The Reality of Automotive Audio in the Age of E-Mobility

The role of audio in the automotive industry has changed significantly. The rapidly growing importance of electronics, software, connectivity and autonomous driving poses major challenges to the audio departments of automotive manufacturers and suppliers. In addition, new fields of development have emerged, sound systems are not only part of the infotainment system, they are also used to shape the sound of cars, i.e. the sound of the car itself due to its movement and thus sound generation.

The AES 2019 AA will provide an overview of the progress made since the last conference two years ago and will gather the leading global authorities in Automotive Audio for three days. Automotive manufacturers and suppliers will present new solutions for shaping the user experience (UX), show new technological insights, demonstrate possibilities on how to develop sound systems in the virtual reality, address new requirements in the emerging field of car sound design plus exhibitions and demos showcasing the latest automotive audio technologies.

Daily keynote presentations will highlight key areas of interest. The keynote from Ivo Muth, Vice President User Exerience/User Interface for Audi will feature the topic “The Holistic User Experience”, “Audio Engineering in Today’s Automotive Industry: from Technical Performance to Sound Quality”, is the topic of the keynote, presented by Laurent Gagliadrini, DQI/DAPF/NVH (PSA Peugeot Citroën), and the keynote, given by Dr.-Ing. Bernhard Grill, Director with focus on Audio and Media Technologies (Fraunhofer IIS), will expound on “Immersive Audio Listening Experience in Cars – the Future of Music.”

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AES 2019 International Conference on Automotive Audio

Sept 11 – Sept 13, 2019
at Audi Driving Experience Center, Neuburg a. d. Donau, Germany

PROGRAM

Wednesday, Sept 11, 2019		
Time	**Topic**	**Location ADEC***
07:00 - 09:00 AM	**Opening Conference Registration & Welcome Morning Coffee**	Lobby
08:00 AM	**Demo & Exhibition Open** [All day]	Ground Floor
09:00 - 09.15 AM	**Opening Comments** Dr. Alfred Svobodnik, Chairman 2019 AES International Conference on Automotive Audio	Meeting room first floor
09:15 - 10:00 AM	**Opening Keynote: The Holistic User Experience** Ivo Muth, Vice President User Experience/User Interface (Audi)	Meeting room first floor
10:00 - 10:30 AM	Paper Session 1: **Self-Testing of Car Audio Systems** Authors: Stefan Irrgang and Wolfgang Klippel (Klippel)	Meeting room first floor
10:30 - 11:00 AM	**Morning Coffee**	First floor
11:00 - 11:30 AM	Paper Session 2: **A Software-Centric Solution to Automotive Audio for General Purpose CPUs** Authors: Mark Every, Len Layton and Jose Maria Marin (Blackberry QNX)	Meeting room first floor
11:30 - 12:00 PM	Paper Session 3: **Automotive Microphone Performance: from Specification to User Experience** Authors: Yu Du, Viktor Dobos, Balazs Varga and Ruiting Yang (Harman)	Meeting room first floor
12:00 – 1:30 PM	**Lunch**	First floor
parallel 1:15 – 1:25 PM	*Sponsors Speaker Slot:* *Sony is presenting "360 Reality Audio"*	*Meeting room first floor*

1:30 - 2:15 PM	Invited Paper: **The Digital Transformation in Automotive Audio;** Roger Shively (JJR Acoustics/Mvoid Group)	Meeting room first floor
2:15 – 3:15 PM	Tutorial: **Testing Voice-Controlled & Smartphone Integrated Infotainment Systems;** Steve Temme (Listen Inc.)	Meeting room first floor
3:15 – 3:45 PM	**Afternoon Coffee**	First floor
parallel *3:15 – 3:25 PM*	*Sponsors Speaker Slot:* *HARMAN AudioworX – a one-stop-shop solution for efficient audio processing & tuning with access to a wide range of unique audio technologies;* *Philipp Krejci (Harman)*	*Meeting room first floor*
3:45- 4:15 PM	Paper Session 4: **Virtual Tuning – A Mixed Approach Based on Measured RTFs** Hans Lahti (Harman) and Dr. Adrian Bahne (Dirac)	Meeting room first floor
4:15- 4:45 PM	Paper Session 5: **Virtual Reality Experience for the Optimization of a Car Audio System;** Authors: Michael J. Strauss, Francois Malbos and Michal Bogdanski (Harman)	Meeting room first floor
4:45 PM	End of Conference Day	

*ADEC = Audi Driving Experience Center

Thursday, Sept 12, 2019		
Time	**Topic**	**Location ADEC***
8:00 AM	**Demo & Exhibition Open** [All day]	Ground Floor
08:30 - 08:45 AM	**Opening Comments**	Meeting room first floor
08:45 - 09:30 AM	**Keynote: Audio Engineering in Today's Automotive Industry: from Technical Performance to Sound Quality;** Dr. Laurent Gagliadrini (PSA Peugeot Citroën)	Meeting room first floor
09:30 - 10:00 AM	Paper Session 7: **On the Impact of Next Generation of Automotive Radio Tuners on Active Noise Cancellation and Engine Sound Enhancement System Capabilities;** Authors: Stefan Kerber, Rolf Schirmacher, Katharina Schmidt, Rita Reger and Qian Ni (Müller-BBM)	Meeting room first floor
10:00 - 10:30 AM	**Morning Coffee**	First floor
10:30 – 12:00 PM	Panel Discussion: **Automotive Audio System – Today Today and in Future – Holistic System Design;** Participants: Wolfram Jaehn (Audi), Markus Koch (Byton), Dr. Adrian Bahne (Dirac), Martin Olsen (Harman), Jose Marin (QNX), Thomas Wuerdinger (BMW), Jonatan Ewald (Volvo) Moderator: Greg Sikora (Harman)	Meeting room first floor
12:00 - 1:30 PM	**Lunch**	First floor
parallel 1:15 – 1:25 PM	*Sponsors Speaker Slot:* *ADI's newest SHARC Audio processor family ADSP-2156x delivers market leading performance scalability for low latency real-time applications;* *Jignesh Sonchhatra, Andrew Lanfear (Analog Devices)*	*Meeting room first floor*
1:30 – 2:45 PM	Tutorial: **Design and Implementation of Electric Vehicle Sound;** Marijn Kooy (Müller-BBM)	Meeting room first floor

2:45 – 3:15 AM	Paper Session 7: **Evaluation Criteria for Engine Harmonic Cancellation;** Authors: Davis Pan (Bose)	Meeting room first floor
3:15 - 3:45 PM	**Afternoon coffee**	First floor
parallel 3:30 – 3:40 PM	*Sponsors Speaker Slot:* *Fraunhofer – We hear the bigger picture;* *Sebastian Scharrer (Fraunhofer IIS)*	*Meeting room first floor*
3:45 – 4:15 AM	Paper Session 8: **Evaluating Binaural Simulations of a Premium Automotive Sound System;** Authors: Eva Hasenberger, Gerhard Krump and Martin Schneider (Fraunhofer IIS)	Meeting room first floor
4:15 – 5:30 PM	Panel Discussion: **Sound Reproduction on Wheels: Aesthetics & Challenges in Automotive** Participants: Stefan Bock (SMS Studio Group), Dr. Angela Linow (Ford), Willy Löster (Producer/Mixing Engineer), Niklas Schmincke (Alpine), Stefan Varga (Harman) Moderator: Dr. Rafael Kassier (Harman)	Meeting room first floor
6:00 PM	**Barbecue**	First floor / balcony
10:00 PM	End of Conference Day	

AES 2019 International Conference on Automotive Audio

Sept 11 – Sept 13, 2019
at Audi Driving Experience Center, Neuburg a. d. Donau, Germany

Friday, Sept 13, 2019		
Time	**Topic**	**Location ADEC***
8:00 AM	**Demo & Exhibition Open** [All day]	Ground Floor
08:30 - 08:45 AM	**Opening Comments**	Meeting room first floor
08:45 - 09:30 AM	**Keynote: Immersive Audio Listening Experience in Cars – the Future of Music** Dr.-Ing. Bernhard Grill (Fraunhofer IIS)	Meeting room first floor
09:30 - 10:30 AM	Workshop: **Assessment of Sound Systems** Jonathan Ewald (Volvo) Moderator: Lars Carlsson (Dirac)	Meeting room first floor
10:30 - 11:00 AM	**Morning Coffee**	First Floor
11:00 - 11:45 PM	Invited Paper: **Extending the Bandwidth of Local Active Noise Control in the Automotive Environment Using Headtracking;** Dr. Jordan Cheer (Signal Processing and Control Group, Institute of Sound and Vibration Research, University of Southampton)	Meeting room first floor
11:45 - 1:15 PM	**Lunch**	First Floor
parallel *1:00 - 1:10 PM*	*Sponsors Speaker Slot:* *QNX Acoustics Management Platform 3.0: A Fully Integrated Software Architecture to Manage Vehicle Acoustics; Len Layton (Blackberry*	*Meeting room first floor*
1:15 – 1:45 PM	Paper Session 9: **Segmented Mass Loading for Loudspeaker Cones;** Author: Karel Goossens (Premium Sound Solutions)	Meeting room first floor
1:45 – 2:15 PM	Paper Session 10: **Crossover Filters Pre and Post Limiters for Basic Loudspeaker Protection: A Case Study.** Authors: Marcin Kalinowski and Matteo Nucci (Harman)	Meeting room first floor

2:15 – 2.30 PM	**Closing Remarks;** Dr. Alfred Svobodnik, Chairman 2019 AES International Conference on Automotive Audio	Meeting room first floor
2:30 PM	End of Conference	

ABSTRACTS

11.09.2019
09:15 – 10:00 AM

Keynote: The Holistic User Experience

Keynote Speaker: Ivo Muth
Audi AG, Vice President User Experience/User Interface

The user experience (UX) customers expect from their automobile is at a turning point. While in the past, especially horsepower and exterior features dominated the emotional experience of cars, in the future the interaction space in the interior will be the main constituent of the costumer UX. In order to prevail as a premium brand in this new competitive environment, automotive manufacturers have to offer a holistic and stunning UX in which an impression for all human senses is orchestrated.

11.09.2019
10:00 – 10:30 AM

Self-Testing of Car Audio Systems

Authors: Stefan Irrgang, Wolfgang Klippel (both Klippel GmbH)

All hardware components required for a test system that checks the quality of the audio system in cars are actually already available in modern cars: DSP, converters, sensors, transducers and connecting links. However, they are not designed as test system components but may be used as such.

Smart amplifiers and loudspeaker control technologies are of special interest for this approach. They provide powerful means to improve transducer properties like robustness, linearity, and bandwidth. By definition, they identify loudspeaker parameters and states. Such valuable information can be exploited for test and measurement tasks such as design qualification, end-of-line testing, quality assurance, long-term monitoring and ensuring safety relevant features (e.g. pedestrian warning systems). This paper investigates benefits and challenges of this approach.

11.09.2019
11:00 – 11:30 AM

A Software-Centric Solution to Automotive Audio for General Purpose CPUs

Authors: Mark Every, Len Layton and Jose Maria Marin (all BlackBerry/QNX)

Current automotive audio systems are in general distributed systems, both in terms of hardware and functionality. An automotive audio system may contain several DSPs, microprocessors and general purpose multi-core CPUs, with increasingly complex functionality split between processing cores. There are many situations where audio signals need to be passed back and forth between cores, such as for mixing or acoustic echo cancellation, and timing, synchronization, data formats and other discrepancies between components have to be managed, which adds significant complexity and makes the whole system more fragile and inextensible. Some reasons for this division of tasks are historical; in the past, specialized DSPs for audio equalization, filtering, etc. were required to offload the main application processors, and functions such as audio chimes have to boot-up quickly and meet more stringent safety requirements than entertainment signals.

Nowadays, general purpose multi-core CPUs (referred to here as GP CPUs), such as ARM or Intel/AMD processors, have advanced considerably and many automotive SoCs feature GP CPUs that run at 2 GHz or more, but the DSP typically remains below 1 GHz. Consolidating audio processing functionality on a single GP CPU with QNX Acoustics Management Platform (AMP) reduces system cost and complexity, improves reliability, accelerates time to market, provides standards-compliance, and brings capabilities and performance to new levels.

11.09.2019
11:30 – 12:00 PM

Automotive Microphone Performance: from Specification to User Experience

Authors: Yu Du, Viktor Dobos, Balázs Varga and Ruiting Yang (all Harman)

This paper discusses correlations between microphone specifications defined in laboratory conditions and the perceived user experience in automotive applications such as in-car voice communication and array beamforming. Experimental recordings are obtained at various driving conditions using three common types of automotive microphones mounted in three vehicle models (Sedan, SUV and Electric). Speech intelligibility index (SII) and subjective listening based on actual in-car recordings are used to evaluate the communication quality of microphones with different specifications including frequency responses, signal-to-noise-ratios (SNR) and acoustic overload points (AOP).

It is shown that, when influences of automotive application environments are considered, microphones with advanced SNR and AOP specifications do not always correlate to higher user experience such as better SII. To study effects of microphone element sensitivity and phase mismatches on beamforming performance, a simulation model is developed. It is found that the tolerance of microphone element-to-element mismatches highly depends on the chosen array processing algorithm. Results in this study could help users and designers choose proper microphone elements for automotive applications.

11.09.2019
3:45 – 4:15 PM

Virtual Tuning – A mixed approach based on measured RTFs

Authors: Hans Lahti (Harman), and Dr. Adrian Bahne (Dirac Research)

Constant introduction of new technologies and features in combination with increasingly advanced automotive sound system designs yield challenges for the automotive sound tuning process. Virtual tuning processes are a hot topic in the industry. The main objective is to be less dependent on car availability and allow for early prototyping. In this paper, we present a mixed in-situ/virtual approach that can easily be extended to a full virtual process. The mixed approach presented is implemented today and clearly shows the benefits inherent to a virtual tuning workflow. The match between the presented approach and in-situ validation measurements is investigated and indicates the validity and usability of the presented approach.

11.09.2019
4:15 – 4:45 PM

Virtual Reality Experience for the Optimization of a Car Audio System

Authors: M. Strauss, M. K. Bogdanski, and F. Malbos (all Harman)

In 2019, Virtual Reality (VR) clearly has found its way into a variety of applications. Leaving behind the gaming and entertainment playground, a significant number of different industries are in the process of adopting Virtual, Mixed and Augmented Reality for integration into their daily workflow. In addition, computational power nowadays allows for highly sophisticated numerical calculations. Multi-physics processes like plastics manufacturing and complex products like a car audio system can be fully modelled and computed within reasonable efforts and time frame.

This report is about recent work on a fully-virtual product development workflow for car audio application. A numerical framework was built, featuring all aspects of an automotive audio system. A Virtual Reality system was used to visualize but also to auralize the computationally generated acoustic data, where the Auralization was based on head-tracked dynamic binaural audio reproduction. Interactively controllable features were implemented to enhance the level of immersion. The underlying simulation foundation was evaluated against real measurements during several validation studies. Informal subjective experience tests were conducted, showing feasibly short adaption time of individual subjects to the VR environment and resulting in good overall acceptance by the probands.

12.09.2019
08:45 – 09:30 AM

Keynote: Audio Engineering in Today's Automotive Industry: from Technical Performance to Sound Quality

Keynote Speaker: Dr. Laurent Gagliadrini
PSA Peugeot Citroën DQI/DAPF/NVH Department for Quality and Engineering /Physical and Functional Architecture Division/Noise,Vibrations and Harshness

Automotive audio distinguishes from the consumer audio mainly because it is designed up to the listeners ears, with a possible control of any of the vehicle system's component. In today's engineering process (Product Lifecycle Management based) automotive systems architects have to ensure the achievement of customers' expectations through cascading requirements. For this purpose, performances of the vehicle, of the audio system and its components have to be defined consistently, and in relation with the quality of the audio system, as the user perceives it. Such a process becomes much easier when objective metrics related to the sound quality exist.

After a review of the perceived quality dimensions that we consider to handle the vehicle system design regarding audio issues, some technical (audio) performances can be set-up at the different engineering levels. Nevertheless, sound quality itself remains mostly a subjective matter. New indicators are then proposed to handle some of the sound quality dimensions. In order to be integrated in the engineering process, these indicators may apply to the whole system (including acoustic propagation in the cabin) as well as single electronic/software components. At the moment, they are limited to monophonic signals and tackle both spectral and dynamic (temporal) effects. After those indicators are defined, the results of their subjective assessment by an expert jury will be presented.

12.09.2019
09:30 – 10:00 AM

On the Impact of Next Generation of Automotive Radio Tuners on Active Noise Cancellation and Engine Sound Enhancement System Capabilities

Authors: Stefan Kerber, Rolf Schirmacher, Katharina Schmidt, Rita Reger (all Müller BBM), and Qian Ni (NXP Semiconductors Germany)

Active Noise Cancellation (ANC) and Engine Sound Enhancement (ESE) nowadays are proven standard technologies for low frequency engine noise reduction and sound quality enhancement for conventional as well as modern electric and hybrid electric powertrains. They make use of audio system components to generate the required acoustical output to the vehicle interior. As these technologies define the acoustical character and attributes of the vehicle and its powertrain, their application and the resulting sound must not depend on the actual vehicle audio system level. Therefore, integration of these technologies within the vehicle head-unit, which is typically independent of the actual audio level, is a preferred solution to reduce overall system development and integration complexity. This integration strategy has been strongly supported by the inclusion of freely programmable, open DSP cores within a radio-audio one-chip as e.g. the NXP Dirana3.

Currently the next generation of such radio-audio one-chip becomes available. They show significant changes on their open DSP cores which are used for ANC and ESE processing, including newer generation of DSP cores and significant changes on the memory availability and layout. This paper analyses and discusses the impact of the new generation of tuner System-on-Chips (SoCs) on the actual ANC and ESE performance in production vehicles, based on existing software implementations and with a strong focus on the additional system capabilities that will become available for NVH noise management engineers in terms of system flexibility and sound options.

12.09.2019
2:45 – 3:15 PM

Evaluation Criteria for Engine Harmonic Cancellation

Author: Davis Pan (Bose Corp.)

Engine Harmonic Cancellation (EHC) is a specific type of Active Noise Cancellation. First introduced inproduction cars almost three decades ago, the application of EHC is now fairly common. Yet, the criteria for evaluating this technology may not be universally known. After a brief explanation of the technology, its applications and benefits, this paper covers 11 key criteria, which should be considered when evaluating competing systems.

12.09.2019
3:45 – 4:15 AM

Evaluating Binaural Simulations of a Premium Automotive Sound System

Authors: Eva Hasenberger[1], Gerhard Krump[2], and Martin Schneider[1,3]
[1] Fraunhofer Institute for Integrated Circuits IIS, [2] Deggendorf Institute of Technology, [3] International Audio Laboratories Erlangen

The sound field excited by high fidelity (hi-fi) audio systems depends on the loudspeaker drivers, their positioning, their enclosures and the listening room. In the case of in-car sound systems, the listening room is the car cabin and its influence is much more pronounced than in typical living-room scenarios. Thus, the user experience results from a complex auditory scene. In certain situations, it is desirable to simulate the resulting auditory scene by means different than the actual audio system, e. g. by using binaural synthesis. In this study, a state-of-the-art binaural synthesis system for living-room scenarios was evaluated with respect to simulate a premium automotive audio system. To this end, listening tests were designed that can identify potential perceptual differences between the original audio system and its simulation. The evaluated aspects include temporal, spectral and spatial attributes. The results show that a convincing simulation of in-car sound systems through binaural headphone reproduction appears to be possible with regard to the evaluated aspects.

13.09.2019
08:45 – 09:30 AM

Keynote: Immersive Audio Listening Experience in Cars – the Future of Music

Keynote Speaker: Dr.-Ing. Bernhard Grill
Fraunhofer IIS, Director with focus on Audio and Media Technologies

With the announcement of the 360 Reality Audio initiative from Sony at CES 2019, music listening will soon see its first signs of shift from current 2-channel stereo to truly immersive 3D audio.

Immersive audio formats such as MPEG-H that powers 360 Reality Audio, make it possible for artists and music creators to create a 360-degree musical experience by mapping sound sources such as vocals, chorus and instruments with positional information of distance and angle to suit their creative and artistic purpose. When listeners play back the resulting content, they can enjoy a music experience that immerses them in sound from every direction as intended by the content creator.

Being able to listen to the latest 3D audio mixes of the most popular recording artist on mobile devices with headphones, on 3D soundbars in consumers' homes and now also in cars, will provide audiences with a seamless immersive experience across playback devices and environments.

Having developed and deployed the high-end 3D sound algorithm Symphoria, Fraunhofer IIS has already raised the quality of conventional stereo music played back in cars. With the upcoming availability of immersive music content for in-car environments thanks to MPEG-H 3D Audio format such as 360 Reality Audio, premium automotive sound systems will soon have access to a premium content source. This will undoubtedly improve the consumer experience of music in cars even further and therefore drive demand for premium sound systems.

13.09.2019
11:00 – 11:45 PM

Invited Paper: Extending the bandwidth of local active noise control in the automotive environment using headtracking

Author: Dr. Jordan Cheer (Signal Processing and Control Group, Institute of Sound and Vibration Research, University of Southampton)

Active control of both engine and road noise in the automotive environment was demonstrated more than 30 years ago, however, the commercial uptake of these systems has been somewhat limited. This can in general be attributed to the ratio between the cost of implementation and the performance of the system. Recently, active control systems have seen some commercial automotive applications due to a relative reduction in their cost, however, the performance of these systems is still generally limited to frequencies below a couple of hundred hertz. This paper presents an investigation into extending the upper frequency limit of an active control system through the use of a localised system with headtracking technology.

13.09.2019
1:15 – 1:45 PM

Segmented Mass Loading for Loudspeaker Cones

Author: Karel Goossens (Premium Sound Solutions)

Common loudspeaker cones have axisymmetric geometry and are made of isotropic cone materials, such as paper. This leads to dominant radial cone breakup modes with ring-shaped vibration patterns that create peaks and dips in the frequency response. By adding local masses on the cone in a circle segment configuration, the isotropy is broken due to non-axisymmetric inertial forces. Consequently, the patterns of the breakup modes are changed from ring shaped zones into irregular areas with in-phase and out-of-phase contributions to the sound pressure that cancel each other partially. This leads to a smoothing of the SPL response.

13.09.2019
1:45 – 2:15 PM

Crossover Filters Pre and Post Limiters for Basic Loudspeaker Protection: A Case Study.

Authors: Marcin Kalinowski and Matteo Nucci (both Harman)

For system designs in which an automotive audio amplifier DSP architecture doesn’t account for a specific loudspeaker protection algorithm, digital crossover filters placed after the limiter block in the signal flow allow to mitigate the risk of a potential transducer failure due to loudspeakers operating outside of their designated bandwidth at high excursions. Considering a real-world automotive audio system use case with given filtering resources and defined DSP flexibility, this paper discusses various choices for crossover parameters selection and distribution in the system in relation to the limiter block (before and/or after). The impact on loudspeaker bandwidth and crossover behavior is evaluated for several filter-design parameter changes, at varying reproduction level: such analysis considers subwoofer, woofer and midrange loudspeaker cases, eventually leading to a best-compromise design approach.