should be used to derive the so called expanded uncertainty of the results, both in one-third octave bands and for the single-number ratings. An approach to presenting and interpreting the results consistent with the ISO GUM is given. The differences from the previous practice are highlighted, in particular when the classification into categories of the barrier under test for the purpose of CE marking (EN 14388) is concerned. Some ideas for the future updates of the relevant standards are proposed. For the first time, it is shown how to deal with measurement uncertainty of airborne sound insulation of noise barriers.

Wednesday 09:20-09:40, Hall Strassburg 1, Paper 0520 (invited)
Conter Marco
QUIESST Database on intrinsic acoustic performances of European Noise Reducing Devices

Conter Marco, Haider Manfred, Czuka Martin
AIT Austrian Institute of Technology, Austria

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 [1] 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 centers 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 summarizes the main findings of work package 4, describing the use of the database developed within the QUIESST project.

Wednesday 09:40-10:00, Hall Strassburg 1, Paper 0211 (invited)
Oltean-Dumbrava Crina
The sustainability assessment of noise barriers for EU project QUIESST: A case study

Oltean-Dumbrava Crina, Watts Greg, Miah Abdul
Bradford Centre for Sustainable Environments, School of Engineering Design and Technology, University of Bradford, UK

Quietening the Environment for a Sustainable Surface Transport (QUIESST) EU grant was a three year, inter and multi-disciplinary project undertaken by 13 EU partners from 8 countries, which began in late 2009. Work package 6 (WP6) and its team focused on carrying out research designed to establish a bespoke sustainability assessment framework and method for assessing the sustainability of noise reducing devices (NRDs) across their whole life cycle. This paper provides an account of the first study carried out to assess the sustainability of two built European NRDs projects (one in Spain, and one in

Italy) via the application of multi criteria analysis (MCA) techniques. The general stages, selection of criteria, data gathering, and the use of three MCA techniques, SAW, PROMETHEE, and ELECTRE III, to assess their absolute sustainability is presented and discussed. The paper concludes that the presented case studies will provide a useful model for practitioners to adopt or amend to conduct their own assessments of NRDs' sustainability in the aim of supporting the growing transport sustainability agenda. The presented research could also support broader aims such as sustainability decision making, reporting, monitoring, procurement, the development of sustainability standards for NRDs, and for conducting "what-if" sustainability analyses.

Wednesday 10:00-10:20, Hall Strassburg 1, Paper 0425 (contributed)
Castiñeira Segio
Analysis of the diffraction on the upper edge of an acoustic barrier formed by arrays of rigid scatterers

Castiñeira Segio[1], Rubio Constanza[2], Sánchez-Pérez, Juan Vicente[2]

[1] Departamento de Física Aplicada, Universitat Politècnica de València, Spain, [2] Centro de Tecnologías Físicas: Acústica, Materiales y Astrofísica, Universitat Politècnica de València, Spain

The use of arrays of rigid scatterers, usually called sonic crystals, as acoustic screens has been extensively studied in recent years due to the band gap properties of such systems. In this sense, several theoretical methods have been proposed to analyze their physical characteristics. However, in the development of these methods, the scatterers of infinite length are considered but, in real cases, the length of the scatterers is obviously finite and a new acoustic phenomenon, diffraction on the upper edge, appears. We present here a comprehensive numerical model to analyze the attenuation properties of arrays of scatterers as acoustic barriers taking into account both band gap and diffraction phenomena. The numerical calculations are checked with accurate experimental results performed in controlled conditions. The promising results obtained can help to design devices based on arrays of scatterers to control environmental noise more efficiently.

Wednesday 11:00-11:20, Hall Strassburg 1, Paper 0862 (invited)
Fernandez Pilar
Noise barriers customized to abate non conventional noise sources

Fernandez Pilar, Diez Itxasne, Eguiguren Jose Luis, Aspuru Itziar
TECNALIA, Spain

Nowadays, conventional noise barriers, built with different materials and designs, form a landscape very common on both sides of roads and railways. The fast growth of cities and the increasing awareness of people about noise, leads to define measures to reduce noise caused by other sources in urban areas. This paper presents two types of barriers, slightly different from those already commons. Their designs are customized to two types of sources: railway lines highly integrated in cities, and temporal events that are noisy, like works, concerts, political acts…. On one hand, it is already known that small barriers could be efficient to reduce railway noise. The challenge in the design of this barrier was not only acoustic, but also to comply with maintenance requirements. The design is still experimental and it is being checked with railway managers to find, if possible, common requirements of safety distances to track to allow works at the line, optimizing its acoustical efficiency. On the other hand, the barrier designed to reduce noise caused by works in the city, is a temporary display, easily movable and adaptable to different sources of noise in a work. It has awarded a patent, being still at experimental stage.

Wednesday 11:20-11:40, Hall Strassburg 1, Paper 0726 (contributed)
Jolibois Alexandre
Sensitivity-based shape optimization of a rigid tramway low-height noise barrier

Jolibois Alexandre[1], Duhamel Denis[1], Sparrow Victor W.[2], Defrance Jérôme[3], Jean Philippe[3]

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An urban low-height barrier meant to attenuate tramway noise for nearby walking pedestrians or cyclists is considered. The efficiency of this type of device is known to depend on the shape of the cross section and the acoustic properties of the surface treatment. Some sort of absorptive material is often required to enhance the performance by preventing the multi-reflection phenomenon, however such materials can be costly compared to acoustically rigid materials such as concrete. In this study, a rigid barrier is assumed but its shape is optimized using a sensitivity-based shape optimization algorithm coupled to the two dimensional BEM. The shape is here described in a very general fashion by mesh nodes coordinates, which can involve a large number of variables. Sensitivities with respect to all coordinates are calculated efficiently using the adjoint state approach, without significant increase of computation time. Numerical results show that optimized shapes tend to be quite irregular but provide a significant improvement compared to simpler shapes, especially in the mid and high frequency range. Intensity calculations seem to suggest that this improvement is due to scattering of the incident acoustic energy in the upwards direction, therefore reducing the diffracted energy which reaches the shadow zone. Extra calculations show that the benefit of the optimized shapes can still be significant even in more realistic situations.

Wednesday 11:40-12:00, Hall Strassburg 1, Paper 0089 (invited)
Jambrošić Kristian
Optimization of noise barrier efficiency using genetic algorithms

Jambrošić Kristian, Grubeša Sanja, Domitrović Hrvoje
University of Zagreb, Faculty of Electrical Engineering and Computing, Department of electroacoustics, Croatia

Although noise barriers are the most common technical solution for decreasing the excess noise levels at a receiver point, there is a constant need for increasing their efficiency. Insertion loss, the acoustic efficiency parameter, largely depends on the barrier's geometry, mostly its height. Nevertheless, the barrier's top and its overall shape can have a substantial influence on the insertion loss as well. This paper presents the use of genetic algorithms in the design phase of noise barriers by using BEM as the numerical tool for calculating its insertion loss. The optimization was not carried out only by taking into account its acoustical performance, but also having in mind the economic feasibility of using different materials and shapes of the barrier modules. An economic feasibility coefficient is defined and used as a final numerical value for comparing the overall efficiency of barrier design. The barrier performance was evaluated for a point sound source in both 2D and 3D simulation space, and its total rating based on the economic feasibility coefficient and its acoustical performance were compared to a reference plain barrier of same height. Scale model measurements were performed as well and compared to the simulation results.

Wednesday 12:00-12:20, Hall Strassburg 1, Paper 0463 (contributed)
Horváth Géza
Inverse optimization of noise barriers

Horváth Géza[1], Kirisits Christian[1], Sachpazidis Ilias[2], Drewes Thomas[3], Krapf Klaus-Georg[3], Kirisits Helmut[1]

[1] Kirisits Consulting Engineers, Austria, [2] Pi Medical, Greece, [3] Wölfel Meßsysteme Software GmbH + Co. KG, Germany

In most cases planning of noise barriers should limit the sound level at defined locations (e.g. windows) below certain thresholds, but also keep the total building costs as low as possible. Currently the height and length of noise barrier segments are determined by manual forward planning which tends to overestimate the barrier area needed and might not use the full potential of the invested budget. We expand our previously developed inverse planning concept, which includes Simulated Annealing and gradient based optimization algorithms. Pareto fronts are used as a visualization tool helping the engineer and decision maker in noise barrier planning. We defined an objective function allowing us to apply the concepts of multiobjective optimization. Using a weighted sum approach we can reliably generate well distributed pareto fronts. We show that our optimization procedure generates more cost efficient barriers than current forward planning methods. With our pareto front visualization we offer a decision making tool to the planning engineer, allowing much more detailed, precise and transparent noise barrier planning.

Wednesday 12:20-12:40, Hall Strassburg 1, Paper 0081 (contributed)
Pleban Dariusz
Measuring sound insulation properties of barriers for ultrasonic noise reduction

Pleban Dariusz, Mikulski Witold
Central Institute for Labour Protection – National Research Institute, Poland

Increased efficiency of production and improved quality have contributed to the development of ultrasonic technological applications, in which ultrasounds are generated to operate, accelerate or facilitate technological processes. Those devices have relatively high power and their nominal frequencies are 18-40 kHz. Efficient ultrasonic noise reduction with enclosures requires the knowledge of the insulating properties of barriers in the frequency range above 5 kHz. However standardized methods determine sound insulations of barriers in the frequency range up to 5 kHz. Thus, two test

stands for determining sound insulation were made. One consisted of two horizontally adjacent reverberation rooms and a special source of ultrasounds. This test stand made it was possible to carry out measurements in the frequency range up to 8 kHz. The other test stand, with a miniaturized test chamber and a special source of ultrasounds, provided a significantly broader frequency range, up to 31.5 kHz. The paper presents results of the preliminary measurements of sound insulation properties of different barriers.

Wednesday 12:40-13:00, Hall Strassburg 1, Paper 0144 (invited)
Buytaert Ann
Control measurements near houses before and after installation of noise reducing devices (NRD's)

Buytaert Ann, Vanhooreweder Barbara
Agency for Roads and Traffic, Department Road Constructions, Belgium

In Flanders, a calculation model will be used to dimension Noise Reducing Devices (NRD's). The calculation can give an idea of the expected effect of the NRD's on the existing noise climate. Due to the assumptions in these calculations, possible differences with the reality cannot be excluded. To evaluate these differences, noise measurements will be carried out before and after the installation of noise barriers. The obtained results will be compared. By comparing these results, many parameters - such as the fluctuating traffic intensities and meteorological conditions – have to be taken into account. By converting these influencing factors, a realistic estimate of the effect of the NRD can be made. Experience has shown that the calculated sound reduction of a soundproof construction is usually overrated in the calculation models. In reality, the sound reduction is often less strong than the expected calculated effect.

Wednesday 14:00-14:20, Hall Strassburg 1, Paper 0949 (contributed)
Bull John
In situ measurements of airborne sound insulation of traffic noise barriers in Auckland

Bull John, Watts Greg, Pearse John
University of Canterbury, Department of Mechanical Engineering, New Zealand

The in situ measurement of the airborne sound insulation, as outlined in EN 1793-6:2012, has become a common means of quantifying the performance of road traffic noise reducing devices. Newly installed products can be

tested to reveal any construction defects and periodic testing can help to identify long term weaknesses in a design. A measurement system was developed and validated at the University of Canterbury to meet the requirements of EN 1793-6:2012. The free-field impulse response of the sound source was determined and the microphone array checked for any reflections that could influence the airborne sound insulation measurements. The system was then used to quantify the airborne sound insulation of eight road traffic noise barriers located along motorways in Auckland, New Zealand. The sample of traffic noise barriers included concrete, engineered timber, plywood, slatted timber and acrylic barriers. Test results agree with previous studies performed in Europe, and proved to be influenced by air gaps and ageing. Some of the practical aspects of performing the field measurements, such as safety, access and timing are discussed.

Wednesday 14:20-14:40, Hall Strassburg 1, Paper 0768 (contributed)
Puš Daniel
Quality analysis of noise barriers

Puš Daniel, Ládyš Libor, Matoušek Aleš
EKOLA group, spol. s r.o., Czech Republic

A frequently faced considerable practical problem is to detect and, primarily, prove wrong installation or workmanship or improper design of already completed noise attenuation structures such as road noise barriers, house noise protection facades and the like. Having detected such a weak point in a structure, it is very difficult to bring evidence to what extent and how much such a weak point will affect the overall acoustic situation. The anticipated project focuses on a realistic combination and application of two existing systems used for the visualisation of acoustic fields, namely the predictive system – 3D mathematic model system, and the measuring system – noise source localisation and identification system (acoustic cameras) for the detection and possibly demonstration of weak points in the noise protection barriers. In the framework of its coverage, the project explored noise protection barriers structures along roads and possible effects on the noise-protected areas in practical and real cases.

Wednesday 14:40-15:00, Hall Strassburg 1, Paper 0747 (contributed)
Ng H. T.
Noise barrier with acoustical cavity structure

Ng H. T., Tang S. K., Choy Y. S.
Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong

A noise barrier proposed in this paper which is based on the working principle of resonance in cavity and coupled with the edge effect of noise barrier. This barrier can provide significant noise attenuation for low frequency noise. The geometry of barrier is a kind of hollow round top edge barrier with slit on its edge and a cavity is then formed inside the top edge of barrier. Numerical simulation by Finite Element Modeling Method is done to predict the performance of barrier. Experiments with scale down model are carried out to compute the performance of barrier. The results show that this resonator barrier provides a high insertion loss on a specific range of low frequency noise in shadow zone.

Wednesday 15:00-15:20, Hall Strassburg 1, Paper 0764 (contributed)
Reiter Paul
Sonic crystals as advanced material for noise barriers

Reiter Paul[1,2], Gasparoni Sara[1], Haider Manfred[1], Conter Marco[1]

[1] AIT Austrian Institute of Technology
[2] Institute of General Physics, Vienna University of Technology

With sonic crystals it is, analog to photonic crystals, possible to produce band gaps. These acoustic band gaps are the reason why sonic crystals are almost opaque for a certain frequency range, while not influencing other parts of the acoustic spectrum. These properties make sonic crystals very interesting for noise protection. The main focus of this paper stands on the open source simulation methods, which were used to investigate the properties of sonic crystals. Therefore two-dimensional simulations were performed to get angular dependent transmission coefficients and sound attenuations for a test noise barrier. The two mainly used open source computer simulation tools were Elmer and openBEM. Elmer is a complete FEM multiphysics suite and openBEM is a boundary element solver specifically designed for the Helmholtz equation.

Wednesday 15:20-15:40, Hall Strassburg 1, Paper 0036 (contributed)
Bengtsson Henrik
NOISUN – Noise barriers with sun energy production for district heating system

Bengtsson Henrik[1], Persson Martin[2]
[1] Municipality of Lerum SE, Sweden, [2] SP – Technical Research Institute of Sweden

Noise exposure is a considerable environmental problem. Noise management is of increasing importance to human health and quality of life. Over two million people in Sweden are exposed to traffic noise exceeding 55 dB. The Swedish municipality of Lerum is divided by major transport thoroughfares for both road and rail traffic. In addition to tackling noise pollution, the municipality aims to invest in energy-saving and renewable energy technology in order to cut the emissions of greenhouse gases by 2050. The project will demonstrate innovative noise barriers producing solar energy for distribution to local district heating systems, hence an environmentally sound technology. This will be achieved by installing and evaluating specially adapted solar collectors at a major transport thoroughfare for both road traffic and rail in Lerum, which has been identified as the most suitable location. The noise barrier effect will be evaluated by measurements and a questionnaire on perceived noise annoyance both before and after the barrier has been built. The number of properties and people with noise levels above the guideline value of 55 dB is expected to reduce by 60-90 percent and noise levels are expected to reduce by 5-10 dB. Solar collectors are expected to produce somewhat 250 000 kWh of heat at 75 ºC to the district heating per year. Reduction of costs associated with noise of SEK 630 000 – 945 000 per year and an increase in the value of properties of 5% is expected.

SS34 Industrial Noise, Construction Noise

Chair: Hantschk Carl-Christian, Previati Guido

Wednesday 08:20-08:40, Hall Strassburg 2, Paper 0213 (contributed)
Lissek Hervé
Development of electroacoustic absorbers as soundproofing solutions for an industrial ventilation

Lissek Hervé[1], Desarnaulds Victor[2]

[1] Ecole Polytechnique Fédérale de Lausanne, EPFL STI IEL LEMA, Switzerland
[2] EcoAcoustique SA, Switzerland

In many industrial environments, room and cavity modes may severely strengthen the annoyance of low frequency noises, such as in ventilation equipments. Moreover, there is an obvious technological gap in the state-of-the-art relative to low-frequency soundproofing, and the only potential solutions basically take the form of heavy and bulky bodies, that can be practically impossible to implement in real situations. With a view to reducing the low-frequency annoyance, in the range of 30 Hz, resulting from the general ventilation system of the CHUV (University Hospital of Vaud Canton) in Lausanne, a prototype of electroacoustic absorber has been developed, consisting of closed-box loudspeakers connected to electric shunt resistances, acting as efficient low-frequency sound absorbers. A numerical model has first been developed and challenged with in-situ measurements. Then the electroacoustic absorber design has been optimized, and theoretical performances have been verified.

Wednesday 08:40-09:00, Hall Strassburg 2, Paper 0288 (contributed)
Yamaguchi Koji
Noise propagation using enclosed demolition method for high-rise buildings

Yamaguchi Koji[1], Masuda Kiyoshi[1], Utsugi Junichi[2], Nagata Atsuyoshi[2], Ichihara Hideki[1], Umetsu Kyoichi[1]

[1] Technology Center, Taisei Corporation, Japan, [2] Environmental Division, Taisei Corporation, Japan

The enclosed demolition method for high-rise buildings utilizes the existing roof to ensure less noise is propagated in the neighborhood than with the conventional demolition method, which doesn't utilize the roof. In order to determine how much noise is propagated, various measurements and

numerical analyses using extended energy integral equations were compared. The results confirmed the prediction accuracy of numerical analysis. Using these analyses, noise propagation in the cases of enclosed and conventional demolition methods were compared.

Wednesday 09:00-09:20, Hall Strassburg 2, Paper 0327 (contributed)
Trompette Nicolas
Determination of acoustic characteristics of pneumatic exhaust silencers: a new procedure

Trompette Nicolas[1], Vauquelin Elodie[2], Pepin Henri[2], Carniel Xavier[2]
[1] INRS, France, [2] CETIM, France

This paper describes the development of a standard test procedure for assessing the acoustical efficiency of pneumatic exhaust silencers. Such silencers are usually tested by their manufacturers using the ISO 6358 standard which aims to determine flow-rate characteristics. Manufacturers would also like to take advantage of existing ISO 6358 test benches to characterize the acoustical behavior of the silencers. Tests were carried out on 40 silencers to assess the number of microphones that are necessary to measure radiated noise. Additional tests were performed to determine the influence of the room. A relationship between pneumatic pressure decay and noise decay was established, making it possible to determine radiated noise as a function of test pressure. Thus, the new test procedure will provide the end-user with the mean acoustic level at 1 m depending on operating pressure. This procedure will be proposed for standardization.

Wednesday 09:20-09:40, Hall Strassburg 2, Paper 0340 (invited)
Junker Fabrice
ANIME3D: A full 3D method for calculating the impact of industrial noise on the environment

Junker Fabrice
EDF R&D – Département Analyses Mécaniques et Acoustique (AMA), France

The prediction of industrial noise impact on the environment has to consider numerous sources and large distances. Though, realistic situations have to be studied with a reasonable calculation cost. This is achieved by using engineering methods based on geometrical approaches. For many years now, such methods have been developed based on 2D approaches, first of all

to deal with transportation noise and then extended to industrial noise in a more or less straightforward way. However, industrial noise has specific features. Among them, especially due to the limited size of the sources, 3D effects have to be taken into account. Moreover, it should be noticed that, today, no available method has fully specified its geometrical part. The aim of this paper is to present an acoustical method called ANIME3D including a 3D optimized ray tracer and acoustical calculations able to deal with 3D multiple diffractions and reflections, an inhomogeneous ground and meteorological effects, in a reasonable computation time. ANIME3D will be soon available in the Code_TYMPAN open source software.

Wednesday 09:40-10:00, Hall Strassburg 2, Paper 0358 (contributed)
Fernández Otero Luis A
Prediction of noise levels in closed industrial plants

Fernández Otero Luis A.[1], Sobreira Seoane Manuel A.[2], González Cespón José L.[3], Vilán Vilán José A.[1]

[1] Department of Mechanical, and Engine thermal, and fluids Engineering Escola Enxeñeria Industrial, Vigo University, Spain, [2] Department of Signal Theory and Communications, Vigo University, Spain, [3] Department Engineering Design, Escola Enxeñeria Industrial, Vigo University, Spain

In this paper, the prediction of noise levels inside industrial plants using empirical equations is discussed. The noise levels calculated using different equations found in the literature on industrial noise, are compared to real measurements taken in different points of a real industrial plant. For the test case it has been found that when using the equations found in the literature, the predicted noise levels are lower than the measured levels. It seems that the general underestimation of the noise level should be due to a factor that is not being considered. In the paper, the possible contribution of the diffracted sound in the measurement points is checked. The diffracted sound on the geometry of the production lines is calculated using BEM and the equations rearranged to include this term. The corrected calculations are finally compared to the measurements.

Wednesday 11:00-11:20, Hall Strassburg 2, Paper 0389 (contributed)
Ahn Sung Jon
Case studies of thermoacoustic vibration of burner/furnace systems in oil fired boilers using transfer matrix method

Ahn Sung Jon, Ha Jin Woog, Ju Young Ho, Kim Cheol Hong
Doosan Heavy Industries and Construction, Korea

Strong thermoacoustic vibration has been occurred in oil fired utility boiler due to the effect of large temperature differential in burner/furnace system. Rijke and Sondhauss tube models were used for thermoacoustic vibration which simply predicted vibration by only using two differential conditions, cold and hot. In this study, transfer matrix method was applied to improve the accuracy of the analysis. It consists of transfer matrices which are several changes in cross sectional areas, temperature gradients, diffusion flame models. Thermoacoustic vibration is evaluated by complex frequencies of global matrix which is the combination of transfer matrices. Three cases were performed by using transfer matrix model of burner/furnace system. As a result, transfer matrix model has proved more accurate result compare to the result of Rijke/Sondhauss tube models. To validate transfer matrix method, test in actual oil-fired boilers will be performed.

Wednesday 11:20-11:40, Hall Strassburg 2, Paper 0430 (invited)
Squadrone Giuseppe
Piping design according to international codes to prevent acoustically induced vibration fatigue failures

Squadrone Giuseppe, Brunazzo Edoardo, Piccione Emanuele
TECNIMONT S.p.A., Italy

Since the issue of pipe fatigue failures caused by acoustically induced vibrations (AIV) was formerly recognized, analyzed and widely documented by Carucci and Müller in 1982, on the basis of their experiences on operating industrial plants, progresses have been m ade both in the elaboration of more reliable methodologies for risk assessment and in the optimisation of preventive measures. At present, there are two majorly recognised methodologies for AIV risk assessment. First one employs the criteria of Sound Power Level “Limit Curve” versus pipe geometrical parameters and the latter is based on the “Likelihood Of Failure”’ criterion, with or without the support of FEM analysis at pipe discontinuity. Other assessment methodologies have been developed taking into acc ount the piping dynamic local stress or the

overall piping system modal response and are proficiently practised by various acknowledged companies. Above methodologies are customarily applied by Tecnimont in AIV risk assessment. Additionally this contribution discusses how the combined use of dedicated international codes such as ASME Sec. VIII, enables to carry out piping design, in terms of stress, number of cycles to fatigue failure and appropriate stress concentration factors, both for connections and fo r supports.

Wednesday 11:40-12:00, Hall Strassburg 2, Paper 0460 (contributed)
Noguchi Eiji
Examination of Noise Environmental Improvement Effect Near an Intersection by the Spread of Eco Car

Noguchi Eiji[1], Mori Hishou[1], Yoshida Motoomi[1], Kokusho Masami[1], Nagaoka Hironori[1], Ueta Tomotaka[1], Ishikawa Kenichi[1], Kabashima Shirou[2]

[1] Oriental Consultants Co., Ltd., Japan, [2] Benec Vibration and Sound Institute Inc., Japan

The targets of this research are to model the measurement result of power level of velocity dependence and to examine noise environmental improvement near an intersection by the spread of eco car. The measurement of electric vehicle revealed that there was not difference in the motor sound between at the time of regular run and acceleration run. It suggests that the electric vehicle noise is composed by fixed level motor sound and velocity dependent tire sound. Eco car had more noiseless engine sound compared with general vehicle.It is because the electric car is driven by only the motor in acceleration running in low-speed area.Therefore the spread of eco car has possibilities to contribute to the improvement of noise environment near an intersection.

Wednesday 12:00-12:20, Hall Strassburg 2, Paper 0554 (contributed)
Yasuhiro Honda
Noise reduction of tunnel blasting with acoustic tubes

Yasuhiro Honda, Mitsutoshi Watanabe
Obayashi Corporation Technical Research Institute, Japan

This paper presents a development of a blasting sound reducer which attenuates low-frequency blasting sound in a tunnel with acoustic tubes. Blasting generates broadband and huge energy instantaneously, and the sound

has an effect on the surrounding sound environment. Many kinds of measures have been used to reduce the sound, for example thick concrete or sand-filled type soundproof doors. However, it is necessary to pay attention to the surrounding environment because low-frequency sound is hard to reduce in tunnels. In addition, low-frequency sound may shake windows and doors. We have developed a low-frequency sound reducer for a tunnel, which applies the resonance of a 1/4 wave length acoustic tube. Tubes have been known to attenuate the effect of noise, as with automotive mufflers. However, it has never been applied to blasting noise, since a huge tubular silencer is necessary. The performance of the reducer was verified in a construction site. The silencer reduces low-frequency sound by at least 15dB.

Wednesday 12:20-12:40, Hall Strassburg 2, Paper 0986 (contributed)
Granneman Jan H.
Construction noise: overview of regulations of different countries

Granneman Jan H.
Peutz bv, The Netherlands

Regulations for the control of construction noise to the environment are often based on a balance between the interests of those who want to build and possible annoyance by neighbors near the building site. The value of these building activities for society is commonly recognized. However, people exposed to the involved noise emission expect a responsible approach from local authorities and builders. To minimize the annoyance of such activities an integral approach is necessary, taking into account practicable mitigating measures and acoustical optimization of location and period of time, especially for loud construction activities and equipment. This paper gives an overview of the way different countries regulate construction noise. Specific considerations for noise limits are described.

SS35 Noise from Recreation-, Entertainment- and Sporting Facilities

Chair: Maly Thomas

Wednesday 14:00-14:20, Hall Strassburg 2, Paper 0023 (contributed)
Zhang Xuetao
Measuring noise emission of snowmobiles

Zhang Xuetao
SP Technical Research Institute of Sweden, Sweden

In 2012, the noise emission of two typical snowmobiles, one with a two-stroke engine and the other with a four-stroke engine, was measured under different operating conditions: (1) immobile: at the idling engine rpm, or at a high rpm just below the engagement, or at one in between; (2) immobile: with engine rpm swept from the idling rpm to the high rpm; (3) cruise-by at a constant speed of 25, 50 or 75 km/h; (4) pass-by at full throttle. Moreover, the noise emission data of four snowmobiles collected in 2009 by SP, and the data found in literature, were also referred to when making the data analysis. Based on the data analysis, it was found that the driveline noise is negligible compared with the power-train noise when the trail is soft. And, the rpm (when immobile) or speed (when in motion) dependency of the power-train noise can be described by 25*log10(X), where X is either for rpm or for speed. Therefore, the sound power level (SWL) of snowmobile noise, of which in most situations the power-train noise dominates, can empirically be modelled by applying this rpm/speed dependency together with a SWL value determined at a typical rpm/speed.

Wednesday 14:20-14:40, Hall Strassburg 2, Paper 0336 (contributed)
Schermer Frans
Reduction, tonal assessment and monitoring of motocross noise

Schermer Frans
Peutz bv, The Netherlands

Measurements were carried out in order to determine the effect of improved exhaust silencing of motocross bikes. Based on the measurement results the Dutch motorsport federations reduced the prescribed pass-by noise level at 7.5 m to 94 dB(A), 4 to 6 dB(A) lower than the preceding noise limits. A survey was carried out in 2012 in order to determine the effect of the 94 dB(A) noise limit on the sound power level emitted by motocross courses. The results of this study show that an average reduction of the sound power level

of 3 to 5 dB(A) is realistic. The audibility of tones in motocross noise has been assessed, using ISO 1996-2, Annex C. The analysis shows that motocross noise should not be characterized as tonal noise. A new monitoring system has been developed, using two microphones, with a mutual distance of 15 m. The average pass-by noise level at 7.5 m is calculated from the two signals and linked to the driver by means of a transponder system. The noise and transponder data are wirelessly transferred to a computer or mobile device, so the monitoring system can be used to guard the noise limits given by the environmental permit.

Wednesday 14:40-15:00, Hall Strassburg 2, Paper 0434 (invited)
Christner Matthias
Consideration of complex loudspeaker setups, including phase effects in the frame of environmental noise predictions on the basis of the ISO 9613-2 and the Nord2000

Christner Matthias[1], Schaal Jochen[2], Zollitsch Dieter[3], Zuleeg Ralf[1]

[1] d&b audiotechnik GmbH, Germany, [2] SoundPLAN International LLC, Germany, [3] Braunstein + Berndt GmbH, Germany

One of the main goals of a perfect loudspeaker layout is to have equal sound distributions all over the spectator area. Modern setups achieve this by the positioning of the speaker arrays, time delays, the directivities due to the speaker chassis, but also due to coherency effects. Loudspeaker manufacturer like d&b audiotechnik GmbH do support their customers with planning tools such as ArrayCalc to predict the sound distribution in the spectator area, taking into account all of the above described effects. In the frame of approval procedures, for example for large open air events it is necessary to predict the sound levels in the surrounding for larger distances. Unfortunately the available tools are made for short distances and are not applicable since they are not considering ground or meteorological effects and reflections or screening is not treated. For this reason the implementation of the ISO 9613-2 [2] and the Nord2000 [3] in the noise mapping software SoundPLAN® was extended to consider such specific loudspeaker setups. During a validation process this implementation was cross checked for short distances against the well introduced planning software ArrayCalc. For long distances the validation process is still ongoing on the basis of real field measurements.

Wednesday 15:00-15:20, Hall Strassburg 2, Paper 0850 (contributed)
Da Silva R.
Noise generated by late-night establishments: a new monitoring and management tool

Da Silva R., Mietlicki F., Sineau M.
Bruitparif, Noise Observatory in Ile-de-France, France

In France, the application in 2008 of the smoking ban in public places increased tensions between the owners of late-night bars and residents due to noise nuisance issues. The City of Paris is required to solve conflicts related to the use of public space between the stakeholders of cultural life, their customers, and local residents, and to try to provide solutions that meet the needs of all parties. In this context, with the cooperation of the City of Paris, Bruitparif led a pilot experiment on rue Jean-Pierre Timbaud, in the 11th arrondissement of Paris. The noise generated on the street by the activity of four bars was monitored for six months, from May to October 2012, with five innovative noise measuring devices. This monitoring system allowed us to identify the noise fluctuations during the day, depending on the type of day, and to obtain objective information on the noise impact of the bars in a context of concern for social dialogue. The main objective was achieved through the development of a noise management tool, alerting the bars' owners with a SMS's in real time when threshold noise levels were exceeded. This article aims to present the results and the lessons learned during the experiment.

Wednesday 15:20-15:40, Hall Strassburg 2, Paper 0373 (invited)
Laval Julien
Line Source Arrays Frequency Contour Variation Control

Laval Julien, Montignies François, Bernard Florent
L-ACOUSTICS, France

In the past, large sound systems made of large box assemblies demonstrated poor sound efficiency due to interferences in the mid and high frequency domain. With the introduction of DOSC patented wave guide and Wave Sculpture Technology, this issue was overcome. In the 1990s, these innovations heralded the advent of Line Source Arrays, which enable more directivity control, SPL and throw capability, with a smooth and controlled frequency response. However, in order to use such technology efficiently, it is critical to understand how frequency response may vary according to the ‘border distance’ of a line array. ‘Border distance’ defines the boundary

where cylindrical wave propagation mode turns to spherical wave propagation mode at a specific frequency. When this behavior is understood, it becomes straight forward to predict frequency response variations according to different parameters such as listening distance, line source array size and curvature. These variations can thus be compensated and controlled with the use of tools based on digital filtering called ‘Array Morphing’.

SS23 Lightweight Constructions and Systems

Chair: Koujoumji Jean-Luc, Pérez Abendaño Marianna, Zeitler Bernd

Wednesday 08:20-08:40, Hall Grenoble, Paper 0147 (invited)
Crispin Charlotte
Some considerations about the “element attenuation” (Project AH+, Part 1)

Crispin Charlotte, De Geetere Lieven, Ingelaere Bart
Belgian Building Research Institute, Belgium

In building acoustics, the classical measurement of the velocity level difference for quantification of the vibration attenuation through a junction is, in the case of lightweight construction, typically overestimated. The main reason is the extra attenuation with distance due to the high damping. This attenuation of the velocity level per meter is called the element attenuation. It depends on all attenuation effects such as the damping, the panel size, the spacing of the joists, wave conversion at each butt joint and the presence of absorption material in the cavity. This article explains on how to take into account the element attenuations in the prediction of the junction attenuation and discusses several measurement results of different types of lightweight walls.

Wednesday 08:40-09:00, Hall Grenoble, Paper 0148 (invited)
Crispin Charlotte
Laboratory measurements of the new quantities necessary for the flanking transmission prediction in lightweight constructions

Crispin Charlotte, Ingelaere Bart
Belgian Building Research Institute, Belgium

The standard EN 12354-1 proposes a calculation method to predict the flanking sound transmission between rooms. These calculation formulas are however not relevant for lightweight constructions. Recently, several adaptations on how to include formulas when dealing with lightweight constructions have been proposed. These new adaptations require new input quantities to be measured in laboratory. This article presents a set of laboratory measurement results for these new parameters, measured on different kinds of junctions composed of lightweight walls. Differences between cross laminated timber walls, gypsum boards on metal frame and OSB boards on wooden frame are discussed.

Wednesday 09:00-09:20, Hall Grenoble, Paper 1114 (invited)
De Geetere Lieven
Vibration level difference measurements on a timber frame mock-up – Project AH+, part 3

De Geetere Lieven, Ingelaere Bart, Rychtarikova Monika
Belgian Building Research Institute, Belgium

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 the normalized direction-averaged vibration level difference $D_{v,ij,n}$ in a 3-room real-size timber frame mock-up have been performed in order to get input data for these new expressions. For cases where bidirectional measurements are not possible, a new expression is proposed to estimate the direction-averaged vibration level difference based on a unidirectional vibration level difference measurement.

Wednesday 09:20-09:40, Hall Grenoble, Paper 1115 (invited)
De Geetere Lieven
Flanking sound transmission measurements on a timber frame mock-up – Project AH+, part 4

De Geetere Lieven, Ingelaere Bart, Rychtarikova Monika
Belgian Building Research Institute, Belgium

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 R_{ij} and the normalized direction-averaged vibration level difference $D_{v,ij,n}$ in a 3-room real-size timber frame mock-up have been performed in order to investigate the validity and applicability of these expressions.

Wednesday 09:40-10:00, Hall Grenoble, Paper 1246 (invited)
Ingelaere Bart
Building guidelines for lightweight constructions - Project AH+, part 5

Ingelaere Bart, Van Damme Manuel
Belgian Building Research Institute, Belgium

The first biennale of the research project AH+ ("optimisation of light weight timber frame constructions") was finished in 2012. The main goals were to extend and to examine prediction methods and measurement techniques especially in the low frequencies and to develop building guidelines to obtain at least equivalent acoustic protection towards neighbour noise as with traditional heavy constructions. Part 5 of this series of presentation focusses on the improved building guidelines and on the airborne sound insulation. Using the same number of boards and materials, it is possible to greatly improve the airborne sound insulation in the lower frequencies compared to tradition building conceptions, obtaining horizontal and vertical airborne sound insulations of R'_{living}> 60 dB. The developed robust details are accompanied with checklists of do's and don'ts and comply with requirements for fire protection, building physics, structural stability, economic cost whilst respecting traditional thicknesses for walls and floors.

Wednesday 10:00-10:20, Hall Grenoble, Paper 1247 (invited)
Ingelaere Bart
Impact sound measurements on wooden floors - Project AH+, part 6

Ingelaere Bart, Wuyts Debby
Belgian Building Research Institute, Belgium

The first biennale of the research project AH+ ("optimisation of light weight timber frame constructions") was finished in 2012. The main goals were to extend and to examine prediction methods and measurement techniques especially in the low frequencies and to develop building guidelines to obtain at least equivalent acoustic protection towards neighbour noise as with traditional heavy constructions. Solutions had to comply with other requirements (fire, structural stability, economic cost, building physics, reasonable architectural dimensions, etc.). Part 6 of this series of presentations discusses constructions and performances of wooden floor constructions. It is especially difficult to obtain good low frequency impact sound insulation in the very low frequencies. The effects of different floating floor systems in combination with suspended ceilings will be discussed.

SS22 Characterization of Structure-borne Sound Sources

Chair: Fischer Heinz Martin, Gibbs Berry

Wednesday 11:00-11:20, Hall Grenoble, Paper 0910 (invited)
Gibbs Barry
Uncertainties in prediction of structure-borne sound power into buildings

Gibbs Barry
Acoustics Research Unit, University of Liverpool School of Architecture, UK

There has been a steady development of methods of measurement and prediction of structure-borne noise in buildings, particularly over the last two decades. In proposing and evaluating these methods, a major consideration has been the likely trade-off between accuracy and simplicity. Structure-borne sound transmission is a more complicated process than airborne sound transmission, but practitioners seek methods of prediction for the former, which are as straightforward as for the latter. This paper considers multi-contact sources in lightweight buildings. The findings point to the limitations of simplified methods, specifically the uncertainties likely as a result of reducing the data sets and computational effort, and the discrepancies resulting from simplifying assumptions.

Wednesday 11:20-11:40, Hall Grenoble, Paper 0796 (invited)
Bailhache Simon
Experimental validation of approximated expressions for structure-borne sound power

Bailhache Simon, Villot Michel
CSTB, France

This work aims at predicting the installed structure-borne sound power of a reference source, using approximated expressions based on equivalent quantities. The installed power level is calculated from the source equivalent free velocity and the equivalent mobilities of the source and the receiving structure. The input data are determined in third-octave frequency bands. Simplified expressions are used according to the source and receiver equivalent mobility ratio. The installed power value obtained can then be used as input data for a model predicting structure-borne noise levels on site. The reference source is characterized from laboratory measurements. The installed power is predicted for two different receivers: a heavy concrete floor and a lightweight wooden floor; their equivalent mobilities are estimated or measured. The calculated installed power values are presented

and compared to experimental results. This provides information about the accuracy of the power expressions used.

Wednesday 11:40-12:00, Hall Grenoble, Paper 0014 (contributed)
Aucejo Mathieu
Bayesian structural source identification using local generalized Gaussian priors

Aucejo Mathieu, De Smet Olivier
Structural Mechanics and Coupled Systems Laboratory, Conservatoire National des Art et Métiers, France

The reconstruction of mechanical sources from vibration measurements is known to be an ill-posed inverse problem. A classical solution to overcome this difficulty consists in including prior information on the spatial distribution of the sources to constrain the space of solutions. Among all the methods developed to this end, the Tikhonov regularization is certainly the most popular. However, it assumes a global a priori on the spatial distribution of sources. Incidentally, poor results can be obtained if a structure is subjected to localized and distributed sources. This paper aims at providing an identification methodology able to take advantage of prior local information on both the nature and location of excitation sources. For this purpose, the Bayesian framework is well adapted, since it offers a rigorous probabilistic approach to exploit our a priori knowledge on the sources to identify. The proposed Bayesian formulation is based on the use of generalized Gaussian priors, which provide a flexible way to introduce local a priori information. Practically, the resulting optimization problem is solved from a Generalized Iteratively Reweighted Least-Squares algorithm. The validity of the proposed methodology is illustrated numerically. It is especially shown that local information improves drastically the quality of the source identification.

Wednesday 12:00-12:20, Hall Grenoble, Paper 0163 (contributed)
Knöfel Björn
Structure-borne Sound Source and Transfer Path Analysis of coupled Structures using the Example of a Railway Air Conditioning Unit

Knöfel Björn, Troge Jan, Drossel Welf-Guntram, Kunze Holger, Linke Moritz
Fraunhofer Institute for Machine Tools and Forming Technology, Germany

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 (AC 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 vehicle. In a first step, forces $\underline{F}$ and accelerations $\underline{a}$ under steady-state conditions were measured on each of the six mounting brackets of the air conditioning unit. Afterwards, all of the dominant vibration sources of the unit were investigated individually concerning their contribution at each of their contact points. Finally, knowing the mobilities $\underline{Y}$ 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.

Wednesday 12:20-12:40, Hall Grenoble, Paper 0017 (contributed)
Himmel Chad
Building vibration control for high plume exhaust fans

Himmel Chad
JEAcoustics, USA

High plume dilution blowers for laboratory exhaust are commonly installed with fans and motors mounted on top of a sheet metal bypass air plenum, often without effective vibration isolation from the building structure. If the fans and motors are properly balanced, fan vibration transmitted to the building structure generally can achieve allowable tolerances for non-sensitive building spaces but can still exceed tolerances for sensitive laboratory uses. If exhaust ducts and roof penetrations are designed with passive measures to reduce fan noise transmission, and if the fan and plenum system is installed with high-deflection vibration isolation mounts to control structure-borne vibration transmission, high plume fan and plenum systems can be installed directly above sensitive laboratory spaces, achieving standard noise and vibration criteria for laboratories and lab instruments. This paper presents field-tested sound and vibration data from two laboratory facilities for forensic sciences and biological research with high plume blowers installed on the roof directly above sensitive spaces. Comparative charts of noise and vibration levels will be presented to show criteria and facility performance before and after building vibration corrections, along with diagrams and graphical illustrations of passive vibration and noise control measures.

Wednesday 12:40-13:00, Hall Grenoble, Paper 1160 (invited)
Vogel Albert
Application of the two-stage method on the characterization of different structure-borne sound sources and a moment actor

Vogel Albert[1], Kornadt Oliver[1], Wittstock Volker[2], Scholl Werner[2]

[1] Technische Universität Kaiserslautern, Germany
[2] Physikalisch Technische Bundesanstalt Braunschweig, Germany

Service equipment in residential and office buildings can be annoying if it produces noise. In this case, structure-borne sound of these sources has to be considered. To avoid noise, a prediction and calculation of structure-borne sound is required. The source-specific parameters: source mobility, free velocity and blocked force can characterize the source and can be used for the prediction of structure-borne sound in buildings. The present investigation aims at the characterization of structure-borne sound sources by using the two-stage method. Different sources were characterized and then their structure-borne sound power injected into different reception plates was predicted. Especially sources which produce moments at the receiver contact point (two displaced shakers) were examined. The measurements were performed by using shakers, fans and a compressor as sources. The reception plates were made of wooden materials, gypsum, steel and perforated metal. For calculating the sound power on the plate the measurement of the surface velocity is necessary. This measurement was carried out by a laser Doppler vibrometer as well as accelerometers.

Wednesday 14:00-14:20, Hall Grenoble, Paper 1139 (invited)
Ruff Andreas
Acoustical behaviour of lightweight solid installation walls

Ruff Andreas, Fischer Heinz-Martin
Stuttgart University of Applied Sciences, Germany

In apartment buildings, the noise from sanitary equipment is often very disturbing. Due to this fact the installation walls, where sanitary equipment is attached to, should reduce the structure-borne sound transmission to the adjacent rooms. To reduce the direct transmission inside the own living area the installation walls should have a sufficient airborne-sound insulation and also a less excitability for structure-borne sound. For the reduction of the sound transmission into the separate living areas a good flanking

insulation is also necessary. This can be realised by installation walls with an adequate mass per unit area (in Germany: 220 kg/m²). Another possibility of the transmission reduction is the decoupling of the installations walls by elastic interlayer. This is a common construction technique for lightweight walls made of solid gypsum blocks with a mass per unit area of 90 kg/m² to 140 kg/m². Within a research project gypsum walls with different densities and elastic interlayer were investigated according their acoustical applicability as installation walls with special consideration of structure-borne sound. The results were also compared to a typical heavyweight installation wall made of calcium silicate. Additionally the characteristics of sanitary installations as structure-borne sound sources were taken into consideration.

Wednesday 14:20-14:40, Hall Grenoble, Paper 0261 (contributed)
Ishak Saiddi A.F.M.
Modeling & experimentation of vibration transmission through an angled joint

Ishak Saiddi A.F.M., Horner Jane L., Walsh Stephen J.
Department of Aeronautical & Automotive Engineering Loughborough University, UK

Analysis of vibration transmission and reflection in beam-like engineering structures requires better predictive models in order to further optimize structural behavior. Various studies have used flexural and longitudinal structural wave motion to model the vibrational response of angled junctions in beam-like structures, in order to better understand the transmission and reflection properties. This study considers a model of variable angle joint which joins two semi-infinite rectangular cross-section beams. In a novel approach, the model allows for the joint to expand in size as the angle between the two beams is increased. Thus, making the model a good representative in wide range of angles. Predicted results are compared to an existing model of a joint between two semi-infinite beams where the joint was modeled as a fixed inertia regardless of the angle between the beams, thus limiting its physical representation, especially at the extremes of angle. Results from experimentation were also compared to the modeling, which is in good agreement for the range of angles investigated. Optimum angles for minimum vibrational power transmission are identified in terms of the frequency of the incoming flexural or longitudinal wave. Analysis of the effect of changing the joint material properties is also reported.

Wednesday 14:40-15:00, Hall Grenoble, Paper 0447 (invited)
Späh Moritz
Correlation between subjective and objective parameters of impact noise sources in wooden buildings

Späh Moritz, Liebl Andreas, Weber Lutz, Leistner Philip
Fraunhofer Institute for Building Physics, Germany

In the recent past, multi-storey wooden buildings are increasingly built in many European countries. Since years it is known that especially in wooden buildings the correlation between the standardized measuring and evaluation methods using the tapping machine and the human perception of impact noise can be poor. For wooden floor constructions it is rather difficult to fulfill given requirements. But even when they are met, low frequency transmission is still a main cause of complaints. In the AcuWood project measurements and recordings on different wooden floor constructions and one concrete floor, equipped with different floor coverings, were performed. Additionally to the standardized tapping machine, other technical impact sources as well as "real" sources were employed. On this database listening tests with subjective ratings of the signals were correlated to many single number descriptors, including standardized and non-standardized proposals. The analysis of the data gives answers to the questions which technical impact noise source is most appropriate to represent walking noise and which single number rating system is a good predictor for annoyance. Additionally, the data can be used to evaluate given requirements in terms of percentage of annoyed persons for the suggested single number ratings.

Wednesday 15:00-15:20, Hall Grenoble, Paper 0059 (contributed)
Chen Kean
A fast algorithm for synthesizing impact sounds of damped plates

Chen Kean, Zhang Bingrui, Yan Shenggang, Ma Xiyue
Department of Environmental Engineering, School of Marine Engineering, Northwestern Polytechnical University, China

A fast algorithm which combines finite-difference time-domain (FDTD) and modal expansion method (MSD) is given based on the ball-plate collision model, in order to synthesize transient sounds of damped plate. In the hybrid method, FDTD is used to solve the ball-plate interaction process, and MEM is used to solve the free vibration of the plate. Finally, the calculation results using the hybrid method and that of FDTD for simply supported rectangular

plate are compared. The results show that, the hybrid method has a prominent advantage in computing efficiency, and the result is good agreement with those of FDTD.

Wednesday 15:20-15:40, Hall Grenoble, Paper 0989 (invited)
Scheck Jochen
Impact sound transmission from decoupled heavy stairs

Scheck Jochen[1,2], Fischer Heinz-Martin[1], Taskan Emre[1], Fichtel Christoph[2]
[1] Hochschule für Technik Stuttgart, Germany, [2] STEP GmbH, Germany

With respect to a given excitation e.g. by the standard tapping machine, vibrating stairs can be treated as sources of structure-borne sound. To improve the impact sound insulation heavy stairs are usually decoupled from the building using resilient supports. In many countries in Europe (e.g. in Germany) this is actually required to meet legal requirements. However, at present there are no standard procedures available neither for measurement in the laboratory nor for the prediction of the impact sound transmission in buildings. Investigations on decoupled stairs and landings have been carried out in a building-like staircase test facility in order to identify and quantify the parameters that are relevant for the sound transmission. It could be shown that the modal behavior of the stair components and the characteristics of resilient elements with respect to the static load have to be considered. Based on the results a standard test method is proposed that gives data that can be used to predict the sound transmission in buildings using EN 12354-2.

SS68 Applied psychoacoustics of machinery noise

Chair: Kuwano Sonoko, Fastl Hugo

Wednesday 08:20-08:40, Hall Igls, Paper 0916 (invited)
Fastl Hugo
Psychoacoustic aspects of noise from wind turbines

Fastl Hugo, Menzel Daniel
AG Technische Akustik, MMK, TU München, Germany

Wind turbines play an important role in the present discussions on sustainable generation of energy. However, sometimes the noise produced is regarded as a serious drawback. Therefore, in a pilot study some psycho- acoustic aspects of noise from wind turbines were investigated. The dependence of annoyance ratings on level and fluctuation of the digitally processed sounds was assessed in a laboratory setting. Moreover, in order to get some ideas about possible audio-visual interactions, in addition to the sounds also videos of a moving wind turbine at different distances were presented. Results show that, as expected, annoyance ratings were correlated with level and, to some degree, with fluctuation, but only three of thirteen subjects showed signs of audio-visual interaction.

Wednesday 08:40-09:00, Hall Igls, Paper 1228 (invited)
Florentine Mary
Importance of microscopic and macroscopic psychoacoustical approaches: an example from binaural loudness constancy

Florentine Mary
Matthews Distinguished University Professor, Department of Speech-Language Pathology and Audiology (106A-FR) with joint appointment in the Department of Electrical and Computer Engineering, Northeastern University, USA

Ideas and concepts acquired over several decades come together in this paper on the topic of the importance of a diverse methodological approach to understanding human perception. Although couched in the topic area of loudness, the thoughts presented in this chapter have general applicability to a wide range of areas, such as the importance of understanding the theoretical assumptions underpinning a research topic, and the complex nature and interconnections among various areas of study. As an academic discipline, psychoacoustics remains broadly defined and is the international and interdisciplinary study of the relation between physical, acoustic stimuli

and the psychological responses to which they give rise. Psychoacoustics includes all perceived sounds in all environments, which are best studied with a combination of microscopic and macroscopic approaches. A microscopic approach entails strict stimulus control under laboratory conditions, whereas a macroscopic approach entails a complex stimulus environment typical of daily environments. When research from microscopic studies alone is used to infer perception in daily environments, errors arise—as in the case of binaural loudness summation and binaural loudness constancy. Listening to speech via earphones with both ears is clearly louder than listening with only one ear (i.e., binaural loudness summation). Listening to a person speaking in a typical room with both ears is usually not louder than when listening with only one ear (i.e., binaural loudness constancy).

Wednesday 09:00-09:20, Hall Igls, Paper 0308 (invited)
Keilhacker Peter
Subjective evaluation of effectiveness of noise abatement measures using ratio scaling

Keilhacker Peter, Hellbrück Jürgen
Catholic University Eichstätt-Ingolstadt Department of Work, Environmental- and Health Psychology, Germany

The study adresses the question, if subjective estimations of loudness reductions of noise abatement measures can be predicted from the loudness expressed in Sone. 30 persons had to answer the question: “How much softer is the attenuated noise compared to the not attenuated noise?” Estimations were made on a scale ranging from zero to 100% remaining loudness. The not attenuated noise consisted of recordings of various noise sources like road traffic noise, railway noise, brushcutter. The attenuated versions (e.g. auditory impression behind a noise barrier) of the respective noise sources were created using auralization. The ratio of the sone values (N5) of the attenuated and not attenuated noise was calculated to predict the judgments (e.g. 50% if ratio attenuated/not attenuated is ½). The subjective estimations of remaining loudness were about 15% higher than the predicted values. Because the values of the predicted remaining loudness of all auralizations were between 0 and 35 % the distribution was right-skewed. It was assumed that this uneven distribution caused the discrepancy between predicted and empirical values. Using an even distribution in a second experiment the discrepancy declined to about 8%, which coincides with former results regarding ratio scaling of loudness of noise.

Wednesday 09:20-09:40, Hall Igls, Paper 0727 (invited)
Töpken Stephan
Preference and loudness judgments of multi-tone sounds and their relationship to psychoacoustical metrics

Töpken Stephan, Weber Reinhard
Carl von Ossietzky University Oldenburg, Acoustics Group, Germany

In sound quality assessments it is often of interest to find objective, algorithm based psychoacoustical descriptors reflecting the results from listening tests. In this paper psychoacoustic metrics are compared with the results of subjective loudness and preference judgments. In separate experiments the points of subjective equality (PSEs) for loudness and for preference are determined for multi-tone test sounds as level differences compared to a fixed reference sound. The spectral content of the overall 25 test sounds, each consisting of up to 460 partials, is varied. For this set of test sounds the values of six loudness and six other psychoacoustic metrics are ca lculated as possible descriptors. The metrics include the existing standards for the loudness of stationary and time variant signals as well as roughness, fluctuation strength, sharpness and tonality measures. The results show that the subjective loudness judgments are best reflected by loudness values based on the DIN 45631/ISO 532-standard for stationary signals. The preference judgments are best reflected by the sharpness metrics.

Wednesday 09:40-10:00, Hall Igls, Paper 0825 (invited)
Hashimoto Takeo
The loudness of double impulsive sounds

Hashimoto Takeo[1], Sekiguchi Kenji[1], Hatano Shigeko[1], Kuwano Sonoko[2], Namba Seiichiro[2]
[1] Seikei University, Japan, [2] Osaka University, Japan

The loudness of double impulsive sounds was evaluated through the method of adjustment by varying various parameters such as durations, stimulus intervals and envelope patterns. As a result, loudness of double impulsive sounds varies due to the variation of the parameters under the constant energy of the single impulsive component by which double impulsive sounds were constructed. After this investigation, subjective pattern of double impulsive sounds were investigated by obtaining the temporal masking pattern. As a result, the temporal envelope pattern of the double impulsive sounds varied systematically according to the variation of the various

parameters constructing the impulsive sounds. This variation of the temporal envelope pattern explained well with the variation of loudness.

Wednesday 10:00-10:20, Hall Igls, Paper 0472 (invited)
Schlittenlacher Josef
Psychoacoustic evaluation of gear noise using category ratings of multiple attributes

Schlittenlacher Josef, Ellermeier Wolfgang
Applied Cognitive Psychology Unit, Technische Universität Darmstadt, Germany

Increasing customer demand and softer motors which do not mask the sound of gear units any longer have increased interest in the perceived quality of gear sounds. In the present study, listeners were asked to rate more than 50 sounds recorded from industrial gear units with respect to 16 auditory attributes. These included com- mon psychoacoustic descriptors like loudness, pitch, sharpness, and roughness, but also machinery-specific verbal descriptors like howling, droning or rattling noise, all rated on seven-point category scales. Annoyance highly correlated with ratings of loudness, sharpness and to a lesser extent with tonality, but not with roughness. The verbal descriptors were either predicted by a combination of some of the more basic psychoacoustic parameters or did not seem to apply to the sample of gear sounds investigated at all. The results further show that loudness ratings highly correlate with values calculated by common standards, sharpness ratings correspond well to the Aures model and roughness ratings can be predicted appropriately by at least two pertinent models.

Wednesday 11:00-11:20, Hall Igls, Paper 0654 (invited)
Sottek Roland
A new hearing model approach to tonality

Sottek Roland, Kamp Fabian, Fiebig André
HEAD acoustics GmbH, Germany

The perception and evaluation of sound events is significantly influenced by prominent tonal sound components. The psychoacoustic parameter tonality was introduced in order to quantify the perception of tonal content. However, existing methods for tonality calculation show problems when applied to technical sounds. This article presents a new approach to tonality calculation, which comprises a hearing model. In accordance with recent

research results, the calculation of tonality is therein performed upon the basis of the partial loudness of tonal content.

Wednesday 11:20-11:40, Hall Igls, Paper 0569 (invited)
Morinaga Makoto
The contribution of event noises to overall noisiness in relation to time interval of intermittent noise

Morinaga Makoto[1], Tsukioka Hidebumi[1], Kaku Jiro[2], Kuwano Sonoko[3], Namba Seiichiro[3]

[1] Defense Facilities Environment Improvement Association, Japan, [2] Kobayasi Institute of Physical Research, Japan, [3] Osaka University, Japan

The effect of time interval between event noises on the overall noisiness of aircraft noise has been examined by carrying out psychological experiments. Intermittent noises composed of aircraft noise for event noise and soft road traffic and railway noise for ambient noise were used as stimuli. The total duration of a stimulus was fixed in our previous experiment reported at Inter-noise 2012. In the present study, the time interval between aircraft noises was varied by changing the total duration of stimuli and kept the number of aircraft noises equal. Two kinds of experimental conditions were set up, which were the condition of equal L_{Aeq} of each stimulus and the condition of equal L_{AE} of each aircraft noise. Participants were requested to judge the instantaneous and overall noisiness using 'Method of continuous judgment by line length'. The results suggest that the time interval between aircraft noises may have an effect to mitigate the contribution of aircraft noises to overall noisiness. This is the similar result to the result of our previous experiment. It was also found that the slope of the function between L_{Aeq},100ms and instantaneous noisiness judgment of aircraft noise was steeper than that of background soft road traffic noise.

Wednesday 11:40-12:00, Hall Igls, Paper 0177 (invited)
Yamada Tomomi
The effect of hearing ability up to 16 kHz on the unpleasant feeling of the sound of a dental drill

Yamada Tomomi[1], Kuwano Sonoko[2], Ebisu Shigeyuki[1], Hayashi Mikako[1]

[1] Department of Restorative Dentistry and Endodontology, Osaka University 1-8, Japan
[2] Osaka University, Japan

Drilling sound at dental clinics has an influence on sound environment and it has high frequency components up to 20,000 Hz. It is well known that hearing ability is age-related. In this study, 59 respondents of three groups, i.e. 22 teenagers aged between 12 and 17, 23 young adults aged between 21 and 39, 14 elder adults aged between 41 and 68, participated. Their hearing thresholds were measured up to 16,000 Hz using the audiometer based on ISO 389. All the respondents judged the impression of the sounds of dental drills which had different frequency components. The effect of hearing in the high-frequency region up to 16 kHz on the subjective impression of dental noise was investigated in order to find clues to create a comfortable environment in dental clinics. The Teenagers and the Young adults in this study had good hearing ability. 73% of the Teenagers and 30% of the Young adults could hear the test tone of 16 kHz even below the reference 0 dBHL. Most of the Teenagers and the Young adults could hear high frequency components in dental drilling sound which were not detected by the Elderly people aged 40 over. It was found that unpleasant impression is affected by the respondents' hearing in the high frequency region.

Wednesday 12:00-12:20, Hall Igls, Paper 1095 (invited)
Bukovnik Monika
Psychoacoustics for railway noise – a "new" approach?

Bukovnik Monika
Rail Data Services Austria Gmbh & Co KG, Austria

The methods used today to assess noise levels of rail transport are based on sound pressure level. The results of previous experiments to determine the perception of people have shown that the disturbing effect of rail transport compared to road transport is low and as a consequence, a railway bonus of 5 dB(A) was set. These criteria are far from sufficient to describe the impact of traffic noise on people. More often this is required with laws and regulations. It is therefore necessary to develop methods which describes disturbance better than before. In this presentation developments on the perception of railway noise by humans are shown. This is also relevant so far as different perception of different sound structures has led to the introduction of the "railway bonus" which assumes that railway noise is "different". The large expansion of railway lines and the increased railway traffic has led in recent years to discuss the validity of the railway bonus. This approach – generally speaking of harmful, disturbing or adverse effects to humans – makes it possible to reduce noise for residents systematically and to increase the

acceptance of freight trains in the night and to improve more economic rail services.

Wednesday 12:20-12:40, Hall Igls, Paper 0590 (contributed)
Gwak Doo Young
Sound design strategy for enhancing subjective preference of EV interior sound

Gwak Doo Young[1], Yoon Kiseop[1], Seong Yeolwan[1], Lee Soogab[2]

[1] Department of Mechanical and Aerospace Engineering, Korea
[2] Center for Environmental Noise and Vibration Research, Engineering Research, Institute, Korea

In this study, sound design strategy for enhancing sound quality of EV interior noise is proposed and effectiveness of that is evaluated. In order to reduce annoyance of EV interior noise caused by its high frequency component, strategy of ‘adding lower harmonics’ was suggested. The strategy was expected to make sound more abundant and to decrease its sharpness. Following this strategy, 6 types of stimuli were composed by adding artificial sounds upon a recorded EV interior sound. Psychological experiments were conducted with 27 drivers using semantic differential method and 11-point numerical scale. Two of designed sounds were more preferred to original sound, and their sound characteristics were evaluated. A relationship between sound characteristics and subjective preference was examined.

Wednesday 12:40-13:00, Hall Igls, Paper 0656 (contributed)
Takada Masayuki
Evaluation of the perceived impulsiveness of operating noise emitted by office equipment with attachments installed

Takada Masayuki[1], Suzuki Satoshi[2], Iwamiya Shin-ichiro[1], Matsuura Kuniya[3], Yamaguchi Masahiro[3], Yoshikawa Shouichi[3]

[1] Department of Communication Design Science, Faculty of Design, Kyushu University, Japan
[2] Department of Communication Design Science, Graduate School of Design, Kyushu University, Japan, [3] Konica Minolta, Inc., Japan

Impact sounds are occasionally generated by the attachments (e.g., a punching system and document feeders) of office equipment (e.g., multifunction peripherals) in addition to the body of the office equipment generating noise and thus affect the equipment’s sound quality. To

investigate the effects of acoustic characteristics of the impact sounds of attachments on the perceived impulsiveness of the noise emitted by multifunction peripherals, psychoacoustical experiments were carried out using synthesized operating noise including impact sounds of attachments in which the spectral features, the degree of salience of the impact sounds and the cycle duration between sounds were systematically varied. The results revealed that impressions of impulsiveness increased as the energy of high-frequency components increased and the cycle duration became shorter. The perceived impulsiveness was highly correlated with an acoustic measure of the fifth percentile of the sound pressure level (L_{A5}), which was also correlated with a similar impression in a previous study. Logistic regression analysis, in which the relationship between the proportions of participants who evaluated the stimuli as bothersome and L_{A5} was investigated, revealed that L_{A5} values of stimuli that were evaluated as being bothersome by more than half the participants were around 50 dB.

Wednesday 14:00-14:20, Hall Igls, Paper 1159 (invited)
Maffei Luigi
A preliminary investigation on some psychological and acoustic aspects of wind farms' noise annoyance

Maffei Luigi[1], Masullo Massimiliano[1], Di Gabriele Maria[1], Votsi Nefta-Eleftheria P.[2]

[1] Department of Architecture and Industrial Design, Second University of Naples, Italy
[2] Department of Ecology, School of Biology, Aristotle University, Greece

In the last years the global installed capacity of the renewable energy grew at very rapid rates. Among renewable energy wind energy is one of the typologies with the most significant growth. However the Wind Farms (WF) entail environmental impact problems specially on people. The major reasons of complaints are the acoustic and visual impact. Recent researches have concluded that noise annoyance from WFs was higher than from several other noise sources at comparable noise levels. Even though the sound levels, as heard by resident, are generally lower than 50 dB(A), many people oppose to WF concluding that they have health problems caused directly by wind turbines. In quiet environments the wind blowing is one of the main sound for inhabitants and its semantic content still exist when we consider the wind turbine noise. Wind turbine noise coexist with wind noise and their relative masking changes according to the functioning conditions. In these conditions it is very difficult to establish if the complaints of residents are due to physical rather than psychological origin. In this paper are presented the

preliminary results of an auditory test in which two groups of subjects, with *chronic* and *no-chronic* exposure to wind turbine noise, have been asked to recognize, by a YES/NO questionnaire, the noise of these plants.

Wednesday 14:20-14:40, Hall Igls, Paper 0803 (contributed)
Rossi Laura
Quantification of perceived sound quality of turbo molecular pumps through psychoacoustics assessment

Rossi Laura[1], Guglielmone Claudio[1], Follo Alessandro[2]

[1] INRiM – Department of Thermodynamics, Laboratory of Acoustics, Italy, [2] Agilent Technologies Italia SpA, Vacuum Product Division, R&D Department, Italy

An experiment has been carried out on the perceived quality of a specific category of mechanical devices – the turbo molecular vacuum pumps used in industries and laboratories – from their noise emitted during the full speed functioning and the warming up phase. The test fits with a real problem of constructors that often need to manage complaints from customers returning perfectly working pumps as their sound generates a malfunction feeling. On the total number of participants (81 subjects), two groups have been selected – expert listeners and naïve – and submitted to two tests: open questionnaire during a jury test and pairs comparison. The parameters investigated through different methods have been mainly: the annoyance, the general preference and the impression of proper operation. Data analysis considers both the influence of different investigation methodologies and the correlation with classical parameters of psychoacoustics. Different models of turbo molecular vacuum pumps have been the objects of the study and a full acoustic characterization of these sources has been done.

Wednesday 14:40-15:00, Hall Igls, Paper 0695 (contributed)
Riebold Benjamin
Imaging localization of sound sources with psychoacoustic weighting

Riebold Benjamin, Neugebauer Stefan, Döbler Dirk
GFaI e.V. - Gesellschaft zur Förderung angewandter Informatik, Society for the Promotion of Applied Computer Science, Charit. Reg. Ass., Germany

Delay-and-Sum-Beamforming is a state of the art investigation technique for complex space and time variant sound sources. It has been applied to various

application fields such as product design and industrial pro- duction. The evaluation is based on a color scaled map, indicating the sound pressure level of the sources superimposed by an optical image of the setting. Nevertheless, sound pressure level does not always correspond to the sensation of hearing. One way to obtain more satisfying results, concerning the human auditory system, is weighting the sources using psychoacoustic parameters. The most widely used psychoacoustic parameters are loudness, sharpness, tonality and roughness of sounds. Psychoacoustic methods enable a more detailed evaluation of sound sources that are more suitable for hearing concerns. In the first two sections this paper gives a brief introduction of beamforming and psychoacoustic parameters. The third section presents a comparison of sound pressure and psychoacoustic based imaging localization of sound sources. Afterwards a discussion of two experiments is done. The first experiment illustrates how psychoacoustic evaluation can be used to optimize sounds. The second experiment engages problems that arise, if the psychoacoustic sensation originates from spatial separated sources.

SS48 Noise from Renewable Energy Technologies

Chair: Wittstock Volker

Wednesday 08:40-09:00, Hall Maximilian, Paper 0666 (contributed)
Tachibana Hideki
Nationwide field measurements of wind turbine noise in Japan

Tachibana Hideki[1], Yano Hiroo[1], Sakamoto Shinichi[2], Sueoka Shinichi[3]

[1] Chiba Institute of Technology, Japan, [2] Institute of Industrial Science, The University of Tokyo, Japan, [3] Institute of Noise Control Engineering, Japan

A study program titled "Research on the evaluation of human impact of low frequency noise from wind turbine generators" has been performed in the past three years from the 2010 fiscal year sponsored by the Ministry of the Environment, Japan. In this study, noise measurements have been performed in immission areas of 34 wind farms across Japan. For the survey, measurement instrumentation was contrived in order to cover the low frequencies including infrasound and measurement techniques were investigated in order to detect wind turbine noise in ambient environmental noises. Each field measurement was performed for continuous 120 hours by unattended method and the sound pressure signal was recorded on the specially manufactured sound level meter. From the recording, A-, C-, and G-weighted and 1/3 octave band sound pressure levels were obtained during the time when the wind turbines were under the rated operation condition. The swishing sound, the most serious problem in wind turbine noise, was also analyzed by putting emphasis on the modulation period and sound pressure level fluctuation. In parallel with the measurements around wind farms, 18 control areas without wind turbine noise were chosen and the environmental noise was also measured for comparison.

Wednesday 09:00-09:20, Hall Maximilian, Paper 0668 (contributed)
Fukushima Akinori
Study on the amplitude modulation of wind turbine noise: Part 1 – Physical investigation

Fukushima Akinori[1], Yamamoto Kazuhiro[2], Uchida Hideo[3], Sueoka Shinichi[4], Kobayashi Tomohiro[5], Tachibana Hideki[5]

[1] NEWS Environmental Design Inc., Japan, [2] ACT Acoustics Inc., Japan, [3] NS Environmental Science Consultant Corporation, Japan, [4] Institute of Noise Control Engineering of Japan, Japan, [5] General Research Institute, Chiba Institute of Technology, Japan

Amplitude modulation (AM) sound, so called swish sound, is generally contained in wind turbine noise (WTN) and it causes serious annoyance in the areas around wind farms. Therefore, the methods to assess the characteristics of this kind of sound should be investigated in both viewpoints, physically and psycho-acoustically. Regarding the former problem, a practical method to evaluate the magnitude of the AM using common acoustic measurement instrumentation is proposed in this paper. That is, the sound pressure level difference between the levels measured by using FAST and SLOW dynamic characteristics of a sound level meter is calculated for the measurement time interval under investigation and then the cumulative distribution function of the level difference is calculated. From the result, the value of 90% range is obtained as an indicator for assessing the AM. Statistical data evaluated by using this indicator for AM sounds contained in actual WTNs were obtained through the field measurements performed nationwide across Japan.

Wednesday 09:20-09:40, Hall Maximilian, Paper 0670 (contributed)
Yokoyama Sakae
Study on the amplitude modulation of wind turbine noise: part 2- Auditory experiments

Yokoyama Sakae[1], Sakamoto Shinichi[1], Tachibana Hideki[2]

[1] Institute of Industrial Science, The University of Tokyo, Japan
[2] Chiba Institute of Technology, Japan

Amplitude modulation (AM) sound, so called swish sound, is generally contained in wind turbine noise (WTN) and it causes serious annoyance in the areas surrounding wind farms. Therefore, the methods to assess the characteristics of this kind of sound should be investigated in both viewpoints, physically and psycho-acoustically. Regarding the latter problem, auditory experiments were performed by using a test facility capable of reproducing low frequency sounds including infrasound. As the first experiment, the fluctuation sensation caused by AM sounds was examined by using actual WTNs recorded on sites, in which the frequency components were limited in steps by low-pass filtering processing. As a result, it has been found that the fluctuation sensation is apt to cause at frequencies higher than about 125 Hz. As the second experiment, the noisiness sensation to AM sounds were examined by using artificially synthesized sounds by changing their modulation depth in eight steps. As a result, a tendency has been seen that noisiness increases with the increase of AM depth even if the time-averaged sound pressure level is the same.

Wednesday 09:40-10:00, Hall Maximilian, Paper 0395 (contributed)
Okada Yasuaki
Experimental study on the radiation characteristics of noise generated from a single wind turbine

Okada Yasuaki[1], Koichi Yoshihisa[1], Iwase Teruo[2], Higashi Kazuki[3], Nishimura Naoto[4]

[1] Faculty of Science and Technology, Meijo University, Japan, [2] Faculty of Engineering, Niigata University, Japan, [3] Kyushu Branch, Japan Weather Association, Japan, [4] Energy Use R&D Center, Kansai Electric Power Company, Japan

Also in Japan, the wind power generation facility was added to the projects subject to the Environmental Impact Assessment Law since April 2013. The investigations on noise including low frequency components at various operating wind turbine power stations have been carried out over the country. In this paper, the field measurements of noise from a single wind turbine with a rated power of 1.5 MW were made in several terms, in order to examine the radiation characteristics of noise generated from the wind turbine. The six receiving points were set circularly around the wind turbine at a height of 1.2 m above the ground, and the four receivers were mounted at heights up to 65 m on a nearby lightning tower. We have also collected meteorological and associated wind turbine operational data at one second intervals with corresponding acoustic data. As a result of this study, it has been found that the A-weighted sound pressure levels in the upwind and downwind directions of the wind turbine are almost the same and are 5 dB larger than those in the crosswind direction. The noise level distributions at distances of 50 m to 200 m are similar to the calculated values assuming the wind turbine to be a circular plane source.

Wednesday 10:00-10:20, Hall Maximilian, Paper 1128 (contributed)
van den Berg Frits
Health related guidelines for wind farms in Belgium

van den Berg Frits[1], Passchier Wim[2], Botteldooren Dick[3], Deggoui Naïma[4], Fallon Cathérine[5], Hens Luc[6], Nemerlin Jean[7], Pauluis Jean[8], Pepermans Yves[9]

[1] GGD Amsterdam Public Health Service, The Netherlands, [2] Maastricht University, Faculty of Health, Medicine and Life Sciences, Department of Toxicology, The Netherlands, [3] Acoustics Research Group, INTEC, Ghent University, Belgium, [4] Academic Hospital Saint-Luc, Université de Louvain, Belgium, [5] Université de Liège, Département de Sciences Politiques, Scientific and Public Involvement in Risk Allocations Laboratory – SPIRAL, Belgium, [6] Vlaamse Instelling voor Technologisch Onderzoek (VITO), Belgium, [7] Cedia, University of Liège, Montefiore Institute, Belgium, [8] Faculté de Médecine, Belgium, [9] Universiteit Antwerpen, Faculteit Politieke & Sociale Wetenschappen, Belgium

In 2011 the Belgian authorities have asked the Superior Health Council (SHC) to advise on the health effects of wind farms. A working group of experts with different backgrounds was put together to assess all the available literature. This group considered the request in the context of sustainable development and drafted an advice that was reviewed by two international experts. It is expected that the advice will be published in the spring of 2013. The advice mentions direct effects of operational wind turbines that may have negative consequences for the health and well-being of neighbouring people. It stresses the importance of factors such as the change in landscape, the possible intrusion on people's attachment to their environment and the effect of local economic benefits and costs associated with a wind energy project. Also, the perception of the future quality of life will determine the social acceptance of a wind project by a local community. The advice gives a number of recommendations to better deal with all these aspects. The paper will give an overview and explanation of these recommendations.

Wednesday 11:00-11:20, Hall Maximilian, Paper 0605 (invited)
Fujitsuka Tetsuro
Approaches to controlling wind turbine noise and infrasound in Japan

Fujitsuka Tetsuro, Koyama Takumi, Azuma Yasuhiro, Kuwabara Atushi
Ministry of the Environment, Japan

In Japan, expectations are recently rising with regard to the potential of renewable energy sources as the country needs to combat global warming and reinforce the security of energy supplies. In particular, wind power is drawing attention as a renewable source of energy with great potential. In recent years, an increasing number of wind turbines have been installed. However, the number of complaints about noise generated by them, including infrasound, has also increased. This situation has required the Ministry of the Environment of Japan to assess the effects of wind turbines and accumulate knowledge on how to investigate, predict and assess such noise and infrasound generated by these installations. In FY2010, the Ministry initiated studies to achieve this. One such study is being conducted by a Ministry-commissioned study group that in March 2012 submitted an interim report on optimal methods and approaches to the environmental impact assessment (EIA) of noise generated by wind power installations based on the best available evidence, including knowledge accumulated within and outside Japan, and taking into account Japan's topographic features and land use patterns. This submission was made before the revised Environmental Impact Assessment

Law takes effect in October 2012. The revised law expands the scope to include wind turbines, among other amendments. The interim report stresses the need to assess the sound propagation characteristics due to topographical features, as many of the wind power plants in Japan are located on mountain ridges. It also emphasizes the importance of ex-post evaluations to assess, if any, the adverse health effects of wind turbine noise and infrasound. The interim report will provide a valuable resource for concerned plant operators and local governments that may be responsible for EIA. It will also serve as an important reference for compiling ordinances and handbooks that the Ministry of Economy, Trade and Industry (METI) will issue, which in turn will serve as guidelines for the EIA of future wind turbine installations under the revised law.

Wednesday 11:20-11:40, Hall Maximilian, Paper 0783 (contributed)
de Beer Eugène
Assessment of low-frequency noise due to wind-turbines in relation to low-frequency background noise

de Beer Eugène
Peutz bv, The Netherlands

Assessment of low-frequency noise (LFN) is one of the aspects in the Environmental Impact Assessment for a projected wind farm at the city of Utrecht. In the Netherlands there are no legal noise limits for LFN. There are only several guidelines for the assessment of LFN. In this Environmental Impact Assessment the low-frequency noise at the dwellings due to this projected wind farm is not only calculated but also the low-frequency noise background levels has been measured during 3 months at three locations in the neighborhood of the nearby dwellings. Simultaneous the wind-speed and wind-direction have been measured. This area-specific information (low-frequency background noise at a certain wind speed and direction) has been used for the assessment of the LFN due to the projected wind farm besides a comparison with the Dutch guidelines as well as the Danish legal LFN limits. The aim of measuring the LFN is to investigate the present low-frequency background noise (due to road traffic, industry and shipping) and the possible increase of LFN annoyance due to the projected wind farm. In this paper a comparison is made between the measured background noise and the several low-frequency noise limits and guidelines.

Wednesday 11:40-12:00, Hall Maximilian, Paper 1163 (contributed)
Backalarz Claus
Calculations of indoor low frequency noise from wind turbines

Backalarz Claus, Holm Pedersen Torben, Søndergaard Lars Sommer
DELTA, Denmark

In 2011 Denmark has introduced mandatory limits for low frequency noise from wind turbines. This paper reviews the experiences and studies on low frequency noise and infrasound from large and small wind turbines, Danish rules for measuring and calculating low frequency noise and an assessment of the consequences of introducing limits for low frequency noise. It is concluded that the proportion of low-frequency noise depends more on wind turbine type and operation than its size. It is usually the "normal" noise that sets limits on how close turbines can be placed to dwellings. Infrasound from modern wind turbines is not an issue. As part of the planning of a wind farm, calculations of the noise contributions from the wind farm at the nearest residences are made. By optimizing the operation of the turbines, it is possible to achieve a significant production improvement and still comply with the limits.

Wednesday 12:00-12:20, Hall Maximilian, Paper 0681 (contributed)
Tréfois Vincent
Wind turbine noise: an efficient and reliable method for extracting the wind turbine noise out of the background noise

Tréfois Vincent, Dasse Stéphane
I.C.A [Acoustic Engineers], Belgium

Wind turbines are mostly implanted in the countryside where the background noise is usually low and at typical distances of 350 to 500 meters from the nearest neighboring dwellings. As a result, their specific noise is about the level of the background noise (typically 35 to 50 dBA) and as such difficult to extract from it. However one can take advantage of the typical wind turbine sound modulation. The method consists first in measuring and storing the time history of the short LAeq(1s) every second in continuous over the period of investigation (typically not less than 1 month if a statistical figure is to be obtained). Then the diagram of occurrences (step 0.5 dB) of these LAeq(1s) is to be plotted for each consecutive period of 10 minutes. On each graph the specific contribution of the wind turbine noise appears out of the background noise, as a group of five consecutive bands that correspond to

the typical 2 to 3 dB wind turbine sound modulation. The wind turbine noise over the 10 minutes period is then the value of the fourth band. This method has been applied and validated on 5 different sites during more than 500 measuring days in continuous.

Wednesday 12:20-12:40, Hall Maximilian, Paper 0254 (contributed)
Larsson Conny
Sound from wind turbines during different weather conditions

Larsson Conny, Öhlund Olof
Uppsala University, Department of Earth Sciences, Sweden

The meteorological conditions change over the day and the year and vary a lot depending of the terrain conditions. The meteorological parameters govern both the wind turbine emission sound level and the sound propagation conditions. Long-time measurements of meteorological effects on sound propagation from wind turbines have been performed at three sites in Sweden. The measurements have been performed during 2 years. Sound propagation is studied in a forest area, over a water bay and over heterogeneous terrain. The first two sites are located in the southern part of Sweden and the third is located in the northern part of Sweden. The aim of the project is to improve the knowledge about sound propagation from wind turbines and especially over varying terrain and different weather conditions. The hub height of the studied wind turbines varies from 80-138 m. Meteorological effects increase with distance and starts to be important somewhere between 400 m – 1000 m. Variations of 7-14 dBA at the immission point are found depending on ground conditions and refraction.

Wednesday 12:40-13:00, Hall Maximilian, Paper 0775 (contributed)
Vaucher De La Croix Daniel
RoBin: meeting the requirements of the IEC 61400-11 standard for measuring the acoustic emission of wind turbines with a one-man operated system

Vaucher De La Croix Daniel[1], Klaas T.[2]
[1] ACOEM, France, [2] WÖLFEL MessSysteme Software, Germany

Wind power becomes a real alternative to solutions based on fossil fuel as corresponding reserves diminish rapidly. Several technical challenges linked with the implementation of wind farms in numerous locations worldwide must be considered, and noise emission by wind turbines is one of these. The

international standard IEC 61400-11 and German “Technische Richtlinie für Windenergieanlagen, Teil 1” of the FGW were set up in order to unify the evaluation of noise emission of wind turbines. Measurements performed according to these standards need practical challenges to be considered, such as the installation of testing equipment and an efficient evaluation of the collected data. The proposed paper will shortly review some parts of the IEC 61400-11 standard and discuss in detail operational constraint linked with on-site measurement and how modern communication technologies help in an easy system deployment and field operation for the benefits of all users.

Wednesday 14:00-16:00, Hall Maximilian
Future Congress Technical Planners (FCTP)

Technical Programs for:
INTER-NOISE 2014, Melbourne, Australia (2014 November 16-19), [web site: http://www.internoise2014.org/]

INTER-NOISE 2015, San Francisco, USA (2015 August 9-12)
[web site: http://www.internoise2015.org]

- FCTP Meeting Agenda (Raj Singh and Charles Don)
- Overview and introduction of participants
- INTER-NOISE 2014 technical program, current plans and needs
- Q & A session, suggestions from the floor, and open discussion
- Summary of the discussion and action items
- INTER-NOISE 2013 experience
- INTER-NOISE 2015 technical program, current plans and needs
- Suggestions from the floor, and open discussion
- Closing remarks and adjourn
- Off-line and informal discussions

Link to FCTP: http://www.i-ince.org/rules4.htm
Attendees will be asked to provide their contact information (email addresses) and suggestions for technical sessions for IN 2014, IN 2015 and beyond.

Key Contacts for INTER-NOISE Congresses INTER-NOISE 2013
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SS74 Aeroacoustics

Chair: Kaltenbacher Manfred, Moon Young J.

Wednesday 08:20-08:40, Hall New Orleans, Paper 1310 (invited)
Guettler Marcus
Investigation of sound radiation and structural vibration of an automotive HVAC system

Guettler Marcus, Marburg Steffen
Universität der Bundeswehr München, Germany

Due to use of electro engines the automotive sector is facing new challenges. The masking characteristics of the combustion engine drowned noise radiation of other vibrating components. With the low noise emission of electro engines other sound sources begin to come in focus. One source is the HVAC system with its rotating fans and duct systems that radiate structure and air born sound into the interior cabin. Utilizing a Laser-Scanning-Vibrometer it is possible to analyze a common HVAC system during operation. While studying the structural vibration excited by the main fan and the flow through the duct and pipe system a microphone is recording the sound emitted in the far field. Joining this information conclusions relating vibration of components and radiated sound through coherence will help to identify main sound sources.

Wednesday 08:40-09:00, Hall New Orleans, Paper 0420 (contributed)
Hüppe Andreas
Aeroacoustic investigation of HVAC systems using perturbation equations

Hüppe Andreas[1], Reppenhagen Aaron[2], Kaltenbacher Manfred[1], Dutzler Gerhard[2], Hartmann Micheal[3], Peller Nikolaus[4]

[1] Vienna University of Technology, Austria, [2] Kompetenzzentrum – Das Virtuelle Fahrzeug, Germany, [3] Volkswagen AG, Germany, [4] Audi AG, Germany

In the cabin of modern automobiles noise is highly affected by flow related sources. Even if the car is not moving, the fan-noise and outlet of the air-conditioning system reduce the drivers comfort significantly. Even though great advances in theoretical aeroacoustics were made, the exact cause of flow induced sound is not fully understood and scientists and engineers need to rely on measurements and simulations to investigate the noise generation mechanisms. In the field of computational aeroacoustics (CAA) the analogy presented by Lighthill in the late 50's is well known and established. In the current application on the other hand, the

aeroacoustic noise is generated very close to the observer, i.e. the driver, inside a region where the acoustic field obtained by using Lighthill's analogy is superimposed by hydrodynamic quantities. CAA approaches based on a perturbation ansatz allow a better separation of flow effects and audible acoustic components inside the source region. Within our contribution, we utilize a stabilized finite element scheme to compute the aeroacoustic field of an air-conditioning outlet based upon perturbation equations (PE).

Wednesday 09:00-09:20, Hall New Orleans, Paper 1133 (contributed)
Vathylakis Alexandros
On the feedback loops of airfoil instability tonal noise subjected to trailing edge serrations

Vathylakis Alexandros, Chong Tze Pei
School of Engineering and Design, Brunel University, UK

This paper presents an experimental study of the effect of trailing edge serrations on airfoil instability noise. Detailed aeroacoustic measurements are presented of the noise radiated by an NACA-0012 airfoil with trailing edge serrations in a low to moderate speed flow under acoustical free field conditions. Because of the unique characteristics of a serrated trailing edge, the airfoil instability tonal noise was investigated by a non-wake based aeroacoustic feedback mechanism. It has been shown that the instability tonal noise generated at a moderate angle of attack could be accurately predicted by this kind of feedback loop.

Wednesday 09:20-09:40, Hall New Orleans, Paper 0257 (invited)
Li Xiaodong
Localization of airfoil self-noise sources by a virtual phased microphone array technique

Li Xiaodong, Jiang Min, Tong Weiming
Beihang University Beijing, China

Phased microphone array technique has received much attention for the localization of sound sources in various acoustic experiments. In this paper, this technique is adopted to locate airfoil self-noise sources at low Mach number and moderate Reynolds number flows based on a high order Computational Aeroacoustics (CAA) data base. Both the near-field hydrodynamics and the far-field acoustics are computed simultaneously by a

Direct Numerical Simulation (DNS) method. In particular, the time-resolved data on a virtual phased microphone array in the acoustic far field is sampled and analyzed using beamforming algorithms. The effect of the angle of attack on the acoustic source location and strength is evaluated by phased array calculations. The results show that for frequencies between 3000 and 4000Hz the dominant noise sources of airfoil self-noise is located at the airfoil trailing edge region which is independent of the angle of attack. While for relatively higher frequencies between 4000Hz and 6000Hz, the acoustic sources start to move downstream for zero angle of attack and move upstream for two and four degrees angle of attack. The strength of the acoustic sources also increases with the increasing of airfoil angle of attack.

Wednesday 09:40-10:00, Hall New Orleans, Paper 1107 (contributed)
Yokoyama Hiroshi
Direct Simulation of Effects of Free-stream Turbulence on Cavity Tone

Yokoyama Hiroshi, Odawara Hiroshi, Iida Akiyoshi
Department of Mechanical Engineering, Toyohashi University of Technology, Japan

In order to clarify the effects of the free-stream turbulence on the cavity tone, the direct simulations of flow and acoustic fields for the cavity flows were performed for the various free-stream turbulence conditions. The contributions of the sound source intensity and the coherence of the sound source in the spanwise direction for the difference of the cavity tone were investigated. The depth-to-length ratio of the cavity was D/L = 0.5 in the shallow cavity, and D/L = 2.5 in the deep cavity. The free-stream Mach number was 0.09 and the Reynolds number based on the cavity length was 4.0×10^4.The velocity profile at the location of the upstream edge of the cavity in the flow over the flat plate without a cavity was good agreement with the Blasius boundary layer. The results for the free-stream turbulence intensity 2.7 % shows that the difference of the cavity tone is 11.3 dB in D/L = 0.5, and 17.5 dB in D/L = 2.5. The analyses of the contribution clarify that the effect of the coherence of the sound source in the spanwise direction is dominant in the flow over the deep cavity (D/L = 2.5) with the acoustic resonance.

Wednesday 10:00-10:20, Hall New Orleans, Paper 0748 (contributed)
Rucz Péter
Air jet and edge tone simulation in an organ pipe foot model

Rucz Péter[1], Angster Judit[2], Augusztinovicz Fülöp[1], Lohász Máté Márton[3], Miklós András[2]

[1] Budapest University of Technology and Economics, Laboratory of Acoustics, Hungary
[2] Fraunhofer Institute for Building Physics, Group of Musical and Photoacoustics, Germany
[3] Budapest University of Technology and Economics, Dept. of Fluid Mechanics, Hungary

The sound generation of labial organ pipes is a complex physical process, since it involves fluid flow and acoustical phenomena inherently coupled. When a pipe is played air flows through the pipe foot and a thin jet of air emerges in the windway. As this jet hits the upper lip an edge tone is produced, which provides the excitation for the acoustic resonator. The edge tone and its interaction with the resonator is of key importance to the sound quality of the pipe. We report and evaluate CFD simulations of the aforementioned air jet using 2D and 3D geometries with a laminar and a Large Eddy Simulation (LES) model. In the first configuration no upper lip is present and the jet can be considered free. The quality of simulation results is assessed by means of comparison to reproducible hot wire anemometer measurements carried out on a high precision pipe foot model. With the upper lip being part of the model, the jet shows oscillating behavior around the edge. We also present flow simulation of this setup and evaluate the mode frequencies of the resulting edge tone. It is found that by extending the flow model into three dimensions the quality of CFD simulations is improved remarkably, achieving better fit to mesurement results both in the free jet and edge tone configurations.

Wednesday 11:00-11:20, Hall New Orleans, Paper 0696 (contributed)
Akishita Sadao
An analytical solution of the non-compact Green's function using conformal mapping

Akishita Sadao
Ritsumeikan University, Faculty of Science and Engineering, Japan

This paper proposes the analytical non-compact Green's function utilizing the conformal transformation. Reviewing the Compact Green's function in the Theory of Vortex Sound suggests a new Green's function similar to the compact function. The two-dimensional Helmholtz equation in the new function replaces the Laplace's equation for the compact function. The variable separation method for solving the 2D Helmholtz equation is revisited, which leads to the analytical solution composed of infinite series of the Bessel functions. Practically the solution of the scattered sound field around a circular cylinder is introduced using the series of the Bessel functions. The solution is applied to represent the analytical solution of the scattered sound field around 2D boundary. For example, the scattered sound field around a flat strip or an airfoil is transferred from the sound field around a circular cylinder by using a reasonable mapping function. The validity of the new scattered sound field for a flat strip is examined with the contour of the equi-potential curves. The examination suggests utility of the new analytical function for the case of flat strip.

Wednesday 11:20-11:40, Hall New Orleans, Paper 0837 (contributed)
d. Rosa Victor H. P.
Analysis of the sound refraction in subsonic jets using a 3D ray tracing method

d. Rosa Victor H. P.[1], Deschamps Cesar J.[1], Salazar Juan P. L. C.[2], Ilário da Silva Carlos R.[3]

[1] POLO, Federal University of Santa Catarina Florianópolis, Brazil, [2] Mobility Engineering Centre, Federal University of Santa Catarina Joinville, Brazil, [3] EMBRAER S.A., Brazil

A numerical implementation of the ray tracing equations is used to study sound refraction in subsonic jets. By launching a large number of rays (~10^5) from virtual monopole sources and tracing these rays in three dimensions through the mean flow, a quantification of the refraction effects is possible. Three operating conditions are considered: two single stream jets with Mach number of 0.75 in cold and heated conditions, and a cold jet with Mach number of 0.90 issued from a chevron nozzle. Three aspects of sound refraction are studied: (a) the dependence of the zone of silence with the source position, (b) the importance of the sound speed gradient in heated jets, and (c) the asymmetry created by chevrons. This study sheds light on aspects of refraction in subsonic jets and demonstrates how a ray tracing method can be applied to aeroacoustics.

Wednesday 11:40-12:00, Hall New Orleans, Paper 0562 (invited)
Yokokawa Yuzuru
Experimental and numerical study on airframe noise from leading-edge slat and flap side-edge of high-lift wing models

Yokokawa Yuzuru, Murayama Mitsuhiro, Ito Yasushi, Ura Hiroki, Imamura Taro, Yamamoto Kazuomi
Aircraft Systems Research Group, Japan Aerospace Exploration Agency (JAXA), Japan

This paper deals with recent experimental and numerical studies by JAXA on noise generation from high-lift devices (HLDs) using a simple rectangular wing model OTOMO and a swept- and tapered-wing model OTOMO2. Results of the far-field measurement in RTRI-Maibara low noise wind tunnel clarify the existence of the multiple tonal components (MTP) in the slat noise spectrum of the OTOMO2 as well as OTOMO. In addition to that, the far-field data and noise source map obtained in JAXA 2m by 2m low speed wind tunnel evaluates the effect of a slat track and a blade-seal on the slat cusp which are usually attached on actual aircraft on noise generation. On the other hand, numerical results explained the physical mechanism of the noise reduction when the shape of the flap side-edge is modified. Protruding-type device which is inspired by well-known lower round flap side-edge shape shows best performance.

Wednesday 12:00-12:20, Hall New Orleans, Paper 1100 (contributed)
Yokoyama Hiroshi
Acoustic Radiation in Flows around a Trailing Edge with an Upstream Kink Shape

Yokoyama Hiroshi[1], Shinohara Taishi[1], Miyazawa Masashi[2], Iida Akiyoshi[1]

[1] Department of Mechanical Engineering, Toyohashi University of Technology, Japan
[2] Dep. [3], Technology development division 10 Honda R&D Co., Ltd. Automobile R&D Center, Japan

Intense tonal sound radiates from flows around a trailing edge with an upstream kink shape such as found in an automotive body. In order to clarify the generation mechanism of this aerodynamic sound and the flow conditions for the high sound pressure, wind-tunnel experiments and direct numerical simulations (DNS) were performed. The experimental results showed that intense tonal sound becomes intense at the specific freestream velocity and the specific model angle. As a result, the feedback loop of the sound generation is clarified as below. A vortex is shed between the kink shape and the trailing edge, and convected downstream. The acoustic wave radiates from

distortion of the vortex due to the interference between the vortices and the wall around the trailing edge or due to the radiation from the trailing edge. The acoustic waves are propagated and lead to the vibrating of shear layers in the reception point of acoustics around the kink shape. And vortex is shed due to the disturbance of shear layers from this vibrating. The acoustic source and the reception position of the acoustics in this loop are also clarified.

Wednesday 12:20-12:40, Hall New Orleans, Paper 0603 (contributed)
Jeon Wan-Ho
Prediction and identification of the aeroacoustic noise source on small axial fan using numerical method

Jeon Wan-Ho[1], Lim Tae-Gyun[1], Minorikawa Gaku[2]

[1] Technical Research Lab. CEDIC Co., Ltd, Korea
[2] Department of Mechanical Engineering, Hosei University, Japan

The paper describes the numerical method for the unsteady flow field and the aeroacoustic noise of a small axial fan. The prediction method is comprised of various CFD methods and acoustic analogy by using Ffowcs Williams-Hawkings equation. The tested axial fan was selected for the study in the noise characteristics of a small axial fan. Virtual anechoic room which has same size with real one was used for numerical methods. URANS and LES models were tested for the accuracy of noise prediction. For mesh dependence study, different mesh types of mesh structure were tested and an optimized mesh was selected. Calculation conditions were also studied such as time step and turbulence model for accurate noise analysis. In this paper, we got optimum analysis conditions and computational results. Numerical results were compared with measured ones. The noise source of blades – such as separation, interaction between rotating blade and separated flow, tip vortex – were also analyzed.

Wednesday 12:40-13:00, Hall New Orleans, Paper 0820 (contributed)
Cho Munhwan
Benchmark Study of Commercial CFD Solvers for Sunroof Buffeting in a Simplified Vehicle Model

Cho Munhwan[1], Oh Chisung[1], Kim Hyoung Gun[1], Ih Kang Duckg[1], Khondge Ashok[2], Mendonça Fred[3], Kim Jung Ill[4], Lee Dong-Guk[5], Cyr Stephane[6], Kim Young Nam[7], Holman David M.[8]

[1] Research & Department Division, Hyundai Motor Group, Korea, [2] ANSYS, India, [3] CD-adapco, [4] Cedic Co., Korea, [5] ESI, Korea, [6] EXA GmbH, [7] Flow&Noise Inc, Korea, [8] Next Limit Technologies

Benchmark study of several commercial CFD solvers is carried out on the simplified vehicle model under the buffeting behavior which contains a wedge-like shape with an upper rectangular opening area. Especially, several absorbing materials are attached on the interior wall in the model to consider the sound absorbing effect by the vehicle interior trims or seats. The experiments are conducted in two steps. The first step is to conduct the acoustic response test to consider the real world effect of the model by the sound absorption and the damping effect. These results are provided prior to simulations for matching the numerical condition to the real world. The second step is to measure the buffeting frequencies and the sound pressures at various wind speeds. These results are used after the simulation for comparison of accuracy of each solver. Total seven commercial CFD solvers based on various numerical schemes such as finite volume method, lattice Boltzmann method, and so on are applied to the prediction of the buffeting phenomenon in order to evaluate their accuracy. It is found that most commercial solvers are applicable to the vehicle development process of sunroof buffeting. Furthermore, the results of this benchmark study are used to progress the accuracy of each solver and promote their practical know-how for the prediction of the aeroacoustic phenomena.

Wednesday 14:00-14:20, Hall New Orleans, Paper 0403 (contributed)
Kårekull Oscar
Comparison of RANS parameters for flow noise prediction

Kårekull Oscar[1,2], Efraimsson Gunilla[3]

[1] Marcus Wallenberg Laboratory, Sweden, [2] Fläkt Woods, Sweden, [3] Aeronautical & Vehicle Engineering, Sweden

The use of Computational Fluid Dynamics (CFD) and especially Reynolds Averaged Navier Stokes Equations (RANS) simulations is a well-established tool in industry for performance evaluation of constrictions in low speed flow ducts. However, the use of CFD simulations for noise predictions is not as common. In this paper, two different models to predict the sound spectra through the use of RANS simulations and a noise reference spectrum are compared and evaluated. One method predicts the sound based on the pressure drop whereas the other method is based on the turbulent kinetic energy. The influence of both turbulence models as well as mesh properties

have been investigated. Noise predictions from simulation results are compared to noise measurement results of an orifice in a duct. The comparison between the simulated results and measured data are in excellent agreement. The benefit of using the pressure drop, as input data, is a lower sensitivity to both the structure and the resolution of the mesh. Also, this model has a more general definition allowing a consistent method for different constriction geometries. Still, predictions using the turbulent kinetic energy result in equivalent accuracy and even if the choice of input data is more complex it can be preferred in special cases.

Wednesday 14:20-14:40, Hall New Orleans, Paper 0646 (contributed)
Jeon WanHo
Study on the unsteady flow field and aeroacoustic noise of ring blower using numerical method

Jeon WanHo[1], Lim Tae-Gyun[1], Jang Choon-Man[2]

[1] CEDIC Co., Technical Research Lab., Korea
[2] Environmental Engineering Research Division, Korea Institute of Construction Technology, Korea

This paper describes the aeroacoustic noise of the impeller used for the high pressure ring blower. Three-dimensional Navier-Stokes equations are introduced to analyze the internal flow of the blower and to find the pressure fluctuation of the impeller and the casing. Relatively good agreement between experimental measurements and numerical simulation is obtained in the present study. Throughout the study of noise source, it is found that the upper part of outlet region and the tip of blades are dominant aeroacoustic noise sources in the ring blower. Local recirculation flow having low velocity is formed on the both sides of the blades by the different flow direction of the inlet and the outlet regions. Detailed flow field inside the ring blower is also analyzed and discussed.

Wednesday 14:40-15:00, Hall New Orleans, Paper 0471 (contributed)
Pramudita Saputra Gabriel
Experimental flow-sound analyses in T-branch model for understanding constriction effect in lung sound generation mechanisms

Pramudita Saputra Gabriel[1], Nozaki Kazunori[2], Ii Satoshi[1], Wada Shigeo[1]

[1] Department of Mechanical Science and Bioengineering, Graduate School of Engineering Science, Osaka University, Japan, [2] Division of Dental Informatics, Osaka University Dental Hospital, Japan

The lung sound has been used as one of the important indicators for respiratory conditions. Some characteristics of audible sounds from the chest such as normal lung sounds, wheezes, and crackles have been introduced, but the sound generation mechanisms are still not understood physically. In studying the normal lung sound generation and its alteration in the inspiratory maneuver, we used a simple circular T-branch to perform aero physical experiments. The model is made of silicone tubes and plaster T-branches with a major diameter of 10 mm; it was tested for several flow rate conditions. The effects of generation numbers, of the presence of constriction, and of changes in the flow rate were evaluated by measuring the sound emitted from the model. Constrictions of 25%, 50%, or 75% were introduced into the parent tube of the model to observe the effect of flow disturbances in the upstream region. The experiment showed that the model with no constriction does not produce any audible sounds, and constriction is necessary to generate the sound. Sound produced by constriction triggers the resonance frequencies of the model. Changing the number of generations of the model will cause a different sound frequency distribution, which is related to the different resonance frequencies of the model, without changing the OASPL. We concluded that a constriction of 50% must be present in the airways in order to produce audible sounds.

Wednesday 15:00-15:20, Hall New Orleans, Paper 1092 (contributed)
Yokoyama Hiroshi
Measurement of velocity field in flows around a cascade of flat plates with acoustic resonance

Yokoyama Hiroshi, Kiyamiya Katsuya, Iida Akiyoshi
Department of Mechanical Engineering, Toyohashi University of Technology, Japan

In order to clarify the effects of acoustic resonance on flows around a cascade of flat plates, aerodynamic noise and velocity field of the wake were measured. Five plates were placed parallel to a uniform flow. Separation-to-thickness ratio, s/b, was 6.0 and chord length-to-thickness ratio, C/b, was 15. Sound pressure level suddenly increases at specific freestream velocity of 44 m/s. At that velocity, the Reynolds number based on the thickness and the freestream velocity was 5.8×10^3. The spanwise and normal direction coherence of the velocity fluctuations in the wake were measured with two hot-wire anemometers. When the acoustic resonance occurs, the coherence between the velocity fluctuations in the wake of a plate and that of a neighboring plate becomes higher. This means that

synchronization of the shedding of the vortices occurs in wakes of the neighboring plates. The coherence of normal direction was clarified to be high. When acoustic resonance occurs, the coherence between the velocity fluctuations in the wake of the plate in the spanwise direction also becomes higher. This means the structures of the vortices is two-dimensional. These synchronized structures of the vortices in the vertical and spanwise direction contribute to the reinforcement of the sound pressure level.

Wednesday 15:20-15:40, Hall New Orleans, Paper 1093 (contributed)
Yokoyama Hiroshi
Control of Noise from a Cascade of Flat Plates by using DBD Plasma Actuators

Yokoyama Hiroshi, Kusumoto Makoto, Iida Akiyoshi
Department of Mechanical Engineering, Toyohashi University of Technology, Japan

The aim of this investigation is to clarify the effectiveness of aerodynamic noise control with a dielectric barrier discharge (DBD) plasma actuator (PA) over the cascade of flat plates. The sound and velocity fields of a flow around a cascade of flat plates were measured with a low noise wind tunnel. The experiments were carried out at the flow velocity from 5 m/s to 20 m/s, with the chord length of 120 mm, the thickness of 2 mm and the distance between plates of 48 mm. The flow around a cascade of flat plates often makes acoustic radiation with resonance at specific freestream velocity. In this case, the most intense tonal noise was observed at the flow velocity of 13.8 m/s. To control this tonal noise, PAs were utilized. The PAs were mounted on both sides near the leading-edge of the vertically central flat plate. At the velocity of 13.5m/s, the maximum reduction of the tonal noise, 10.8 dB was achieved. The tonal noise was reduced by using PAs. The noise reduction level depended on the applied voltage of PAs. Moreover, the frequency of vortex shedding, which causes the acoustic radiation becomes lower when the PAs were driven. As a result, the acoustic resonance was weakened. It indicated that the PAs are useful devices to control of aerodynamic noise.

SS49 Underwater Noise

Chair: Cuchieri Joe, Wittekind Dittrich

Wednesday 08:20-08:40, Hall Lugger, Paper 0479 (contributed)
Bretschneider Herbert
Underwater noise of merchant ships: Prediction tools and developments

Bretschneider Herbert
Hamburgische Schiffbau-Versuchsanstalt GmbH (HSVA), Germany

From studies in marine biology it is known that the behaviour of marine animals, mainly sea mammals, is effected by increasing background noise. Cavitation of ship propellers has been identified as a main source of this background noise. The EU requires member states to demonstrate that human caused underwater noise does not harm marine life. This paper presents actual European research projects as well as related ITTC activities. The first objective is to enhance the understanding of underwater noise generated by a cavitating ship propeller and to develop tools to predict noise levels of individual ships. Finally the mapping of underwater noise generated by shipping in general is required to investigate mitigation measures for quietening the oceans. This paper presents actual prediction tools to be applied and developed within the a.m. projects.

Wednesday 08:40-09:00, Hall Lugger, Paper 0589 (invited)
Wittekind Dietrich
Underwater noise generation of merchant ships: mechanisms and mitigation

Wittekind Dietrich
DW-ShipConsult GmbH, Germany

Underwater radiated noise from shipping became a major concern in the past 10 years. It can be shown that the low frequency part of the background noise spectrum of most of the seas is dominated by shipping. This paper discusses the mechanisms of noise generation and mitigation for lower noise. For a ship at service speed the dominating noise source is the propeller. It is shown that the global noise level at frequencies below 300 Hz can be directly related to noise characteristics of most of these ships. The second noise source is the 4-stroke diesel. While resilient foundations are a safe means to isolate diesel noise from the environment; the options for the propeller are scarce. As the particular contribution to underwater noise is not subject to consideration for onboard noise for various reasons there is

no incentive for the designer to improve on radiated noise. A propeller once optimized for high propulsive efficiency does not leave much room for substantial quieting. The paper describes the noise characteristics of the ship, shows proof of the dominance of propeller and diesels and indicates ways to improve the situation.

Wednesday 09:00-09:20, Hall Lugger, Paper 1011 (invited)
Stoye Thomas
Propulsion Concepts for Reduced Underwater Noise of Merchant Ships

Stoye Thomas
Flensburger Schiffbau-Gesellschaft, Germany

The main contributor to underwater noise in shipping is often the propulsor. Besides displacement effects of the propeller, cavitation can be regarded as the main reason for radiated noise in frequencies higher than the blade passing frequency. Cavitation therefore contributes to both vibration and noise on board. In today's ship design, the task for the propulsion concept and propeller design usually consists in both an optimal efficiency (low fuel consumption) and the fulfillment of comfort and vibration requirements on board. In many cases, fuel efficiency and low cavitation are contradicting requirements. In the future, underwater noise aspects may also have to be considered. Additionally, off-design operation (e.g. slow steaming) becomes more often a design requirement by ship operators. If this is not appropriately considered in the design, operating a vessel in a condition significantly different from the design can cause broad-banded noise contributions. The paper presents numerical design tools for cavitation prediction in design- and off-design conditions and tools for the qualitative assessment of vibrations and noise. It is furthermore presented, how the consideration of the whole propulsion train affects the potential for both fuel-efficient and silent operation. The potential of alternative propeller designs and propulsion concepts with consideration of the whole operating spectrum of the vessel is presented for a passenger ferry.

Wednesday 09:20-09:40, Hall Lugger, Paper 0601 (contributed)
Li Liaoyuan
Study on characteristic of hull underwater radiation noise considering different main engine mounting position

Li Liaoyuan[1], Cao Yipeng[1], Li Hongbo[1], Zhang Wenping[1], Wang Yun[2]

[1] College of Power and Energy Engineering, Harbin Engineering University, China
[2] College of Shipbuilding Engineering, Harbin Engineering University, China

This paper is related to investigation of the effect of hull radiation noise with different main engine mounting position. A finite element model of bulk carrier including shafting is built, finite element method is employed to simulate the vibration response of the hull structure due to the propeller excitation in consideration of fluid-structure interaction, and then the underwater radiation noise characteristic is calculated with boundary element method. Comparing the numerical results which considering different main engine mounting positions, an optimum selection approach of main engine installation site is put forward which can be the guiding suggestion about underwater radiation noise reduction.

Wednesday 09:40-10:00, Hall Lugger, Paper 0174 (contributed)
Cao Yipeng
Study on underwater noise characteristic of ship Structure induced by propeller exciting force

Cao Yipeng, Li Liaoyuan, Ma Xiuzhen
College of Power and Energy Engineering, Harbin Engineering University Harbin, China

For the propeller running in the non-uniform wake fluid field, the periods excitation is formed on blade surface other than constant thrust. That excitation transfers from shafting, rear bearing, intermediate bearings and trust bearing supporting to hull structure. Decided by the rotation speed of shafting and the number of propeller blades, the propeller exciting force can be mainly found in low frequency. Such kind of excitation can cause the vibration of whole ship structure. The ship radiates large noise underwater that can promulgate very far. The marine ecological environment will be impacted. In this paper, FEM/BEM is adopted to calculate underwater noise characteristic of ship structure. The propeller, shafting, each bearing supporting and ship structure model are built by finite element method by the fluid structure interaction taken into account. The characteristic of underwater noise transmission function and the characteristic of radiated sound pressure distribution are studied. Then, the differences of ship structure radiated sound caused by power equipment excitation and propeller excitation are studied.

Wednesday 11:00-11:20, Hall Lugger, Paper 0806 (contributed)
Kim Ki-Sun
Vibration Control for Ship's Deck House using Vibration Intensity Analysis Method

Kim Ki-Sun, Kim Heui-Won, Joo Won-Ho
Advanced Technology Institute, Hyundai Heavy Industries, Korea

Ship vibration analysis using finite element model has been conventionally carried out based on the mode superposition method. However, the structural modification based on the modal approach typically tends to be massive because the countermeasures to avoid a resonance are derived from the mode shape which vibrates globally. Also it is difficult to exactly consider the effect of damping elements in this method. On the other hand, vibration intensity analysis with the direct method visualizes the transmission and dissipation of vibration energy over the structure. In this paper, the vibration intensity analysis code was developed and then it was applied to a ship vibration problem. Through the application, the top-bracing and its supporting structure were identified as the main path of the vibration energy from the main engine. By the local modification of the top bracing and its supporting structure, the vibration intensity transmitted to the hull structure was controlled and thus the vibration at the deck house was reduced without notable variation of a natural frequency. Therefore, it was concluded that the vibration intensity analysis can be utilized as an effective approach to a ship vibration problem.

Wednesday 11:20-11:40, Hall Lugger, Paper 0348 (contributed)
Shi Dongyan
Research on Self-noise Characteristic of sonar platform and its optimization

Shi Dongyan[1], Wang Qingshan[1], Xie Xiaozhong[2], Zhuang Zhong[1]

[1] College of Mechanical and Electrical Engineering, Harbin Engineering University, China
[2] College of Shipbuilding Engineering, Harbin Engineering University, China

The statistical energy analysis model of sonar platform is established with SEA (Statistical Energy Analysis) method. Based on this model, the self-noise characteristic and optimization is investigated. The effect of mechanical and hydrodynamicload on the self-noise characteristic of sonar platform is analyzed. Through the analysis, the main noise excitation source and its distribution are obtained. Then the self-noise contribution of mechanical load for sonar platform is discussed with different load

position. The study shows that the self-noise contribution of mechanical load is different with various load positions. The self-noise contribution of mechanical load, which is close to sonar energy exchange cabin, is larger than other conditions. Based on the self-noise analysis of sonar platform, the noise reduction optimization of sonar platform is carried out. Three different noise reduction measures are discussed. They are changing loss factor of materials on the transfer path, laying sound absorption wedge on the front and back wall of sonar platform cabin and laying sound absorption wedge and changing material loss factor, respectively. Through the comparison analysis, the optimal sound reduction measure is obtained.

Wednesday 11:40-12:00, Hall Lugger, Paper 0160 (contributed)
Torres-Guijarro Soledad
Evaluation of underwater dredging noise

Torres-Guijarro Soledad, Sobreira-Seoane Manuel, Santos-Domínguez David, Pena Sonitum Antonio
EE Telecomunicación, Universidad de Vigo Maxwell s/n, Spain

In this contribution we analyse and quantify the submarine noise produced by a dredger. The boat is being modified in a research project aimed at reducing the pollution produced by suction dredging operations. The initial assessment tasks previous to the planned modifications to the dredger include in-situ measurements of the submarine noise produced by dredging. Measurements were performed with three hydrophones, located at different depths and distances to the dredger, and during different operation modes while suction dredging in the outer port in A Coruña (Spain), under construction. The main target of this work is to calculate the source levels from measured levels. To this aim, we have developed a propagation model to compute source levels, whose results show a strong correspondence with the propagation losses derived from the measurements. Our results are compared with published data from other dredgers. Besides, noise generation mechanisms and noise variations on the dredger operation condition are also investigated, and the environmental impact of the dredging noise analysed. As the main conclusion of this work, a methodology to evaluate underwater noise sources is proposed.

Wednesday 12:00-12:20, Hall Lugger, Paper 0298 (contributed)
Göttsche Klaus Marco
Numerical prediction of underwater noise reduction during offshore pile driving by a Small Bubble Curtain

Göttsche Klaus Marco[1], Møller Juhl Peter[1], Steinhagen Ulrich[2]

[1] University of Southern Denmark, Denmark, [2] MENCK GmbH, Germany

Small Bubble Curtains are an effective technique to reduce the underwater noise being emitted during offshore pile driving. In order to protect the marine fauna, noise reduction becomes even more important, since the increasing contribution of offshore wind energy leads to a rising number of offshore construction sites in order to cover the need for clean energy. Within the Bubble Curtain air bubbles are injected into the water surrounding the pile. When these are driven by the pressure wave being emitted from the pile, reflection, scattering and absorption effects occur. Within this paper, a method is presented in order to predict the rate of noise attenuation achieved by a Small Bubble Curtain. For this purpose, the bubble distribution is determined with Computational Fluid Dynamics. The noise radiation during pile driving is simulated by Finite Element Analysis and an Effective Medium Approach considers the acoustic effects within the Bubble Curtain. The pressure level at an arbitrary distance from the pile is determined by a Parabolic Equation method. Furthermore, comparisons between simulations and offshore measurements are presented. This combination of four methods provides a flexible and efficient noise prediction tool.

Wednesday 12:20-12:40, Hall Lugger, Paper 0987 (contributed)
Yang Desen
Experimental research on wave non-linear interaction in complex medium

Yang Desen[1], Jiang Wei[2], Shi Shengguo[2], Zhang Haoyang[2]

[1] Science and Technology on Underwater Acoustic Laboratoryof Harbin Engineering University, China, [2] Harbin EngineeringUniversity, China

The effects of wave frequency, amplitude, and media equivalent nonlinear parameters on the wave interaction were theoretically analyzed when considering the second-order nonlinear, and several experiments were carried on in water, brine and salt-mud water. The laws of the sum-and-difference frequency wave magnitude which generated by two-wave interaction were

obtained. When the amplitudes of two waves were much larger, the acoustic energy generated by the third-order nonlinear was at the same magnitude order of the second-order nonlinear in the experiments, so it should not ignore the third-order nonlinearity. The above studies can provide the experimental foundation for vibration and noise reductionon account of the energy transfer mechanismin wave interaction.

SS76 Noise Annoyance and Communication Problems at the Workplace

Chair: Bockstael Annelies, Kundi Michael

Wednesday 08:20-08:40, Hall Aalborg, Paper 0833 (invited)
Bockstael Annelies
Listening experience during music exposure with different augmented hearing protectors

Bockstael Annelies[1], Keppler Hannah[2], Vantieghem Marie[2], Botteldooren Dick[1]

[1] Ghent University, INTEC, Acoustics Research Group, Belgium
[2] Ghent University, Dep. of Oto-rhino-laryngology and logopaedic-audiologic sciences, Belgium

Personal hearing protectors are more and more commonly used during leisure-time music exposure. Attenuation of standard protectors typically increases with increasing frequency and might therefore lead to suboptimal listening experience, inducing suboptimal use. Hence, different types of augmented protectors have been brought on the market, aiming for better music quality by improved frequency characteristics. However, scientific studies assessing the perceived benefits of these interventions are scarce. This study evaluates listening experience during music exposure for five commercially available earplugs: four augmented passive premolded devices, and one classical standard earplug often distributed by music events' organization. The four augmented devices have been carefully selected to cover the variety in price, design and attenuation of earplugs currently sold. During five different test sessions, participants wear one particular protector while listening to popular music played at sound pressure lev- els representative for concerts and bars. Afterwards, they completed a questionnaire addressing perceived sound quality and general appreciation of the earplugs. Reported listening experience is then assessed as a function of the earplugs' attenuation to study the effect of adapted frequency-characteristics.

Wednesday 08:40-09:00, Hall Aalborg, Paper 0697 (invited)
Koskinen Heli
Developing an individual hearing protector selection process for better communication and use

Koskinen Heli[1], Hyvärinen Ville[1], Toppila Esko[1], Terho Armi[2], Junttila Sakari[2]
[1] FIOH, Finland, [2] Outokumpu Stainless Oy Terästie, Finland

Hearing loss is most common occupational disease in steel industry. However, the sound levels in general should not cause hearing loss if the hearing conservation measures are correctly performed. Finnish Institute of Occupational Health did a research at a steel factory about usage of hearing protectors and found several deficiencies in the selection process. The factory's different working sites were inspected, and evaluated concerning hearing protector usage and accidents risks. A questionnaire about usage, complacence with protectors and self-evaluated hearing was made to the workers. Audiograms of the workers were in use and real attenuation of the hearing protectors was measured at work. A new process was developed that takes into account the hearing of the user, need to communicate and accident risks involving hearing protector usage (warning signals etc.). The process was implemented not only to occupational health care but also to work safety procedures and line organization.

Wednesday 09:00-09:20, Hall Aalborg, Paper 0745 (contributed)
Fujiwara Mai
Subjective evaluation of a masking sound environment in a contemporary open plan office

Fujiwara Mai[1], Watarai Ken[2], Yamakawa Takashi[1], Hata Masato[1], Shimizu Yasushi[2]
[1] Yamaha Corporation, Japan, [2] Tokyo Institute of Technology, Japan

In a contemporary open plan office background noise is getting quiet, and then there may be a problem that intelligible neighbors' conversation gives "a sense of disturbance (SD)" to their work. In such a circumstance, it is well known that sound masking system is utilized to reduce a degree of SD from an intelligible neighbor's conversation and in other words sound masking system is possible to make conversations unintelligible as Normal Privacy. However, if masking sound is getting loud, it may cause uncomfortable effect of SD from its noisiness to a worker.Therefore, on an appropriate masker level, it is necessary to investigate a point of minimizing both "SD from speech intelligibility (i-SD)" and "the sense of disturbance from noisiness (n-SD). "The purpose of this study is to investigate an evaluation method of sound masking system focusing on an optimum balance of "i-SD" and "n-SD" in masking sound environment. By using 3 different types of maskers, 2 types of background noise in 1 types of architectural condition, we performed a numerical evaluation on the degree of "SD'' measuring a numerical value of "noisiness" and "speech intelligibility". And then, we studied a relationship between those subjective characteristics. As a result, the possibility of setting an

optimal masker level to balance “i-SD” and “n-SD” has been suggested in a sound masking environment.

Wednesday 09:20-09:40, Hall Aalborg, Paper 0075 (contributed)
Ikuta Akira
Noise Suppression of Speech Signal by Considering Finite Range of Amplitude Fluctuation in Real Environment

Ikuta Akira, Orimoto Hisako
Prefectural University of Hiroshima, Japan

Several noise suppression methods for the speech signal have been proposed up to now. On the other hand, the actual speech signal fluctuates within a finite range and the observed data sometimes display amplitude saturation owing to the existence of a definite dynamic range. In this study, a signal processing method to suppress the noise for actual speech signal is proposed in a form appropriate for the finite amplitude range of the measured data. More specifically, by introducing a statistical orthogonal expansion expression of the probability distribution based on a Beta distribution defined within a finite fluctuation range of speech signal, a new type of noise suppression method is proposed. Furthermore, the effectiveness of the proposed method is confirmed experimentally by applying it to actual speech signals contaminated by noise.

Wednesday 09:40-10:00, Hall Aalborg, Paper 1231 (invited)
Preis Anna
Noise interference during rest and communication

Preis Anna, Hafke-Dys Honorata, Kaczmarek Tomasz
Institute of Acoustics, Adam Mickiewicz University, Poland

The annoyance of noise depends both, on the characteristics of noise source, and on the form of activity of the person exposed to it. The objective of our paper is the comparison of the assessment of noise annoyance during speech comprehension and during rest. In the typical laboratory experiments noise annoyance judgments are obtained for the rest condition only. We assume that annoyance assessment depends significantly on the kind of activity the person is performing and rest condition should not be considered as exemplary. To find out if and how noise annoyance judgments depend on the subject’s activity two psychoacoustics experiments were performed. In Experiment I participants’ task was to assess difficulty with speech comprehension during the speech intelligibility test performed in 8 different

environmental noises. In Experiment II participants' task was to assess noise annoyance of the same noises presented in the rest condition. The results of both experiments represent noise annoyance assessments of the same environmental noises, judged under two different conditions: communication and rest. The annoyance ratings obtained in both experiments were found to have a high correlation coefficient, however, significant differences were only found for the highest ratings on the annoyance scale.

Wednesday 10:00-10:20, Hall Aalborg, Paper 0545 (contributed)
Mahn Jeffrey
Integration of dosimeter measurements with images from a wearable camera as an educational tool to reduce noise exposure levels

Mahn Jeffrey
University of Canterbury,Department of Mechanical Engineering, New Zealand

Concern has been raised in New Zealand over the growing number of new cases of noise induced hearing loss that are reported each year. Risk perception plays an important role in worker's use of hearing protection to reduce their chances of noise induced hearing loss. Workers who do not perceive noise to be a danger are less likely to wear hearing protection. It would therefore be advantageous to be able to correlate the exposure level with the activities that cause the higher noise exposure in an engaging format to be used as an educational tool to teach about the risk of noise induced hearing loss. This paper describes a program that combined instantaneous sound pressure level measurements with images taken with a wearable camera. The integration of dosimeter measurements of the instantaneous sound pressure level with first person still images to create a video which shows the exposure level with activity represents an engaging and powerful research and education tool for understanding and educating at risk workers about the noise exposure levels associated with common activities occurring at the jobsite.

Wednesday 11:00-11:20, Hall Aalborg, Paper 1101 (contributed)
Probst Fabian
Noise reduction in working areas with sound absorbing baffle systems

Probst Fabian
DataKustik GmbH, Germany

In many types of workrooms like large offices or machinery halls open structures of absorbing elements are applied for reasons of noise reduction, because closed plane structures like suspended ceilings cannot be installed due to technical devices like cranes or ventilation ducts. Such arrangements of absorbing elements can be modeled as plate with a given spectral absorption and transmission, but this will not reproduce the angular variation of the acoustic properties of such a construction. This can be achieved by simulating each element separately and then creating the virtual model of the complete construction by integrating each element in its original position. Examples are shown how even complex arrangements can be simulated that way and how the resulting level distributions are influenced by the arrangement of the elements. The method allows the "virtual" integration of even complex noise reduction measures like baffle structures locally installed above machines surrounded by screens or partial constructions in different heights.

Wednesday 11:20-11:40, Hall Aalborg, Paper 1123 (contributed)
Kittel Maria
Auditory babble as a masker of disruptive speech

Kittel Maria, Wenzke Erik, Drotleff Horst, Liebl Andreas
Fraunhofer Institute for Building Physics IBP, Germany

Numerous studies have shown that task irrelevant background speech impairs the performance of working memory. This well established effect is related to practice in open-plan offices, where employees are potentially disturbed by the speech of their colleagues. One option to reduce the disruptive effect is masking the speech, for example by noise. In open-plan offices babble of voices might be a useful natural masker of disruptive speech. Prior studies suggest that a small number of one or two background voices cause a high level of disturbance, whereas six voices talking simultaneously produce significantly lower error rates. The aim of this study was to examine the potential benefit of background speakers placed outside the radius of distraction with regard to masking a speaker placed close to the receiver. Therefore working memory performance of subjects listening to a speaker and one to six background voices was tested. Additionally, the intelligibility of the presented speaker sentences was checked. We expected the performance to improve with the number of background voices, whereas intelligibility should decrease. The results show a significant trend towards an improvement of

working memory performance when the number of babble voices grows from one to six.

Wednesday 11:40-12:00, Hall Aalborg, Paper 1135 (contributed)
Takahashi Yukio
Measurement of the equal-sensation levels for the perception of vibration in the head of subjects exposed to complex low-frequency tones

Takahashi Yukio
National Institute of Occupational Safety and Health, Japan

Our previous study suggested that the head was the part of the body most sensitive to vibratory sensation induced by low-frequency noise. In a recent study, we measured the threshold levels for experiencing “vibration perceived in the head” using complex low-frequency tones composed of a 40- or 50-Hz tone and another even lower tone, and found that, in contrast to the hearing sensation, the “vibration perceived in the head” was significantly contributed not only by the 40-Hz or 50-Hz tone but also the even lower frequency tone. In the present study, to investigate further the perception of vibration in the head of subjects exposed to complex low-frequency noise, we measured “vibration perceived in the head” in response to the same stimuli, but used a different method, the equal-sensation measurement method. The equal-sensation levels for experiencing “vibration perceived in the head” showed significant contribution from both tonal components, consistent with the characteristics of subjective perception of vibration in the head using the threshold level measurement method in our previous study.

SS75 Occupational Noise Exposure and Hearing Protection

Chair: McBride David, Fuente Adrian

Wednesday 12:00-12:20, Hall Aalborg, Paper 0990 (invited)
McBride David
Firearms noise and hearing conservation: hearing protection fit testing, noise assessment and hearing surveillance

McBride David[1], Baxter Marian, Fletcher Dion, Lalahi Karoline[2]

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Background: Noise induced hearing loss (NIHL) continues to be a prevalent problem in Military Service. Purpose: To assess the 'SureFire' earplug, a Hearing Protective Device (HPD), within the context of a hearing conservation programme. Methods: The Sperian 'VeriPro' system was used to test the HPD attenuation. Otoacoustic emissions (OAE) base-line testing assessed base-line status of hearing. Noise exposure during test firing was measured using a B&K precision noise level meter, and a post firing OAE test was carried out to measure any deterioration in hearing due to excess noise exposure. Results: There was a 'between ears' difference in HPD fitting, with better attenuation in right ears. The HPDs were rated to reduce the noise by at least 15 dB in 84% of those exposed. In practice 84% of individuals would have achieved attenuation of between 8.4 and 23.6 dBA. The noise levels during the practice averaged 110 dBA, the actual exposure being 94 dBA, with 84% receiving between 86.4 and 101.6 dBA The OAE testing did not show any significant before and after differences. Discussion: Some individuals achieved good HPD fit, some quite poor. The average noise levels received were excessive, but the daily noise dose would have been within acceptable limits because of the short duration of exposure. This may explain the non-significant differences in OAEs. We recommend that individuals should only use HPDs which are 'fit proven'. Additional testing under more typical conditions with a larger group is required, but OAEs show promise as a practical monitoring tool.

Wednesday 12:20-12:40, Hall Aalborg, Paper 0169 (contributed)
Vergara E. Felipe
Evaluation of earmuff attenuation by finite element method when subject to high-intensity impulsive noise

Vergara E. Felipe[1], Birch Robert S.[2], Junckes Rafael[1], Gerges Samir N. Y.[1]

[1] Laboratory of Vibrations and Acoustics, Mechanical Eng. Dept., Federal University of Santa Catarina, Brazil, [2] University of Liverpool, School of Engineering, UK

Several studies have focused on experimental techniques to determine the attenuation of hearing protectors when subjected to high-intensity impulse noise and where, for reasons of safety, it is not feasible to use human test subjects. Based on a simplified geometry of the human ear, it is possible to model external ear canal and earmuff conveniently within the normal hearing frequency range using the finite element method (FEM). The acoustic impedance characteristics of the walls of the ear canal and eardrum are taken into consideration in the model. Temporal excitation is based on short duration high-intensity sound pressure pulses obtained from experimental tests using the shock tube technique. The results indicate that the geometry and material properties of the protector are influential on the rise time and peak sound pressure of the transmitted pulse. This FEM model can provide valuable information about the characteristics of earmuffs and permit the manufacturer to optimise earmuffs for maximum comfort and attenuation.

Wednesday 12:40-13:00, Hall Aalborg, Paper 0328 (contributed)
Trompette Nicolas
Suitability of Commercially Available Systems for Individual Fit Tests of Hearing Protectors

Trompette Nicolas, Kusy Alain
INRS, FRANCE

Hearing protector attenuation is measured according to the REAT method given by ISO 4869-1. This method relies on optimum fitting under laboratory conditions and group statistics to predict an individual wearer’s hearing protector performance. The consequence is that there has been an emergence of commercially available systems that offer the capability of individual fit testing of hearing protectors in the field to control how much attenuation each individual user will actually experience. The purpose of this paper is to appraise these methods. Four commercially available systems were

used under laboratory conditions to assess the performance of two ear-muffs, 4 pre-formed or foam ear-plugs and 2 custom molded ear-plugs for at least 20 test subjects. Results were compared to REAT attenuations (obtained for the same group of subjects) and also to attenuations obtained from MIRE (ISO 11904-1). Three of the four systems provided mean attenuations close to the benchmark values. For these three systems, individual comparisons are acceptable in terms of personal attenuation rating, although discrepancies with REAT individual can be improved. Thus, these systems can be used to validate the hearing protection choice as long as a 10 dB safety margin is considered.

Wednesday 14:00-14:20, Hall Aalborg, Paper 0301 (contributed)
Shibata Nobuyuki
Noise and hand-arm vibration exposure in construction workers

Shibata Nobuyuki[1], Sasaki Takeshi[1], Hisanaga Naomi[2], Shibata Eiji[3], Kubota Hitoshi[1], Nakamura Kenji[1], Koda Shigeki[1]

[1] National Institute of Occupational Safety and Health, Japan, [2] Aichi University of Education, Japan, [3] Aichi Medical University, Japan

A five-year cohort analysis performed for construction workers including carpenters has showed that the workers exposed to noise and hand-arm vibration (HAV) frequently complained of hearing loss rather than those who are exposed only to noise. This study examined the dose level of noise and HAV of tools commonly used by carpenters. For twenty four carpenters, noise at the collar and HAV were measured during operation of various wood-processing tools. The tools measured in this study were roughly classified into two groups: the hand-held tools and the desk-top or grounded machines. Both the noise levels measured for the hand-held tools and those for the desk-top or grounded machines fell into the same range of 88-101 dB(A). In contrast, HAV levels changed depending on tools, showing particularly high acceleration magnitudes at sanders and tackers. As well as the processing machines, a majority of the hand-held tools showed the daily allowable durations of exposure to noise shorter than those to HAV. Although further research is required to discuss the combined effect of noise exposure with HAV, our results suggest the daily allowable exposure durations of noise-generating/vibration tools should be considered based on both the health risk of noise and HAV.

Wednesday 14:20-14:40, Hall Aalborg, Paper 1259 (contributed)
Kundi Michael
Early prognosis of noise-induced hearing loss

Kundi Michael[1], Moshammer Hanns[1], Wallner Peter[1], Herbst Alois[2], Feuerstein Anton[2], Hutter Hans-Peter[1]

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Occupationally acquired noise-induced hearing loss (NIHL) is the most prevalent occupational disease in Austria and among the most frequent in many other countries. Because of the broad distribution of hearing losses after equal exposures it has long been assumed that some individuals are more vulnerable to NIHL. Earlier attempts to define predictors of NIHL before commencing occupational noise exposure have largely failed. Between 1982 and 1989 overall 311 apprentices were included into a prospective study during their initial health screening visit. At this occasion a standardized noise exposure was applied (20' 200-500 Hz, 100 dBA) and the temporal threshold shift (TTS) at 4 kHz was determined during 2-10' after exposure. Hearing loss was monitored at follow-up visits every 3-5 years. Follow-up was 13 years on average. Permanent threshold shift was predicted by noise years, frequency of wearing noise protectors, but also by the initial TTS at 4 kHz. In this longitudinal study again the importance of personal protective measures was documented, it was also established that individual susceptibility plays an important role. The TTS peak at 4 kHz occurring independent of exposure frequency but especially after low-frequency exposure is a predictor of long-term hearing loss.

Wednesday 14:40-15:00, Hall Aalborg, Paper 0197 (contributed)
Smagowska Bożena
Preventing exposure to ultrasonic noise in the work environment

Smagowska Bożena
Central Institute for Labour Protection, Poland

This article discusses physical traits of ultrasonic noise, their influence on the human body during exposure in the work environment. However, the literature on this subject is limited. The article presents prevention activities for workers' protection against the effects of exposure to ultrasonic noise in the work environment. It describes a method of assessing occupational risk

resulting from exposure to ultrasonic noise at workstations as well as general technical, organizational and medical methods of reducing occupational exposure.

Wednesday 15:00-15:20, Hall Aalborg, Paper 0627 (contributed)
Ruppert-Pils Eva
Noise exposure of employees in educational institutions

Ruppert-Pils Eva, Wahler Wilhelm
AUVA-Austrian Workers' Compensation Board Adalbert, Austria

During measurements at different primary schools, nursery schools, and after-school care clubs, the respective noise levels to which employees are exposed were investigated. For this study, personal dosimeters were used to determine the effective noise level at the ear of the supervisor. These measurements were spread over several days to achieve a lower measurement uncertainty. To classify the different activities with the pupils and in order to get a better understanding of the resulting sound exposure level, the employees wearing such measurement devices were required to take notes of their activities and the number of kids present. Other factors, such as the reverberation time in the rooms were also taken into account. First results show relatively high sound pressure levels L_{Aeq} of over 80 dB at the ear of the supervisor, especially during lessons of physical education and during breaks. Room acoustics tend to have an impact on the resulting sound pressure level, but seem not to be the sole influencing factor. Detailed measurement results of the different educational institutions are compared and presented in this work. Also, possible precautions to avoid noise exposure are discussed.

Wednesday 15:20-15:40, Hall Aalborg, Paper 1005 (contributed)
Chmielewski Bartosz
Evaluation of influence of work analysis data on determination of occupational noise exposure for fitter–welder workstation

Chmielewski Bartosz, Baranski Filip
KFB Polska Sp. z o.o., Poland

In the article authors present results of determination of occupational noise exposure (performed in accordance with standard PN-EN ISO 9612:2011) for fitter–welder working in one of the manufacturing plant in Poland. The main

objective was to verify the measurement results contained in two earlier reports of other laboratories, who obtained noise indicators by measurements using task-based method (strategy 1). The results varied considerably, despite the lack of change in the production cycle for the workstation. To verify those two results, an additional measurement session with full-day measurement (strategy 3) was performed, extended by highly detailed recording of work activities (tasks, operations with tools, events) and their duration. Emphasis was placed on matter of determination and identification of tasks. Finally, for both strategies, the comparison of the contribution from each identified task to daily noise exposure level was made. The equivalent sound level values (total and octave bands) was obtained for each identified operation. Analysis of collected results led to evaluation of influence of the analysis of work on determination of occupational noise indicators. The authors point out that significant differences in periodic measurements do not allow employers to monitor the effectiveness of anti-noise solutions. Problem is that in most cases, employers require from acoustic companies warranty on the effectiveness of the proposed acoustic solutions.

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SS01 Tire/Road Noise - Low Noise Pavements

Paper 0536 (contributed)
Paje S. E.
Field performance evaluation of Stone Mastic Asphalt with crumb rubber

Paje S. E.[1]*, Vázquez V. F.[1], Terán F.[1], Viñuela U.[1], Hidalgo María Elena[2], Costa Andrés[3], Loma Javier[3], Cervantes Rocío[3], Lanchas Santiago[4], Núñez Ruy[4], Hergueta José Antonio[5], Sánchez Fernando[5], Pérez Félix E.[6], Botella Ramón[6], Rubio Baltasar[7], Jiménez Rafael[7], Potti Juan José[8]

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Re-using crumb rubber from waste tires in engineering construction projects such as road pavement reduces the negative impact of the waste materials on the environment. The current study presents an experimental research on the application of crumb rubber (CR) as a fine aggregate in stone mastic asphalt (SMA). Pavement noise evaluations were conducted using the Close Proximity Method (CPX) via the TireSonicMk4-LA²IC noise trailer. A set of different types of roads pavements segments were tested. In some cases, the results show significant noise reduction when compared to other common types of surface layers.

SS03 Modelling and Simulation of Road Vehicle, Tire and Pavement Noise

Paper 0901 (contributed)
Beigmoradi Sajjad
Optimum acoustical design of muffler using numerical simulation

Beigmoradi Sajjad[1], Jahani Kambiz[2]

[1] Automotive Engineering School, Iran University of Science and Technology, Iran
[2] Mechanical Engineering School, Sharif University of Technology, Iran

The level and character of noise emitted by exhaust system has significant effect on the overall acoustic performance of vehicle powertrain and sound quality which is received by occupants. In addition to meeting aforementioned objective, the exhaust system must meet exterior noise regulation which is ordered by governments. In this study, acoustic performance of the vehicle exhaust system is investigated. Numerical simulation is applied for this aim that is the fastest and the most economical method in early design

stages of vehicle development process. Thickness optimum design is performed in order to improve acoustic performance of exhaust system. Robust parameter design, based on Taguchi method, is utilized to find proper values for muffler thickness components. It is concluded that robust parameter design method significantly reduces time and cost of calculations for estimating optimum thickness of exhaust system parts.

SS04 Measurement Methods for Road Vehicle, Tire and Pavement Noise

Paper 0088 (invited)
Shimura Masayuki
Wind noise estimation functions for low frequency structure-borne sound measurement in natural wind

Shimura Masayuki[1], Kamiakito Noboru, Aoki Atsushi, Tateishi Kengo, Niwa Hisashi, Nomura Takashi[2], Hasebe Hiroshi, Osafune Toshikazu[3], Iwabuki Hiroshi, Terazono Shiniti[4], Kawasaki Yasuhiko, Tanaka Keiichi, Ito Yoshiki[5], Uchiyama Shinji, Iwai Yoshinori

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It is generally known that structure borne sound including the low frequency components is emitted from the structural vibration by the running load on the viaduct. By the excitation of the low frequency mode of the floor slabs, a low frequency sound is dominant in infra-sound domain. The low frequency sound of this frequency range often causes complaints from neighboring inhabitants because it wobbles a shoji which is a lightweight sliding paper door typical in Japanese houses. On the other hand, since the influence of the wind noise is very much for the outdoor measurements of the low frequency sound, it is difficult to identify whether the measured data is an emission sound from a viaduct or it is a pressure purterbation due to the wind. Therefore, by means of the simultaneous measurement of a low frequency sound level meter and an ultrasonic anemometer, we have conducted the study to introduce an evaluation function to estimate the wind noise that a microphone catches. In this report, we show the latest results of our research about the wind noise evaluation in natural wind.

Paper 0375 (contributed)
Vázquez V. F.
Dynamic stiffness of bituminous mixtures. Measurement technique and influence on tire/road noise

Vázquez V. F., Paje S. E.
University of Castilla-La Mancha - Laboratory of Acoustics Applied to Civil Engineering (UCLM – LA2IC), Faculty of Civil Engineering, Spain

Traffic noise is one of the main problems in urban areas because of the health issues it can produce. The dynamic stiffness of the pavement is one of the factors involved in the generation of tire/road noise, besides surface texture and absorption coefficient. The experimental technique presented in this paper deals to measure the in-situ dynamic stiffness of bituminous mixtures by means of a vibration exciter. The measurement set-up allows us to determine the dynamic stiffness Frequency Response Function (FRF) of the studied surfaces. Moreover, the CPX noise of these mixtures is also measured. The tests have been carried out by the LA^{2}IC in a test track section. The results are discussed to achieve a better knowledge of the rolling noise generation.

Paper 0397 (contributed)
Mun Sungho
A prediction model for the sound pressure level related to vehicle velocity by measuring NCPX method

Mun Sungho[1], An Deoksoon[2], Kim Do-Wan[1], Kwon Soo-Ahn[2]

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[2] Korea Institute of Construction Technology, Korea

A measuring technique for tire-pavement interaction noise that uses a novel close proximity (NCPX) method equipped with surface microphones has been employed to perform pavement noise evaluations on different pavement sections. Through field tests, the appropriate noise-measuring procedures have been developed and proofed for evaluating pavement surfaces at varying vehicle speeds. Results show that tire-pavement noise levels vary widely according to the various surface types, vehicle types, and vehicle speeds. In addition, power-by noise (power-train plus tire-pavement interaction noise) measurements, based on the NCPX method, were found to be applicable to the prediction model used for outdoor sound propagation.

SS05 Road Vehicle Exterior and Interior Noise

Paper 0296 (contributed)
An Deoksoon
Analysis of Traffic noise of various transverse rumble strips' geometry

An Deoksoon[1], Lee Jaejun[2], Lim Jaekyu[1], Kwon Sooahn[1], Son Hyeonjang[1], Eo Myeongso[3]

[1] Korea Institute of Construction Technology, Highway Research Division, Korea, [2] Chonbuk National University, Korea, [3] Metropolitan Road Division, Government Complex Sejong, Korea

The main purpose of transverse rumble strips (TRS) is to warn drivers by generating noise and vibration at close intersections or stop zone. TRS has been approved to be effective in reducing traffic accident due to sleeping from previous research. However, the external traffic noise creates complains from resident nearby the highway. The object of this paper is to investigate an external traffic noise of TRS as changed geometry design. TRS is common used by the agency for the purpose road safety on highway in Korea. As expand the urban and increase population, the resident area is getting closed a highway. Thus, the complains of the external traffic noise by generated TRS is more frequent. In order to investigate an effect of TRS geometry for the traffic noise, this study conducted the measurement of traffic noise as function of various width and depth of TRS. The vehicle speed was a factor to measure the traffic noise. The range of speed was from 60km/h to 100km/h. The wide width of transverse rumble strips was about 6dB(A) greater than the noise from the narrow width of TRS.

Paper 0904 (contributed)
Shin Su-Hyun
Advanced Evaluation Method of Squeak and Rattle Noise for Vehicle Interior Module

Shin Su-Hyun[1], Choi Young-Woo[2], Cheong Cheolung[3], Kang Dae-Hwan[1]

[1] Automotive Parts Institute Center, Korea, [2] National Forensic Service, Korea, [3] Pusan National University, Korea

Automotive interior noise such as squeak and rattle affect a customer's evaluation of vehicle quality. We propose an advanced evaluation method that can be used to reduce these noises in a vehicle cabin. First, potential source regions of the instrument panel and seat module are localized by using the near-field acoustic visualization system and electric vibration shaker. Then, a sound quality analysis of the detected potential noise

sources was performed using the Zwicker metrics and jury test. Second, the non-stationary and transient characteristics of squeak and rattle noises were analyzed using the statistical method and time-frequency sound pressure level maps. Finally, the computed sound metric and jury test result is evaluated to represent squeak and rattle noise of automotive interior module. It improves that the advanced testing system and sound quality technique can be used to measure the squeak and rattle noise in terms of subjective levels as well as objective levels.

Paper 0922 (contributed)
Erol Haluk
On the dynamics of a gearshift system in manual transmission

Erol Haluk[1], Karabulut Hüseyin[2], Kaynar Kayhan[2]

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Automotive manufactures constantly strive for enhancements in drive quality. A key element of this noise and vibration reduction within the passenger compartment. This can come from many sources including “combustion” from the engine and “gear whine” from the gear box. Much of this noise is transferred through components that pass from the engine cell to the passenger compartment, one such component being the gear shift transmission cable. The cable shift system is the mechanism, which provides the driver interface to the manual transmission and provides the ability to select the desired gear position. The driver, moving the shift knob to the desired gear, controls the subsystem. This selection of gear position should be accomplished within the acceptable efforts and with a high level of customer pleasure. In the gearshift system an inner cable provides the mechanical movement between the gear shifter and the gear box and an outer conduit houses the cable. A support attaches this conduit to a body of a vehicle. Considering the complexity of the structure and the numerical difficulties associated with dynamic modeling, the goal of this work is to investigate and improve the vibrations transmitted to the shift knob by using numerical and experimental methods.

SS08 Road Traffic Noise Characterization

Paper 1311 (contributed)
Han Dae-Cheol
Basic Experiment of the Noise Reduction Using Simulator

Han Dae-Cheol, Moon Hak-Ryong
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This research is to analyze the characteristic of road traffic noise in social, economic, and environmental problems using simulator and to study for contents of noise reduction. The purpose of this research is to analyze the basic characteristic of road traffic noise through simulator and to secure the possibility of realizing the technique of electronic based soundproof walls technology that can reduce noises through arising noise and anti-phase frequency. This research basically analyses characteristics of white noise and pink noise. By vehicle noise data collected from actual field, the experiment of noise characteristics is conducted in a lab using simulator on the assumption of road field through basic noise characteristic. After making the field noise in the simulator and arising opposite frequency, the noise reduction experiment is conducted to understand noise reduction effect. The result of the experiment confirms the effectiveness of control technique realizing background noise in test environment. There is the effect of about average 3 to 4dB noise reduction as the test result of opposing control sound by changing distance between generation point of noise source and control point of control sound to 0m, 2m, and 3m. However, this research need to identify the possibility of realizing electronic based soundproof walls technology although reduction effect according to distance by actual field test was confirmed.

SS11 Aircraft Noise Modeling - from the individual aircraft to the airport scenario

Paper 0001 (contributed)
Kamenický Milan
Determining of noise immission in vicinity of airports in Slovak republic

Kamenický Milan
EUROAKUSTIK, Ltd., Slovakia

According to legislation of Slovak Republic, noise pollution from air traffic is evaluated by A -weighted Equivalent Continuous Sound Level and A-weighted Maximal Sound Level SLOW. This environmental noise can be determined by measurement or calculation. Calculation, which is mostly done with the use of mathematical modeling in a large area around the monitored airport, requires input of several parameters, including noise emission parameters of aircraft operating at the airport. The paper describes the method of obtaining aforementioned data by measurement for aircraft whose input data were unavailable for determining the noise pollution in the vicinity of three airports in Slovak republic. The calculated results, describing the noise pollution caused by air traffic, were compared with measured data obtained in the broader area of monitored airports.

SS14 Aircraft noise management and mitigation measures

Paper 0717 (contributed)
Özkurt Nesimi
Evaluation of noise pollution based on the seasonal flight variations around the Antalya Airport in Turkey

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Evaluation of the impacts of aircraft movements over residential areas has been a focal point of public concerns. This study assesses the periodical changes on aircraft noise based on seasonal flight densities of the Antalya Airport. Noise contours around airports can be used as evaluation and decision-making tools by relevant authorities to avoid or minimize reactions of the community against the noise produced by aircrafts. Aircraft noise contour assessment is a complex procedure due to the diversity of flight route schemes, flight densities and procedures applied around an airport. For Antalya Airport, number of flights is higher in summer months when compared with other times of the year, because of tourism activities. The study was conducted in 2012 among the population living within a 25-km radius of Antalya Airport, one of the large airports in Turkey. The analyses were carried out with the aid of the SoundPlan software. The evaluation of noise mapping results has shown much higher noise values for the period between May and October, depending on the number of flights in the study area. The most

affected parts of the study area are located on the southern side of the airport.

SS15 Building Acoustics / Architectural Acoustics – General

Paper 0565 (contributed)
Sen Zhang
Investigation on the Acoustic Environment of General Hospital of Tianjin Medical University

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Studies on the sound environment of hospital mainly focus on the patient's feeling and ignore the staff's experience. In this study, medical care personnel in General Hospital of Tianjin Medical University were asked to evaluate the acoustical condition in their working environment. Furthermore, sound measurement including noise sources, noise level and noise frequency was done in several typical places in this hospital. It was found the staffs in this hospital were exposed to a high noise level of more than 65dB. And this severe sound environment brought adverse effects to staff's welfare and work efficiency. According to noise problems, improvement suggestion on soundscape design was put forward in this paper.

Paper 0864 (contributed)
Martín Julio
Study of sound absorption in cavities with different surface roughness practiced in building materials

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The purpose of this paper is to study and characterize the acoustic absorption coefficient structures based on resonant cavities made in building materials. First, the position and intensity of the absorption peaks were analyzed by varying the diameter of holes to a depth determined. Next, we studied the variations in the intensities and peak width to vary the texture of the surface roughness on the inside of the hole, maintaining the volumetric porosity of the material. In this paper, the material chosen was the plaster.

SS20 Impact Sound

Paper 0437 (contributed)
Pavarin Cora
Laboratory evaluation of impact noise insulation of dry systems for floating floors

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The evaluation of the insulation properties of dry systems for impact noise reduction is usually performed in laboratory, according to ISO 10140 standard. The use of dry systems made by panels consisting of mineralised spruce wood-wool bound with Portland cement combined with recycled rubber is a good solution for improving acoustic performance of floors. This kind of dry systems is very interesting not only from the acoustic point of view, but also for environmental sustainability. In fact both materials derive from recycled elements or from ecological and bio-compatible production cycles. 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 configurations that were chosen of these different layers starting from feedback of dynamic stiffness, rated according to EN 29052-1 standard [1]. The results were then compared with the estimated assessment of the acoustic performance proposed by EN 12354-2 standard.

SS25 Room Acoustics

Paper 0145 (contributed)
Nuri Ilgürel
Acoustical Comfort Conditions in Eating Establishments
Case Study on Student Dining Hall

Nuri Ilgürel
Yıldız Technical University, Turkey

Dining halls are to be considered as architectural spaces, which should satisfy different requirements such as dining and social gatherings. Mutual communication is the essential part of the acoustic requirements in dining halls. Therefore, in such establishments disturbing noises should be avoided or at least minimized, besides the speech Intelligibility should be ensured throughout the seating area. Acoustic comfort conditions in dining halls are determined by the architectural properties such as the volume, proportions of

the space, inner surface materials, the seating layout, etc. The total amount of absorption should ensure the required minimum absorption per person in order to obtain an acceptable acoustic environment in dining halls. That is essential in order to decrease the ambient noise levels and to avoid the Lombard Effect, which usually occurs due to the speaking persons, who tend to raise their voices above the ambient noise level. In this study, a student dining hall has been investigated in terms of its acoustic conditions; besides a survey was conducted among the students regarding their attitudes for acoustic comfort inside the dining hall. Furthermore, acoustical simulations have been carried out and some principle solutions were proposed to improve the acoustic environment inside the dining hall.

Paper 0164 (contributed)
Trematerra Amelia
The Acoustic of the Catacombs of “San Gennaro” in Naples

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This paper reports the results of acoustic measurements made inside the Catacombs of “San Gennaro”in Naples. The Catacombs are underground places where the early Christians were buried. The Catacombs were used until the 5th century AD, they were abandoned when the bodies of Christian martyrs were moved inside the churches built in the cities. The Catacombs were rediscovered only towards the end of the 15th century, and used as a place of prayerand religious meeting. The Catacombs of “San Gennaro”have been excavated in a rock called “tufa”, over the centuries the Catacombs has not changed, and the current configuration corresponds to that the 5th century AD. In origin the Catacombs were not only places of burial, but they were also performedsacred functions, but we don’t know thistype of function, if they were spoken, sungor psalm. The acoustic measurements were made using the impulse responsemethod. By the analysis of the acoustic parametersas RT, EDT,C80, D50 and STI, we tried to understand the type of religious ceremony performed.

Paper 0208 (contributed)
Takala Joose
In search of lost acoustics: Nya Teatern in Helsinki, 1860–1863

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In Helsinki, a new theatre building was completed in 1860. The building became known as Nya Teatern, 'the New Theatre', as it replaced the earlier wooden theatre building. The new theatre building was expected to become a stage for drama, opera and orchestral music. It also became the first Finnish building which was a discussion topic because of its acoustics. Already its building plans were criticized, and newspapers wrote critically about the completed building. The architect responsible for the design also participated in the discussion and explained the design principles of the building. Contemporary opinions say that the acoustics of the theater considering music was a disappointment and that there were many seats that had very poor audibility. Only three years after its inauguration, the theater burnt down. Nowadays it is not possible to listen or measure its acoustics. However, the building plans still exist, which makes it possible to model the acoustics. The aim of this study was to compare the results of room acoustic modelling with the contemporary opinions on the theatre. According to the modelling, theater's reverberation time was short, 0,8 at mid-frequencies. For drama purposes, the theater's acoustics was fairly good in many seats, but for opera and orchestral music it was not very suitable. By acoustic modelling, large differences between the seats could be found which was expected on the basis of the contemporary opinions. At the upper circle, there were several seats that did not have any visual contact with the stage. Thus, the acoustic modelling verified the contemporary opinions.

Paper 0402 (contributed)
Dolejší Jan
Acoustical Properties of Five Historical Theatres

Dolejší Jan[1], Šturmová Iveta[1], Majchráková Barbora[1], Dolejší Jana[1,5], Dolejší František[1,5], Rychtáriková Monika[3,4], Pouzar Ladislav[2]

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This paper deals with interior acoustic parameters of five historic theatres in Europe, namely of historic theatre in Český Krumlov (Czech Republic), Litomyšl (Czech Republic), Gotha (Germany), Drottningholm (Sweden) and Weitra (Austria). We investigated acoustic parameters of these theatres during last few years. All these theatres have excellent acoustic parametres, event though that at the time when these theatres were built, there were no advanced computer programs for acoustic prediction. Acoustical sollutions

were based on experience of the architectby adoptaion of a room geometry. Today, we achieve optimal acoustic results by using modern materials. The acoustic simulation of all mentioned historic theatres was performed using ODEON® software.

Paper 1240 (contributed)
Buchegger Blasius
Acoustic Redevelopment of a Heritage-Protected Room

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A significant acoustically improvement of historical auditoriums and halls can be a huge challenge due to limited possibilities of structural changes. In this case computer based simulation investigations can be extremely helpful to get a reliable prediction of the effect of foreseen improvements. In this paper, the design process and results of the acoustically upgrade of the historical auditorium of the University of Technology in Graz/Austria is presented. Design goal is to optimize the speech intelligibility for presentations and lectures. First the fundamentals, the detailed geometry and material data of the room have to be determined. After that, a computer - simulation model using the software "CATT - Acoustic" of the current situation is created. The auditorium space is subdivided under application of a fine grid, and the quality of the room acoustic is measured by “MLS” – measuring technique. In a further series of measurements, the “STI” values are determined, which can give a seat-related information on speech intelligibility. On the basis of the obtained data, the simulation model can be calibrated and adapted to the reality as closely as possible to create reliable results. In conjunction with appropriate planning calculations there are measures developed, which are interfered as little as possible in the historical structural substance. The complete acoustic design process is based on current valid and relevant international and national standards. The investigation shows, that with regard to the very limited possibilities of structural changes the targets can not be achieved only by room acoustic measures. So also the existing electro-acoustic equipment has to be redesigned. The results show, that in case of application of the proposed measures very satisfying acoustic conditions can be provided in this historical room. The main focus should be set to generate enough sound energy for the auditorium, while suppressing the excitation of the diffuse sound field.

SS27 Long and Short Range Sound Propagation

Paper 0677 (contributed)
Hiraguri Yasuhiro
Improvement of estimation method of land cover acoustic characteristics using hyperspectral imaging data

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Outdoor acoustics simulation methods based on wave acoustics and energy-based model are being established with a lot of discussions until now; however, data for use in the simulation, especially geographic information such as land cover acoustic characteristics, have not been discussed to any great degree. Authors presented a possibility of the land cover classification estimation method specialized for acoustic simulations using high-accuracy hyperspectral imaging data through a case study using a Nagaoka sample. Consequently, the usefulness of the estimation method by MED-SD method using hyperspectral imaging data is indicated despite some incorrect estimation. Therefore, an improvement of estimation method needs to be suggested for more accurate acoustic simulations. In this paper, number of training data and optimum threshold value necessary for correct estimation are discussed.

SS31 Barriers

Paper 0090 (contributed)
Štulíková Lenka
Development of a new gabion structure with an absorptive face

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The article deals with the description of a new gabion structure with an absorptive face and its acoustic characteristics. The working name of such a structure is a multifunctional gabion. The construction is based on composites from recycled materials with a high absorption capacity. These composites are

applied in the structure by means of sound absorbing plates placed in between the gabion structure and the stones inside. The composites are produced from rubber granules. In this way, the structure not only fulfils its primary structural function, but a protective acoustic function is added. A multifunctional gabion offers a wide scope of applications in transportation engineering as a structural and, simultaneously, sound absorbing structure – a noise barrier. Thanks to its excellent acoustic parameters, a multifunctional gabion may be recommended as a reinforcing element of slopes near the transportation infrastructure situated in areas of existing as well as planned settlements and urban agglomerations. The article describes the design of a multifunctional gabion with several alternatives, the construction of a test structure outside the traffic route polygon and the verification of the sound absorption of the structure by direct in-situ measurements. The development of a multifunctional gabion was financially supported and funded from the TACR project No. TA 01020760 “A multifunctional gabion with utilizing of recycled materials“.

Paper 0283 (invited)
Yoon Je Won
A study on the development of noise reducing device installed on the top of noise barrier for noise reduction of 400km/h class high-speed railroad

Yoon Je Won[1], Kim Young Chan[1], Jang Kang Seok[1], Choi Chan Yong[2]
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The purpose of this study is to develop of noise reducing device installed on the top of noise barrier which will be used to reduce the noise of 400km/h class high-speed railroad. For this purpose, the frequency spectrum was analyzed through the noise measurement of high-speed railroad running 400km/h. And, the prototype was decided with the model having the most outstanding acoustic performance among many various shapes using the prediction method (2D BEM). Also, the acoustic performance measurement in anechoic chamber was conducted with the prototype which was verified by simulation. Finally, the acoustic performance measurement by small-scale outdoor tests was conducted as the prototype which was verified by simulation and anechoic chamber measurement. According to the these results, it was investigated that the noise reduction values were more than 3dB(A).

Paper 0289 (contributed)
Jung Joo Mok
A study on the development of core soundproof device for reduction of the environmental noise in 400 km/h high speed

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[1] Unison Technology, Ssangyong-dong, Korea, [2] Korea Railway Research Institute, Korea

This study, for the development of next generation high speed railway system of a train which has maximum speed over 400km/h in South Korea, is to develop core generic environmental technologies in order to noise reduction by train. Also this technology contains the emitting noise performance test of 400km/h speed operated trains. The ultimate purpose of this study is to develop a new technology of core sound proof system which is more economical and efficient to cope with the noise increased as the operating speed increased to 400km/h. In this study chose two types device for noise reduction of high speed train. One is the interference device installed on the top of a soundproof wall for reducing the diffracted noise, and the other one is the sound absorption block for reducing the slab reflection noise. In this study was completed to develop the shape and to evaluate the performance of the two devices. Also the noise source of 400km/h vehicle was researched by on-site measurements using microphone array system. In 2014, the performance test is a scheduled on test bed for 400km/h high speed vehicle.

Paper 0312 (contributed)
Bertó Laura
Characterization and validation of a reverberation chamber built to scale in order to test small prototypes of acoustic barriers

Bertó Laura, del Rey Romina, Alba Jesús, Teira Andrés

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A reverberation chamber is an essential laboratory for acoustic characterization and validation of materials and barriers, among others. However, for the case of flat absorbents, the acoustic Standard requires to count on an area of the materials to be tested between $10m^2$ and $12m^2$. At research level, we haven't always got amount of material enough. Test small samples of materials in a reverberation chamber built to scale could be a solution to this problem. The objective of this work is the adaptation of a

small reverberation chamber reduced in size (1/6 of the original size) to be used as a laboratory to characterize small samples of materials. In order to carry out this objective, several materials were tested in the standardized reverberation chamber and in the small reverberation chamber. Then, the sound absorption coefficients obtained for each material in both chambers were compared. This comparison was used as a starting point to implement the necessary improvements in the small reverberation chamber. Final results reflect that the small reverberation chamber could be used as a laboratory to obtain the sound absorption coefficient of small samples with reliability. Furthermore, time, effort and costs required to test materials according to ISO 354:2003 were reduced.

Paper 0438 (contributed)
Castiñeira-Ibáñez **Sergio**
Design of the upper edge of noise barriers based on arrays of scatterers to reduce the diffraction phenomenon

Castiñeira-Ibáñez Sergio[1], Rubio Constanza[2], Sánchez-Pérez Juan Vicente[2]

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Diffraction on the upper edge is one of the mechanisms that can reduce the effectiveness of the noise screens, and much of the research work done is about how to reduce this phenomenon. On the other hand, the use of arrays of scatterers as noise barriers is presented in last years as a good alternative to the ones formed by continuous layers. The advantages and disadvantages about the use of such systems as acoustic barriers have been widely discussed in the bibliography. We present here a numerical analysis about the way to reduce the diffraction on the upper edge of this kind of barriers, proposing new designs based on the destructive interference of the acoustic waves. The results are obtained using a three-dimensional numerical model developed by us, allowing the design of the upper edge of these barriers to reduce diffraction with a low computational cost. The promising results obtained can help to develop devices based on arrays of scatterers that are competitive respect to classical screens under acoustic standpoint.

Paper 0838 (contributed)
Tsukernikov Ilya E.
Estimation of A-weighted sound pressure level reduction by noise screen

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On an example of calculation of the *A*-weighted sound pressure level reduction by a thin screen for a point sound source with a flat spectrum (pink noise), high-frequency spectrum (white noise) and low-frequency spectrum with recession by 3 dB in frequency bands, it is shown that there are essential divergences in a single-number rating of a noise screen depending on the sound spectrum. The expressions for estimation of *A*-weighted sound pressure level reduction by a noise screen for motor transport and railway noise are derived, using the normalized traffic noise spectrum to be stated by European standard EN 1793-3 and the linear approximation of the known graphic dependence of screen efficiency on Fresnel's number to be given by Z. Maekava.

Paper 0942 (contributed)
Lee Ju Haeng
Effects of thickness and materials of soundproof panel with air layer on transmission loss

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Transmission Loss representing sound performance of noise barriers is widely known greater in proportion to weight per unit area. Expected that even in case of double layer panel having air layer inside, transmission loss would be better depending on thickness of panel, we experimented to reveal how much thickness of panel with air layer can influent on sound performance. The differences according to materials were investigated as well. All panels tested were made of polymer such as PC (polycarbonate), PMMA (Polymethyl methacrylate), which are generally used for transparent noise barriers and PP (Polypropylene), PE (Polyethlyene) to compare with wide uses. Thickness of air layer in all samples was identified as 4 mm. Thickness of soundproof panel varied as 3 mm, 4 mm, 5 mm. The heavier thickness of panels was, the greater transmission loss was except the case of PMMA panel. Interestingly, 5 mm-PMMA panel showed much less performance

compared to that of 4 mm. In conclusion, it is found that while transmission loss increase proportionally to weight per unit area even for air layered panel, there could be exceptions according to materials. We suggest there be further studies on effects of materials and structure such as air layere in noise barriers.

SS32 Noise Mapping and Action Planning

Paper 0615 (contributed)
Xia Dan, Zhou Yude
On Noise Management Application of Noise Mapping

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Noise mapping development and application has a mighty long time in the world. But few examples of noise mapping used in environmental noise management appear. In this paper, noise mapping is used in urban environmental noise management since the cities in China develop quickly with many noise problems. The composition, working process and input factors of noise mapping are studied. The computing software suitable for domestic cities is chosen and secondly developed. The study focuses on the accuracy of the noise mapping and its corresponding verification system, completing the human-friendly display management system. An environmental noise management system is developed and tried based on the study above. Then a method of noise management based on this system is found. The study results may be helpful and referential for the construction of noise management platform.

Paper 0769 (invited)
Junek Pavel
History of road noise mapping in the Czech Republic

Junek Pavel
National reference laboratory for environmental noise of the Czech Republic, Institute of public health in Ostrava, Czech Republic

Road noise mapping in the Czech Republic has quite a long history. The first road noise maps were produced 35 years ago. It was a time when groups of noise experts came to every district town and measured noise close to the

roads. It was a time when storage of measured data was difficult or impossible and the most used storage device was paper. The noise levels were plotted on a map by hand. From 1980 till 1990 every district town in the Czech Republic had a noise map of main roads. Since 1990 modern noise analyzers have been used and modern data processing has been performed. Night noise maps of some cities have been created. After 2000, a number of calculated noise maps started to be more common. The problem was calculation methodology. From 2005 to 2007 strategic noise maps of roads was calculated using EU recommended interim calculation methods. The result was the first compact road noise map on the territory of the Czech Republic. The second round of strategic noise mapping in 2012 included quite dense road networks.

Paper 1026 (contributed)
Berlier Filippo
Monitoring and estimating of noise traffic in the transalpine corridors and related effects

Berlier Filippo[1], Tartin Christian[1], Tibone Christian[1], Crea Daniele[1], Carnuccio Enrico[1], Cipriani Valerio[2], Merlino Arturo[2], Piani Luca[2], Salvagni Miro[2]

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iMonitraf! is the name of an Alpine Space Project that lasted from 2009 to 2012. The project studied the effects of road and rail traffic along the Alps and involved the following regions: Rhône-Alpes, Piemonte, Valle d'Aosta, Central Swiss Cantons, Ticino, Tyrol, Trentino Alto Adige and Friuli Venezia Giulia. About noise, the purpose of the work was to harmonize the measurement methods and to give a common guideline for the population exposure evaluation. The noise impact was evaluated using L_{DEN} and L_{night} parameters, while to evaluate the disturbance on the inhabitants living along the transalpine corridors the Annoyance concept was used. Results of noise measurements and population exposure are the main outputs of the Project. Furthermore, only for the Tarvisio corridor, a pilot study on noise modeling was made. The comparison between the L_{DEN} values and the relative degrees of Annoyance could be used as a method to check the traffic distribution strategies. During the Project, noise levels were consistent with traffic flow data in the measurement points and they haven't nearly changed over the years. The aim of the pilot study was to develop a methodology for noise modeling studies in alpine areas and the relative population exposure.

SS33 Noise Monitoring and Measurement

Paper 0422 (contributed)
Taimisto Pekka
Noise exposure during commuting in three European cities

Taimisto Pekka[1], Yli-Tuomi Tarja[1], Pennanen Arto[1], Vouitsis Ilias[2], Samaras Zisis[2], Keuken Menno[3], Lanki Timo[1]

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In the TRANSPHORM study, noise exposures during commuting were measured. Measurements were performed with noise dosimeters in three European cities, Helsinki, Thessaloniki and Rotterdam, during spring 2011. In each city, two to five approximately 8 km commuting routes were selected to represent typical commuting routes of the city population. Measurement campaigns lasted for 6 days, each day including 4 one-way drives on the same study route with a bike, a bus and a car with first open and then closed windows. In Helsinki, the median L_{Aeq} levels were 72.9 dB, 71.2 dB, 66.4 dB and 67.8 dB for a bicycle, a bus, a car with closed windows and a car with open co -driver window, respectively. Corresponding results in Thessaloniki were 74.9 dB, 73.2 dB, 70.7 dB and 72.1 dB. In Rotterdam , the median L_{Aeq} level during bicycling was 69.3 dB and during the bus journeys 68.9 dB. There were clear differences between the cities in the noise levels, but in all cities bicyclers were exposed to the highest noise levels, followed by the bus passengers. It is unclear to what extent noise effects on the selection between a private car and eco-friendlier commuting modes.

Paper 0823 (contributed)
Bite Maria
Research results of the meteorological data influencing the accuracy of noise measurement results

Bite Maria, Bite Pal, Dombi Istvan, Fay Endre
VIBROCOMP Ltd., Hungary

Meteorological circumstances are significantly influencing the accuracy of traffic noise measurement data. Similarly to the authoritative traffic data, it seems necessary to introduce the concept of authoritative meteorological

conditions and the actual measurement data need to be converted to it. Especially, this topic is important for the evaluation of measurement data of the current monitoring systems. The literature gives correction for measurements over 200 m primarily, but in most cases the noise measurement and its evaluation is performed within 200 m. Based on the data of long-term (24-hour) noise and corresponding meteorological measurements performed in the past, we established the relation between half-hour equivalent noise and meteorological parameters (temperature, humidity, etc.). We developed correlation with correction. We determined the critical distance, altitude, weather condition over which the data of the noise measurement give inaccurate results without correction. We set a function with the least squares method on the resulting sound pressure level-humidity-time functions. We assigned an equation to it – with the available statistical accuracy - which describes, inter alia, noise load - humidity relationship in mathematical form. We present the tests performed and its results, developed mathematical correlation, its applicability too. We analyze in detail the specific areas of application of the method developed and our suggestions for modernizing the noise measurement method. Meteorological circumstances are significantly influencing the accuracy of traffic noise measurement data. Similarly to the authoritative traffic data, it seems necessary to introduce the concept of authoritative meteorological conditions and the actual measurement data need to be converted to it. Especially, this topic is important for the evaluation of measurement data of the current monitoring systems.

SS36 3D Sound Reproduction

Paper 0661 (contributed)
Hidaka Tomoaki
Subjective Evaluation of Sound Quality of a Vehicle Headrest Acoustic System

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Greater power-saving performance is a high priority for recent onboard vehicle equipment. Therefore, high-quality power-saving car audio systems are very much in demand. Under these circumstances, we developed a headrest acoustic system (HRAS), with speakers built into the headrest,

capable of being operated on low power, which aims to be a "new power-saving and comfortable car audio system." In our experiment, a subjective evaluation was conducted, comparing a standard car audio product and the HRAS. The evaluation terms were 12 pairs of words related to sound quality, comfort, added value, and safety. There were 10 sound sources: narration, fusion, classic, J-pop, vocal, healing, nature, jazz, rock, and pop; and each source was presented in 3 ways: in stereo by the standard car audio system (standard CAS), and in two ways by HRAS (in stereo, and in binaural reproduction with stereophonic signals processed to produce 3D audio effects). The two types of HRAS reproduction received higher scores than the standard CAS for the evaluation items related to comfort, and equal or higher scores for the items related to safety. Principal component analysis was also conducted and extracted three factors; sound field factor, palatability factor, and clarity factor. The scores for these factors were compared, and the HRAS binaural reproduction obtained higher scores than the standard CAS for all factors, but the HRAS stereo reproduction obtained poorer scores for the palatability factors. These results indicate that binaural reproduction by HRAS is the most effective configuration.

SS38 Sound Visualization and Aurealization

Paper 0363 (contributed)
Fernández Comesaña Daniel
Visualization of acoustic intensity vector fields using scanning measurement techniques

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Sound propagation paths are not always well understood mainly because of the complex nature of the source or the environment. A direct method to capture the sound energy flow throughout a room is to measure the three-dimensional sound intensity distribution across space. In the past years, several studies have been carried out using step by step measurements with a three-dimensional intensity probe consisting of a sound pressure transducer and three orthogonal particle velocity sensors. The probe's ability to measure even in highly reverberant environments and its small size are key features required for numerous applications. However, punctual measurements are time-consuming, especially when a large number of measurement positions are evaluated. The use of advanced scanning

measurement techniques, such Scan & Paint, allows for the gathering of data across a time stationary sound field in a fast and efficient way, using a single sensor and webcam only. The acoustic signals are acquired manually by moving a probe across a measurement plane whilst filming the event with a camera. In the post-processing stage, the sensor position is extracted and then used for linking a segment of the signal acquired to a certain position of the space. In this manner, the overall measurement time is reduced from hours to minutes. In this paper, the acoustic intensity vector fields of several complex examples are investigated; revealing the acoustic energy flow of several vehicles, a loudspeaker in a room, and also the interaction between an absorbing sample and a reverberant sound field.

SS39 Active Noise and Vibration Control

Paper 0496 (invited)
Wu Ming, Yang Jun
Performance analysis of LMS algorithm in presence of tonal disturbance

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In active noise control system, the filtered-X LMS algorithm is a frequently used algorithm. Before implementing the filtered-X LMS algorithm, the secondary path should be estimated in advanced. For time-varying circumstances, it is desirable to track the secondary path online. One common used online secondary path modeling technique is proposed by Eriksson, where an adaptive filter is induced to model the secondary path. The coefficients of the adaptive filter are updated by using LMS algorithm. Much work has been done to analyze the performance of the LMS algorithm in presence of disturbance. Almost all of them assume the disturbance signal is white noise. In this paper, the performance of LMS algorithm in presence of tonal disturbance is analyzed. The analysis is validated by simulations.

Paper 0754 (contributed)
Rosa Nishida Pedro Pio
Smart Structures Applied to Active Control of Higher Order Noise in Ducts

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The best option for higher order noise control is the use of axial splitters in the duct. It is possible to perform the active noise control in each splitted section by using a single channel control system. The use of smart structures takes advantage of the splitter plate and uses it as the control source. In order to evaluate this possibility of the noise control using smart structures, an analytical model of a plate with piezoelectric actuators was built then the acoustic field generated by this vibrating structure inside of the duct was obtained. However, to obtain the acoustic field inside an splitted duct, a numerical method such as the Component Mode Synthesis has to be used. Using the equation of the acoustic field generated in the duct by the plate, it was possible to obtain the acoustic field inside the splitted duct. The active noise control simulations for harmonic and random excitations were performed and the influence of the size of the plate excited by the piezoeletric actuators and of the number of actuators was studied. In conclusion, it is possible to say that the smart structures can be used in active noise control of ducts with splitters.

Paper 0934 (contributed)
Miranda João Gabriel
Active Noise Control with Ducts: Optimization of the Receiver Sensor Position

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Most studies of ANC are designed to tonal signal and discrete frequencies. One of the main difficulties of Active Noise Control (ANC) in Ducts is to develop a methodology that can achieve control in a wide frequency range due to fact that some specific frequencies are not so easy to control. In this paper is conducted an experimental study to understand the reason of this problem. The main idea of this paper is to obtain the acoustical Frequency Response Function (FRF) among excitation point in various points of a duct and conduct a study that correlates the influence of resonance and anti-resonance regions. In experimental procedure were used microphones as receivers sensors and a micro-accelerometer attached to a loudspeaker to measure the excitation pressure field. After the selection of frequencies of interest, a mono-channel Broadband Feedforward ANC were used to noise control purpose. The results show that the frequency response positions has a strong influence in ANC performance.

Paper 1070 (contributed)
Cho Youngeun
Optimization of direct impedance control gain of electroacoustic absorber for maximizing sound absorption coefficient area

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Electroacoustic absorber can vary specific acoustic impedance in front of the loudspeaker diaphragm using direct impedance control gain. It facilitates to absorb noise in the low frequency range (0Hz~500Hz) using impedance matching principle and has already been demonstrated as a remarkable solution in view of noise reduction recently. Theoretically, the ratio of direct impedance control gain should be similar to the value of the characteristic impedance of air for the noise absorption. In this paper, optimization of direct impedance control gain is implemented for maximizing the sound absorption coefficient area in the interested frequency range. Also, the effect and change of the direct impedance control gain on the sound absorption coefficient area according to the interested frequency range are investigated. The optimization process is investigated by means of response surface method for determine optimal direct impedance control gains.

Paper 1224 (contributed)
Nakayama Shohei
Effect of an active noise control system on acoustical noise during magnetic resonance imaging diagnosis

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A magnetic resonance imaging (MRI) equipment generates loud sounds during its operation. The sound pressure level depends on the imaging sequences but is generally around 100 dB. This makes patients uncomfortable, and temporary hearing loss is possible if ear protection to decrease the sound pressure level by 20 dB is not used. This situation is so discomforting to the patient that in some cases MRI diagnosis and treatment may be refused. We studied ear protectors with an active noise control (ANC) system. Traditional protectors can decrease sound pressure level for high frequencies, but ANC

systems can control low-frequency sounds as well. This study considers improvements to the acoustical environment when using ANC systems for MRI patients. The ANC system we developed is a feedforward system because MRI acoustical noise is unsteady and pulsed. The system uses nonmagnetic devices, ear protectors, and optical microphones because MRI rooms are highly magnetic environments. A computer simulation showed that the transition of the level of MRI acoustical noise was controlled by the ANC system during a diagnosis. As a result, the system reduced the MRI acoustical noise from 110 dB to 70 dB and was capable of changing the imaging sequences during MRI operation.

SS40 Signal Processing and Analysis

Paper 0332 (contributed)
Kang Byung Ok
Noise Robust Spontaneous Speech Recognition Using Multi-Space GMM

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In this paper, we propose a new approach using a multi-space Gaussian mixture model (GMM) for a large-scale spontaneous speech recognition system that is robust to the acoustic environmental noise. Current speech recognition systems based on a hidden Markov model (HMM) perform well in matched conditions, but their performance is degraded by mismatch conditions, such as mobile environments with diverse additive noise. In the case of mobile voice search services, the real noise environment is reflected in rich speech log data, and using speech logs, performance improvement is achieved in the growing matched condition. However, because most of this speech data is short with a limited pattern, when it is used for large-scale spontaneous speech recognition tasks like voice SMS, the performance improvement is limited and degradation is even observed in a quiet environment. Therefore, this paper proposes a new approach which, using rich voice search speech data, constructs a multi-acoustic space GMM with distributions of speech corrupted by diverse environment noise and reflects these statistics in an acoustic model for a speech recognition system with a distinct domain like dictation speech. The evaluation results obtained from the voice SMS task show that the proposed method provides

meaningful improvements over conventional adaptive training methods to handle multi-style training data.

Paper 0431 (contributed)
Liu Wei
Research on spectral kurtosis for the rolling bearing fault diagnosis

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As usually done in rolling bearing fault diagnosis, a band-pass filter is used to improve the signal-to-noise ratio (SNR) before carrying out envelope demodulation of the fault signal. Spectral kurtosis (SK) can indicate not only the transients in non-stationary signal, but also their locations in the frequency domain. Thus, SK is widely used to identify the resonance frequency band of the fault signal. However, when using SK to analyze the practical fault signal of the rolling bearing, it is found that the estimated SK of the signal with sparse pulses is abnormal which leads to a wrong determination of the resonance frequency band. In this paper a method is proposed to avoid this problem. Moreover, based on SK, Time-Spectral Kurtosis (TSK) is proposed in this paper. Just as its name implies, TSK indicates the locations of the transient components in both frequency domain and time domain. A noise cancelling filter is built using TSK, with which the out-band and in-band noise in the fault signal can both be filtered out. The envelope demodulation results demonstrate the validity of the proposed method.

Paper 0513 (contributed)
Tabacchi Mattia
Water boiling stages classification using acoustic features - Towards a cooking appliance monitoring and control

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Anyone could easily remember the sound produced in several cooking processes, like frying chips, or boiling pasta. This is because these processes are intimately linked to the generation of sound, which has

information that a cook can exploit during the cooking. Nevertheless, although it has been largely used in acoustics, very few studies have applied pattern recognition for the monitoring and control of cooking processes. In this paper, we describe a pattern recognition application on a simple case of boiling water, as way to test the technique, trying to find the best approach for a future wider scope. Besides defining and analysing the efficacy and the performance of a statistical pattern recognition approach when applied to different signals in the appliance (sound and vibration), an optimisation module has been proposed to boost the classification rates by adding syntactical analysis that enables the inertia of the process to be considered. In the specific case of boiling water, almost 100% successful recognition has been reached. These results prove the validity of this methodology, opening new research lines for new scenarios such as different cooking processes, acoustically polluted environments, sensor optimisation, etc.

Paper 0576 (contributed)
Wang Xin
The Influence of hammers on Chinese Dulcimer Timbre

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In this thesis, the influence of three hammers on Chinese dulcimer timbre was studied. Subjective evaluation method was applied to obtain dulcimer timbre preference of three hammers, which used different styles of music as experiment signals. Acoustic features of three hammers tones were calculated, such as spectral centroid and spectral flatness. Based on the subjective and calculative results, dulcimer timbre with organic plastic hammer which was covered with rubber sleeve at the head was mellow, fullness and most preferred; dulcimer timbre with red wood hammer which was wrapped with rubber tape at the head was noisy, sharpness and least preferred. The results showed that organic plastic hammer with rubber sleeve covered was suitable for smoothing and graceful music; red wood hammer with rubber sleeve covered was fit for exiting music; red wood hammer with rubber tape wrapped around wasn’t suitable for playing because of noisy and sharp timbre.

Paper 1155 (contributed)
Park Kiyoung
A robust endpoint detection algorithm for the speech recognition in noisy environments

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A method to detect voice segments in audio signals recorded in noisy environments is proposed in this paper. The endpoint detection is one of the most important part of speech recognition. Despite of many studies, it is still challenging especially for the mobile applications since they are used in very diverse conditions. The hierarchical endpoint detection algorithm which was proposed is further enhanced and tested for the real-world data which are collected using the mobile speech recognition application opened to the public. Many cases where the conventional algorithm fails to work are analyzed and categorized in several classes. A detector is designed for each class and augmented to the hierarchical detection algorithm. Experiments are performed to measure the detection accuracy and the speech recognition accuracy for the real-world database collected. The users uttered short sentences for writing e-mails, twitters and short messages in diverse environments. The voice segments are detected and then recognized by the large vocabulary continuous speech recognizer in real time. The results show that the proposed method works well in harmony with other detectors and the overall performance is improved greatly in the aspect of the detection accuracy as well as the speech recognition accuracy.

Paper 1222 (contributed)
Nakasako Noboru
Acoustic distance measurement system for close-range based on interference between transmitted and reflected waves by introducing analytic signal

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Since the distance to target is very important information, we have proposed an acoustic distance measurement using a standing wave, which is generated by interference between transmitted and reflected waves. This method is very simple in that the distance between the microphone and the target is estimated as the peak value of the range spectrum (i.e., the absolute value of the Fourier transform with respect to the power spectrum of the observed wave). However, in order to measure short distances, a transmitted wave

with a wide bandwidth is required. The present paper describes a compact system for very-close-range measurement based on the standing wave of audible sound without changing the bandwidth of sound. More concretely, we introduce an analytic signal instead of the power spectrum and examine the validity and effectiveness of the proposed system through its application to an actual sound field.

SS44 Vibroacoustics and Vibrations

Paper 0042 (contributed)
Souza Karllyammo L.
Influence of Cavitation Vibration Levels of a Centrifugal Pump

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Centrifugal pumps are hydraulic machines, which transfer energy to the fluid, with the purpose of transporting it from one location to another. These machines are applied in various industries such as: chemical, food, petroleum and others. Failures in this equipment can lead to stop the production line, causing heavy losses to the company. One of the major causes of faults in centrifugal pumps and components is cavitation. Phenomenon originated by sudden drops in pressure, forming bubbles in the low pressure zone of the pump and posterior collapse of these bubbles in the high pressure zone. These bubbles release shock waves and micro highly energetic jets, causing damage to the surface reached. In this paper we conducted a practice analysis of vibration behavior of a centrifugal pump of a petroleum processing unit, operating in real-world process under the action of the phenomenon of cavitation. At the end of the analysis it was found that the vibration levels of equipment are significantly altered by the action of cavitation, and that vibration analysis is an excellent tool to help diagnose equipment influenced in their operation by random phenomena.

Paper 0203 (contributed)
Sokolov Aleksei
Vibration of fluid-filled pipes with flexible inserts taking into account the fluid–structure interaction

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In this paper longitudinal vibration of fluid-filled pipeline with flexible insert (bellow) taking into account fluid-structure interaction is considered. Transfer matrix method is used for calculations. Special feature of metal bellows is complex geometry and, consequently, a strong fluid-structure interaction. This interaction can be classified as junction coupling. Based on approximate equation of corrugated shell, analytical expressions for the transfer matrix of the bellow are obtained. Numerical results using analytical formulas are compared with calculations by finite element method. Strong influence of fluid-structure interaction to the dynamic behavior of the system is shown on the example of the pipeline section.

Paper 0594 (contributed)
Kim Seockhyun
Radiation Characteristics of the Beating Sound in a Slightly Asymmetric Bell

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Any oriental bell or western bell has small asymmetric elements which exist in an axi-symmetric basic structure. These asymmetric elements make pair of each natural vibration mode and it produces a frequency pair having a slight difference. Exciting the mode pair by striking the bell, beating sound occurs by the interaction of the two modes consisting of the mode pair. Beat is often suppressed in a western bell, while it is desirable and controlled in an oriental bell. In this study, we discuss how the beating sound depends on the mode pair property and striking condition, and consider the radiation characteristics of the beat on the circumference of the bell. For the analysis, revolutionary shell theory is used and the effect of the small asymmetry is investigated. Finally, we introduce a method and an application for the estimation and control of the beating sound in the belfry.

SS46 Materials for Noise and Vibration Control

Paper 0311 (contributed)
del Rey Romina
Acoustic barriers made from textiles wastes and PET

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The use recycled materials or eco-materials in the design of acoustic barriers is an added value to solve traffic noise problems. Using this kind of acoustic barriers we hope to reduce acoustic pollution both in roads and in railway track. Moreover, recycled materials have been used to reduce costs and wastes in the production lines. In this paper, samples made from textile waste, or from recycled PET of plastic bottles, are acoustically characterized, avoiding using for processing any toxic resin. Acoustic absorption of perforated acoustic barriers made from recycled materials is studied using the standardized method ISO 354: 2003. The first results show that these eco-screens have a comparable absorption with those made conventionally from mineral wool.

Paper 0314 (contributed)
Alba Jesús
Coating based on nanofibers as a solution to reduce noise pollution

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The reduction of noise pollution in urban or industrial areas close to urban ones can be achieved using textile materials as elements of installations (walls, floors, ceilings or acoustic barriers). Within the project LIFE - NOISEFREETEX was realized a composite nanostructure by the deposition of electrospun nanofibers PET recycling directly on a non-woven. In this way, we have got a solution to noise pollution using recycled textile materials as coating. In order to characterize these solutions, several sound absorption tests were carried out. The standardized sound absorption tests (ISO 354:2003) require a sample size between 10 m^2 and 12 m^2. At the present time, the LIFE - NOISEFREETEX project is going on a validation step of different kinds of nano-recoatings. At this step, the sound absorption of different small size samples is being tested in order to validate or dismiss the coatings which are put on each of them. So, using small samples, we are improving in efficiency and economic budget. In this work, acoustic barriers reduced in size were tested in a reverberant chamber built to scale. They are made from recycled PET covering with nanofibers. Final results show that these nano-eco-barriers could be used as solutions to noise pollution.

Paper 0693 (contributed)
Akasaka Shuichi
Influence of fiber diameter on sound absorption characteristics of silica nanofiber laminates

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Nanofiber is a fiber with a diameter of less than 1 micrometer. The nonwoven-fabric-like laminate sheet comprised of it has high porosity and the continuous pore structure. In this study, we made laminates (3 mm thickness) of silica fiber with a diameter of about 0.5-3.5 micrometer by electro-spinning method and investigated the relationship between fiber diameter and sound absorption characteristics of it. Even if the silica fiber laminates was thin, it showed higher absorption coefficient comparing to a glass wool (48kg/m3). As fiber diameter decreased, a pore diameter decreased, but porosity was almost constant. As a result, flow resistivity increased since surface area of fiber increased. We found that the sound absorption characteristics of laminates which comprised of thin fibers like nanofiber was affected by sample vibration.

Paper 0770 (contributed)
Bustamante Marcelo
Experimental curves of damping as a function of acceleration and frequency of an elastomer particle damper called EniDamp™

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Research testing has led to the development of an innovative damping treatment called EniDamp™. This treatment can add considerable damping to a structure by directing vibration through a rigid connection to a set of interacting elastomer particles. Previous studies have shown that this vibration treatment presentsa highly nonlinear behavior and maximum damping is achieved when the particles are in thefluidization state. However, these studies were carried out exciting the system at a fixed low frequency. Therefore, the dissipative behavior of EniDamp™ over a broader frequency

rangestill needs to be investigated. In this paper, 3D curves forthedamping as a function of acceleration and frequency over a broad frequency range are reported. Important conclusions drawn fromthese experiments will guide future studies and provide supporting data to implement this damping treatment in real applications.

Paper 0976 (contributed)
Zhao Junjuan
Sound absorption characteristics for double-layer plate construction using viscoelastic membrane

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Currently, there is a great interest in panel absorber design. These absorbers, except simple porous layers, are compound absorbers, i.e. they consist of elements in special arrangements, such as air volumes, foils (either limp or elastic, tight or porous), membranes, plates (either stiff or elastic, tight or porous) mostly with perforations in the shape of e.g. slits or circular holes, porous absorber layers, etc. For such absorbers, the challenge is to increase the natural, viscous losses to attain an acceptable absorption bandwidth. This paper presents a novel sound absorber of double-layer plate construction which involves a micro-perforated layer and a coating viscoelastic membrane layer which formed on outer surface of the micro-perforated layer. The purpose of this design is to increase the input impedance of such absorbers. The energy dissipation takes place in the double-layer plate construction, especially in the viscoelastic membrane layer where the viscous energy dissipation has been enhanced by the use of glue. The results by simulations had demonstrated such double-layer plate construction has outstanding sound absorption characteristics, excellent external appearance and good productivity.

SS55 Noise and health related quality of life

Paper 0082 (contributed)
Carvalho Luiz C. L.
Interleukin-6 gene polymorphism and hearing loss related to the history of occupational noise exposure in Brazilian elderly

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Noise-induced hearing loss (NIHL) is an interaction of both genetic and environmental factors. Some studies have led to the identification of possible NIHL susceptibility genes. The aim of the present study was to investigate whether the polymorphism of the interleukin (IL)-6 gene at position -174 was associated with complaints of hearing loss due to occupational exposure. Cross-sectional study in a population sample with 141 individuals aged over 60 years with and 50 without history of occupational noise exposure in Brazil, through anamnesis and audiological evaluation and IL-6 genotyping by the PCR-RFLP technique. The variables studied were frequency of hearing loss and polymorphism (SNPs). Chi-square test was used in order to control likely confusion or modification the effect of other variables on interest associations. Hearing loss was reported in 73.8% of elderly with history of occupational noise exposure. 37.2% and 56.0% of the elderly were heterozygous and homozygous for allele G, respectively. No significant associations between the genotypes of these SNP and NIHL were obtained in the Brazilian population. The NIHL was statistically associated with sex and age (χ^2=11.24; $p<0.05$; χ^2=7.34; $p=0.007$; respectively). No association was found with the polymorphism of the IL-6 gene and hearing loss associated with the occupational noise exposure history in Brazilian elderly.

Paper 0291 (contributed)
Son Jinhee
Datum handling method of noisemap and survey for %HA and %A prediction curve

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Predicted noise level has been used to assess the annoyance response since noise map was generalized and being the normal method to assess the environmental noise. Unfortunately using predicted noise level for the annoyance prediction curve caused some problems. The datum has to be grouped manually to use the annoyance prediction curve. So the aim of this paper is to propose the method to handle the predicted noise level and the survey data for annoyance prediction curve. This paper used the percentage of persons annoyed (%A) and the percentage of persons highly annoyed (%HA) as the descriptor of noise annoyance in a population. The logistic regression method was used for deriving annoyance prediction curve. It is concluded that the method of dichotomizing data and logistic regression was suitable to handle the predicted noise level and survey data.

Paper 0481 (contributed)
Bijelovic Sanja
Assessment of noise annoyance in the city of Novi Sad

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Survey was carried out in the city of Novi Sad, Province of Vojvodina, Republic of Serbia, for 2012. It was conducted on the population subjective assessment of noise impact on human health, based on 352 valid completed questionnaires. The questionnaire for the subjective assessment of noise annoyance was based on national surveys approved by Ethical Committee of Medical School University of Novi Sad and on ISO/TS 15666:2003. It was found that most respondents (49%) consider the road traffic as the main source of environmental noise (p=0.0000), followed by the noise from the neighborhood (23%), noise from construction work (21%), noise from restaurants (20%), noise from the lifts and other electrical wiring (11%) and noise originating from industrial facilities (11%). During the day 28% of respondents were highly annoyed and 49% were annoyed, while during the night 41% were highly and 64% annoyed. The conducted research established that there is a strong need for reducing the level of noise in the urban environment of the city of Novi Sad, especially during the night.

Paper 0499 (contributed)
Mizumachi Mitsunori
How do we perceive noisy and noise-reduced speech?

Mizumachi Mitsunori
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It is important for speech applications to quantify the intelligibility and the quality of speech. There are some means of evaluating the intelligibility and the quality objectively and subjectively. The objective evaluation is economical, but the general-use distortion measure is not available. On the other hand, the subjective evaluation requires a cost-consuming formal listening test. The right evaluation should be carried out in the right purpose. No almighty methodology has been established at the moment. In this paper, brain activities involved in evaluating the noisy and noise-reduced speech are measured using the functional magnetic resonance imaging (fMRI) technique. It is found that the brain activity in evaluating the noise-reduced speech varies depending on the noise reduction approach. The noise-reduced signals, which are obtained by the linear processing such as the delay-and-sum beamforming, calm down the brain activity compared with the noisy speech signals. On the other hands, non-linear signal processing such as the spectral subtraction activates the auditory cortex intensely. It is necessary for designing the advanced speech distortion measure to independently consider how the noise is removed and how the speech is distorted by noise reduction.

SS58 Psychological effects, cognitive effects and mental health

Paper 0974 (contributed)
Tamesue Takahiro
Effects of acoustical noise on selective attention to auditory and visual stimuli, performance and annoyance during intellectual task

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The presence of noise during the performance of cognitive tasks involving such as memory, commonly causes a subjective experience of annoyance, which can lead to a decline in performance. This tendency is stronger for

meaningful noise such as conversation and music than for meaningless noise such as road traffic noise and heating, ventilating and air-conditioning noise. This paper first focus on the degree of meaningfulness of noise, then discuss how the brain responds during auditory and visual cognitive tasks under the meaningful/meaningless noise. Transient event-related potentials (ERPs), elicited by internal or external stimuli, can be measured using electroencephalography (EEG). P300 ERPs are related to the operation of selective attention. The present experiment was designed to determine the effects of meaningfulness of the noise on selective attention to auditory and visual stimuli under the odd-ball paradigm. To this end, we examined differences in the P300 ERPs of these components. In addition, we considered the psychological impression of annoyance in response to the noise, and a performance such as reaction time. Our results suggested that meaningful noise has a strong influence on selective attention to stimuli in auditory and visual cognitive tasks.

SS64 Noise policy and economic evalution of noise effects

Paper 0818 (contributed)
Fabris Christian
German Noise Policy

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This summarizes the principle and main noise policy instruments in Germany from the point of view of the Federal Environment Agency. It shows a simple model of these instruments, embedded both in European and German federal state legislations. German legislation on noise is divided into several laws, ordinances and other regulations concerning the various sources of noise (traff ic, industry, mobile machinery, sports grounds, etc.) Noise emissions are generally governed by European legislation. Examples are the so-called ‘Outdoor Directive’ and the ‘Energy-using-Products Directive’. Other laws limit the noise exposure from noise sources. Another example is the implementation of the Environmental Noise Directive into German noise policy. This contains the principles to create feasible noise abatement plans considering public concerns. The planning of traffic routes as the most annoying noise source in Germany is regulated in particular laws and ordinances for the respective sources. Noise exposure of the most stationary noise sources is limited by a national instrument of legislation, the ‘Technical Instructions on Noise

Abatement - TA Laerm'. There are also some governmental economic development schemes which are related to noise criteria. Last but not least there is the environmental label 'Blue Angel', which awards several products that are outstanding quiet in their product family.

Paper 0952 (contributed)
Park Youngmin
Current state of apartment noise and environmental impact assessment scheme to resolve the noise in Korea

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In Korea, the ratio of residents who living in multi-housing such as apartment is about 71% and the number is significantly higher compared to foreign countries. Apartment noise has emerged as a major social problem over the past few years because murder cases involving apartment noise recent years alerted the nation to the severity of the issue. The flooring defect is considered the first reason of growing dispute, but behind the growing disputes over apartment noise are more fundamental reasons such as growing individualism, miscommunication and lack of understanding. If a dispute arises due to apartment noise, there is no standard for residents living noise in Korea. This study identifies the current state of apartment noise compared to other countries and propose effective plan for the Environmental Impact Assessment to resolve the Noise.

SS67 Psychoacoustics of environmental and mobile noise sources

Paper 0457 (contributed)
Shukunami Atsuto
Uncomfortable Level Estimation for Audible Alarm Using Brain Magnetic Field

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The traditional concept for production of artificial sounds that are common in daily life has changed from finding a solution to unwanted noise to designing a particular sound. Uncomfortable level (UCL) is an important factor to be considered when designing sounds such as alarms and notification

signals. Although UCLs have been widely investigated using psychoacoustic methods, brain activity associated with them is not yet clear. Here, we measured magnetoencephalographic (MEG) [1] responses when participants passively listened to a series of pure tones that varied in frequency and intensity. A psychoacoustic experiment was also performed on the same participants to obtain their subjective UCLs. Our results indicated that the amplitude and latency of the evoked auditory responses increased/decreased logarithmically as a function of increasing stimulus intensity level and the subjective UCL was appeared in the relaxation part of the change rate of auditory evoked responses. The relationship between the neurophysiological signals as indexed by the auditory-evoked and spontaneous responses and subjective UCL was captured and utilized to infer a model to estimate the UCL objectively.

Paper 0610 (contributed)
Kitajima Takumi
Development of a new sound evaluation system using cymbals

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Generally speaking, human audibility can be 20 kHz. While, it is said that the high-grade musical instruments such as Stradivarius violin can make very beautiful harmonic sound over 20 kHz. However, the mechanism of high frequency sound generation isn't clear and the current sound evaluation system only depends on sensory evaluation. Therefore, in this study, we newly focus on sound including high frequency over 20 kHz and develop a new sound evaluation system which can measure the high frequency sound. At the moment, the evaluation and analysis of sound are comprehensively tested by taking the correlation of analyses between sound and electroencephalogram (hereafter EEG) recording results when audiences are listening to the sound of prototype and mass-produced model cymbals and these sound is simultaneously recorded up to 50 kHz. As a result, larger sound pressure in the region of 20 kHz or more generates not only alpha waves but also beta waves, which means that the high frequency sound over 20 kHz is affected to the brain waves and gives us well balanced hearing and exciting effects.

SS68 Applied psychoacoustics of machinery noise

Paper 0621 (contributed)
Ji Hae Young
Sound characteristics analysis in the cabs of railway

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People use various means of transportation for public convenience. Especially, railway is used for public and freight transportation mainly in South Korea. Technical development on railway system has been continued throughout the world, but noise problem is being raised along with the development. Many researches on noise mitigation measures are going on currently to improve the quality of railway utilization by passengers, while studies fall short of the noise mitigation measures for drivers of cab although they are exposed to the noise for a long time. In this paper, we have categorized train type as urban train, freight train and high-speed train. Also, we measured noise level in similar driving conditions for cabs where railway vehicle drivers are located to finally conduct a detailed analysis of characteristics including 'Sound Quality Metrics'. Identifying the characteristics that harm the drivers depends on operating conditions of trains and providing the index data to prepare noise mitigation measures for driving cabs in the future shall be the purpose of this study with using the result of the above analysis.

SS69 Soundscape and Human Resources

Paper 0548 (contributed)
Kogan Pablo
Early identification of urban locations towards soundscape analysis

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Soundscape management in a city implies mitigating harmful sounds and promoting useful ones, according to their environmental, social or cultural significance and considering a more human centered paradigm. The Soundscape approach does not consider sound as a waste but a resource and

its application may reach more benefits than solely noise control actions. This conception conveys an emerging paradigm, which requires novel and cross-disciplinary methodologies for its application. In this direction, every location in a city has its own dynamics and this should be weighed. Thus, preliminary area exploration represents a strategic action allowing one to identify key soundscape spots, optimize the data acquisition, and adjustment of methodologies. This work presents the conceptual foundations, empirical methods and some preliminary results for the early identification of urban study sites.

SS72 Fan Noise

Paper 0587 (contributed)
Choi Youngsoo
Optimization of phase control and fan position to reduce noise of projector

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A significant problem with many electronic instruments is the acoustic noise caused by cooling fans. Moreover, an increase in power consumption due to demands for higher performance has led to the use of faster and larger fans, which has in turn given rise to the difficulty of noise management. To solve this problem, many engineers have suggested an active noise system, despite many limitations. This study proposes a method of reducing fan noise using phase control and the optimal fan location. The elimination of noise using the phase difference between fans determines the effectiveness of complete destructive interference of acoustic pressure waves, thereby reducing noise. Thus, this paper focuses on the reduction of tonal noise from fan noise and the optimization of fan location. To achieve this, we analyze an acoustic phenomenon using a simulation tool. The result of the present study is expected to facilitate a configuration design for the manufacturers of low noise.

Paper 0939 (contributed)
Hidechito Hayashi
Interaction Noise and Unsteady Flow at Tongue of Cross-Flow Fan

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The relationship between the unsteady flow and the interaction noise of the cross flow fan is investigated with experiments and numerical simulations. The interaction noise is mainly generated at the tongue. In this research, it is cleared the sound source characteristics at the tongue. It is cleared that the sound source at the tongue is divided to the three parts. The one is the round corner where the flow out of the impeller is stagnated and divided to the outflow and the recirculation flow near the tongue. The second one is the middle part of the tongue where the recirculation flow pass along the tongue and the pressure is fluctuated with the passing blade. The third one is the edge of the tongue end where the flow on the tongue is separated. The phase of the pressure fluctuations near the round corner are shifted to a half period at positions and the sound from the positions are cancelled each other. The middle part is the main source where the phase of the pressure fluctuation is almost same at each position, so the large sound generates from this part. The short tongue is proposed to reduce the interaction noise that is removed the middle part of the original one. The interaction noise can be reduced by the short tongue.

SS73 Ducts and Mufflers

Paper 0131 (contributed)
Kuang Zheng
Acoustic energy transfer with audible sound waves in duct

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In recent years, there has been a growing interest in the acoustic energy transfer (AET), which is considered to be an alternative method for the power supply of electronics. Most of the researches focus on the AET systems for biomedical and through-wall applications by using ultrasonic sound waves. In this study, an acoustic-electric power transfer system is presented allowing for wireless transfer of electric power through a cduct using the audible sound waves with two piezoelectric transducers. The experimental results show the power transfer capability and efficiency of the system. The technology is potentially applicable for sensing in duct in the area of noise control and condition monitoring.

Paper 0240 (contributed)
Nishimura Yuya
Experimental study of sound proofing ventilation grilles with various shapes of inlet and outlet

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Ventilation grilles are widely used in the house in tropical climates countries. However, the annual increase in traffic noise in developing tropical countries has rendered this kind of ventilation grille to be useless. A previous study, the authors are presenting a concept for calculated and manufacturing a new type of ventilation grilles called SPVG which are capable of ventilating and reducing traffic noise inside the homes of the developing countries in tropical climate zones. Based on the results obtained, the acoustic characteristics of SPVG are experimentally considered in present work. To maximize the soundproofing ability, various shapes of inlet and outlet are determined by an investigation of the distribution of higher order mode waves formed inside the SPVG.

Paper 0365 (contributed)
Tang Y.J.
Narrow Side-branch Array For duct noise control

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In this research project, a passive method of using narrow side-branches has been used for improving the sound transmission loss along ventilation duct. A microphone was installed at the end of each side-branch. While 4 other microphones were installed in front of and at the back of the array. Four settings with different tube length arrangement had been compared. Two microphones transfer method was used in calculating the sound transmission loss. The result shows that this narrow side-branch array can produce a higher transmission loss within a relatively wide frequency range. The performance of the side-branch array can improve the effect of resonance across narrow side-branch arrays and hence broaden the resonance frequency band to maximize transmission loss.

Paper 1004 (contributed)
Bednarik Michal
Nonlinear acoustic fields in two mechanically coupled resonators

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The paper deals with a description of nonlinear standing waves in cylindrical resonators which are separated by an elastically mounted wall. The wall represents a quasi-harmonically driven oscillator which connects nonlinear acoustic fields in the resonators. For the description of the nonlinear acoustic fields were derived model equations. The model equations are represented by the inhomogenenous Burgers equations. These two model equations are supplemented by an oscillator motion equation. The assumed resonant system contains many optional parameters which enable to investigate a number of interesting configurations of parametrically excited nonlinear acoustic fields. The system of model equation was numerically solved both the time and frequency domain. Some of the assumed configurations were solved analytically for the case of steady acoustic fields. Thanks to many optional parameters the investigated resonant system is relatively complex and enables to study a number of interesting configurations. The resulting acoustic fields for some of the chosen configurations are included in this paper.

SS74 Aeroacoustics

Paper 0909 (contributed)
Jahani Kambiz
Numerical Study of Aero-Acoustic Characteristics in an Automotive Air-Intake System

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Compartment noise has gained significant importance to meet customer expectation. One of the dominant sources of noise from whole engine as a system is the one which is induced from fresh air intake. Geometrical features in air induction systems (AIS) airflow path are often responsible for unusual noise due to the complex air flow structure and its interaction with the internal acoustic field. To reduce air intake noise basically resonator and expansion chamber are used on automotive vehicles. Resonators are widely used for noise reduction of air induction systems. Although, airflow bench

tests are faster to evaluate various alternate design geometries, understanding the mechanism of such noise generation and silencing devices is necessary for developing an effective design. In this study, a 3D computational fluid dynamics (CFD) simulation was performed on baseline geometry (fresh air intake along with resonator), in order to predict the distinct acoustic characteristic. The associated results are extracted and the acoustic behavior of the air intake is studied in order to identify the probable problematic area. Further investigation has been conducted on a modified geometry, with the aim of minimizing the noise produced by air charge drawn into the AIS according to the base case. The computational analysis should be able to predict the flow field with high accuracy so that the pressure fluctuations, which are actually the source of longitudinal waves (sound), can be first monitored and later analyzed to obtain the required results. These pressure fluctuations are caused by the turbulent behavior of the fluid.

SS75 Occupational Noise Exposure and Hearing Protection

Paper 0175 (contributed)
Meneses-Barriviera Caroline Luiz
Hearing loss at high frequencies and history of occupational noise exposure

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Noise exposure is one of the most common health risk occupational factors and is capable of producing hearing loss. This study aimed to determine the prevalence of high frequencies hearing loss and possible association with history of occupational noise exposure in the elderly. We conducted a prospective study in subjects aged over 60 years. The subjects were submitted to anamnesis and audiological assessment. The Mann Whitney test with 95% confidence interval and p value <0.05 was used for statistical analysis. A total of 498 subjects of both genders, with a median age of 69 years were evaluated. Of these, one did not answer the question of noise during the audiologi cal survey, totaling 497 elderly. Comparing the thresholds of individuals with a history of occupational noise exposure and those without a history of occupational noise exposure were obtained with mean (500, 1000 e 2000Hz), p=0, 9542 and with mean (3000, 4000 e 6000 Hz), p=0, 0007. From this research there was a statistically significant association between hearing loss at high frequencies and occupational noise exposure in the elderly.

Paper 0629 (contributed)
Dado Miroslav
Modelling of noise generated by woodworking machinery with respect to occupational noise exposure

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Noise is a common occupational hazard in the woodworking shops. This paper describes results from a study designed to verify suitability of noise maps for use as information tool in terms of legis lative requirements for occupational health and safety provision regarding the exposure of workers to the risks arising from the noise. In order to evaluate the accuracy of simulation model, comparison was made between daily noise exposure based on prediction and measurements at woodworking shop. Good agreement was found between occupational noise exposure results based on measurement and modelling with computer algorithm which is implemented on software tool IZOFONIK.

Paper 0789 (contributed)
Morzyński Leszek
Wireless monitoring system supporting correct use of earmuffs

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Earmuffs are one of the most frequently used technical means of hearing protection. In real conditions, sound attenuation of earmuffs is lower than sound attenuation determined in laboratory during the certification process, mainly as a result of improperly using the earmuffs. In the worst cases, exposure to noise of workers wearing earmuffs can exceed admissible values, which can lead to hearing loss. Therefore the use of the earmuffs by workers should be supervised. In this article the model of the system developed for remote supervision of the use of earmuffs is presented. The system consists of earmuffs with integrated measurement devices with a radio module for wireless data transmission and a main unit of the system. In the proposed system, parameters of noise measured under the cups of the earmuffs are transmitted to the system's main unit via the wireless network based on ZigBee protocol. Basing on the results of measurements collected

from earmuffs, the supervisor of the system can determine the noise exposure of workers using earmuffs as well as improper use of the earmuffs.

Paper 0943 (contributed)
Cha Aran
Headset-based active noise control system for reducing MRI noise

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The noise generated by gradient systems in magnetic resonance imaging (MRI) is very annoying and harmful to patients. Although passive methods have been used to block the MRI noise by wearing earplugs and earmuffs, the emitted high noise levels make it difficult to use it. In this paper, we present an active control (ANC) technique to control such noise from MRI system. ANC system uses a headset mockup with microphones and control speakers, and the feedforward filtered-x least mean square (FxLMS) algorithm was used for updating the filter coefficients. Experimental results indicate that the performances of the system depend on each MRI sequence but also are achieved effectively. Later, additional simulations are conducted to compare the performance of the variable step size FxLMS (VSS-FxLMS) algorithm with the FxLMS algorithm. Its results show that the performance of the VSS-FxLMS algorithm is more stable than FxLMS algorithm on different MRI sequences.

Paper 1083 (contributed)
Qin Qin
The Progress of Noise Exposure Limits Research At Workplace

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During recent years, with an increasing attention to occupational health, a great number of countries and regions have updated relevant standards according to current situations. This article will give a brief introduction of the latest released acoustic noise exposure limits in about 20 countries including the UK, the USA, and Japan.

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Impressum:

Medieninhaber:
Österreichischer Arbeitsring für Lärmbekämpfung (ÖAL)
1200 Wien, Dresdnerstrasse 45
Österreich

ZVR-Zahl 783724553

Präsidium:
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Herstellung:

Satz: Diesignerin Agentur für individuelle Werbegestaltung
Barbara Weilguny, www.diesignerin.eu
Druck: Druckerei Walding, Gewerbepark 2, A-4111 Walding

Fotos Titelseite: ©TVB Innsbruck

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