SW7 - 4-CAD: Advancing Over-The-Air Testing in Vehicular Communications and Automotive Radar Sensing

Abstract:

Today, safe operation of road traffic relies solely on humans. At the advent of Connected and Automated Driving (CAD), as technology takes over control of vehicles and traffic, testing plays a central role to ensure safety and reliability of such systems. Suitable verification and validation methods have to go beyond software by providing in-the-loop and over-the-air testing on component and system level. In recent years, researchers from TU Braunschweig, TU Ilmenau and RWTH Aachen have worked on these procedures for V2X communications and automotive radars. Within this workshop, we demonstrate results and draw our vision of a unified CAD testbed.

Workshop outline:

The workshop will present the results of a DFG package application project consisting of two sub-projects. It is divided into topical blocks addressing EM simulations, OTA channel emulation, and OTA radar target emulation. We will explain our emulation workflows as well as the software and hardware systems developed for this purpose. We will also report on the validation of our systems via measurements. The collaboration between the two subprojects has revealed interesting connections between communications and sensor testing, which we will highlight. Finally, we will present our ideas for combining the two validation methods in a single testbed.

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Scientific Workshop

What it is about:

- **How to test V2X and automotive radar in connected and automated driving**
- **Dynamic EM ray-tracing for traffic scenarios**
- **Influence of road users and environment**
- **Over-the-air testing with channel emulators and radar target emulators**
- **11 speakers from 6 different research groups**

We are looking forward to your participation!

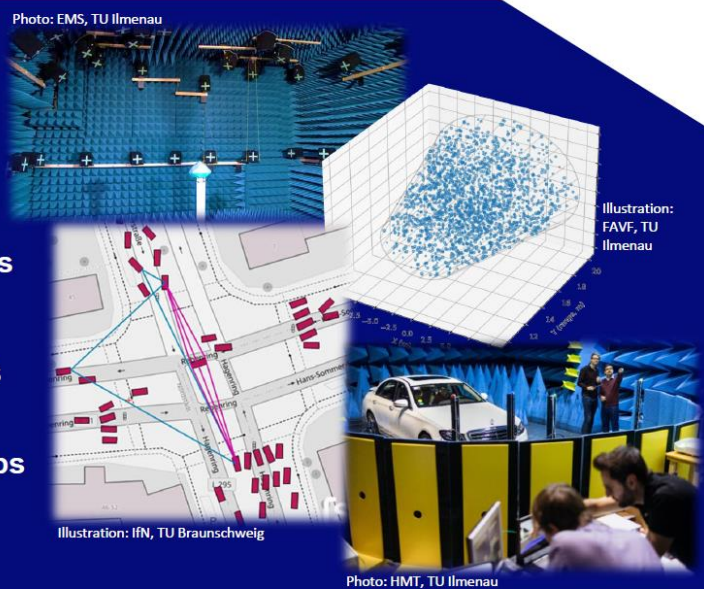

Photo: EMS, TU Ilmenau

Illustration: FAVF, TU Ilmenau

Illustration: IfN, TU Braunschweig

Photo: HMT, TU Ilmenau

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Agenda:

Time Slot		Topic
08:00 – 08:15	Thomas Dallmann	4CAD - What for?
08:15 – 08:35	Vittorio Degli Esposti	Advanced ray tracing modelling and applications
08:35 – 08:50	Ainur Ziganshin	Ray-Based Simulation of Scattering from Discretized Curved Bodies
08:50 – 09:05	Thomas Kürner	Multi-stage Over-the-Air Testbed for dynamic V2X scenarios
09:05 – 09:15	Maik Weber	Realistic Performance Evaluation of NR-V2X in Urban Scenario Using Ray Tracing and ns-3
09:15 – 09:25	Maik Weber	Insights into Software Defined Radio-Based Channel Emulation
09:25 – 09:40	Renato Zea Vintimilla	Emulation of a V2X communication link using Over-the-Air (OTA) Testing
10:10 – 10:25	Matthias Hein	Over-the-air vehicle-in-the-loop testing: Method and its application to automotive radar
10:25 – 10:35	Isabella Varga	Data-driven radar target modelling
10:35 – 10:50	Sonakshi Gupta	Environmental Modeling for Radar Verification and Validation
10:50 – 11:00	Muhammad Luqman Nazar	Ground reference benchmarking for scenario-based virtual verification and validation
11:00 – 11:15	Lukas Ostendorf	Automotive Data Collection for Development and Testing
11:15 – 11:25	Lukas Ostendorf	Joint Scenarios for V2X and Radar
11:25 – 11:50	Thomas Dallmann	4CAD - What next?

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Speakers:

Thomas Dallmann received the Dipl.-Ing. degree in electrical engineering from RWTH Aachen University, Germany in 2010 and the Dr.-Ing. degree from RWTH Aachen University in 2017. From 2016 to 2022, he was with the Fraunhofer-Institute for High Frequency Physics and Radar Techniques FHR, Wachtberg, Germany and lead the Research Group Aachen in Aachen. He is currently Junior Professor at Technische Universität Ilmenau, Germany and responsible for the Radio Technologies for Automated and Connected Vehicles Research Group and Electronic Measurements and Signal Processing Group. His research is concerned with joint communication and radar sensing networks and virtual validation of automotive radars.

Thomas Kürner (Fellow IEEE) received his Dipl.-Ing. degree in Electrical Engineering in 1990, and his Dr.-Ing. degree in 1993, from University of Karlsruhe (Germany). From 1994 to 2003, he was with the radio network planning department at the headquarters of the cellular operator E-Plus Mobilfunk GmbH & Co KG, Düsseldorf. Since 2003, he is Full University Professor for Mobile Radio Systems at Technische Universität Braunschweig. In 2012, he was a guest lecturer at Dublin City University within the Telecommunications Graduate Initiative in Ireland. Currently he is chairing the IEEE 802.15 Standing Committee THz and the ETSI Industrial Specification Group THz.

Vittorio Degli-Esposti is Full Professor with the Department of Electrical, Electronic and Information Engineering "G. Marconi" (DEI) of the University of Bologna. He teaches courses on Electromagnetic Fields, Propagation for Wireless Systems and Vehicular Radio Propagation. He is IEEE Senior Member and Editor of the IEEE Transactions on Vehicular Technology. He has been Vice Chair of EuCAP2010 and EuCAP2011, Chair of URSI EMTS2025 and Director of Research in 2015 and 2016 of Polaris Wireless Inc., California, USA. He received the "EurAAP Propagation Award 2023" and is author or co-author of 7 patents and more than 160 peer-reviewed technical papers.

Prof. Dr. Matthias A. Hein joined the TU Ilmenau in 2002 as head of the RF and Microwave Research Laboratory. He has founded the multi-purpose automotive antenna test range "VISTA - Virtual road simulation and test area" at the Thuringian Center of Innovation in Mobility. His research focuses on antennas and microwaves, wave propagation, and over-the-air testing. He has co/authored over 700 publications and talks, supervised 48 doctoral and 102 Master projects. His research has attracted a cumulative funding of nearly 25 MEUR. Since 2021, Matthias Hein is the Director of the Thuringian Center of Innovation in Mobility at TU Ilmenau.

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Speakers:

Ainur Ziganshin received the B.E. degree from the Kazan National Research Technical University in 2020, the M.Sc. degree from the Technische Universität Ilmenau in 2023. He is currently pursuing his Ph.D. degree at the Technische Universität Ilmenau. His research interests include channel measurement data analysis, stochastic and deterministic channel modeling for ISAC, ray tracing for radiowave propagation, and object scattering.

Maik Weber was born in Vechta, Germany, in 2001. He received the B.Sc. and M.Sc. degrees in Computer and Communication Systems Engineering from Technische Universität Braunschweig, Braunschweig, Germany, in 2023 and 2025, respectively. In February 2025, he joined the Institute for Communications Technology at Technische Universität Braunschweig, where he is currently working toward the Ph.D. degree. His research interests include software defined radio-based wireless channel measurements and characterization with focus on sub-6 GHz applications.

Renato Zea Vintimilla received the MSc. degree in communications and multimedia engineering from the Friedrich-Alexander-Universität Erlangen-Nürnberg in Germany in 2016 respectively. Since 2018 he works as researcher for Fraunhofer IIS and Technische Universität Ilmenau in the development of testing techniques for wireless devices, particularly in the Over-the-Air testing method applied to GNSS devices. His research interests include signal processing, wireless communications and GNSS measurements.

Isabella Varga received the B.Sc. and M.Sc. degrees in electrical engineering and information technology from Technische Universität Ilmenau, Ilmenau, Germany, in 2021 and 2023, respectively. She is a research scientist pursuing her doctoral degree in the RF and Microwave Research Group at the Thuringian Center of Innovation in Mobility working in the field of radar technologies for automotive applications. Her current research focuses on radar signatures of extended targets based on reflectivity measurements, including modelling, calibration techniques and signal processing.

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Speakers:

Sonakshi Gupta earned her Bachelor of Technology in Electronics and Communication Engineering from Guru Nanak Dev University, Amritsar, India, in 2018 and her Master of Science in Communication and Signal Processing from Technische Universität Ilmenau in 2022. She is currently a Research Scientist in the Radio Technologies for Automated and Connected Vehicles group at the Thüringer Innovationszentrum Mobilität (ThIMo). Her work focuses on statistical modelling, advanced driver-assistance sensor validation, and sensor virtualisation for simulation and testing environments.

Muhammad Luqman Nazar received his BSEE from University of Engineering and Technology (UET), Taxila in 2011 and MSEE from National University of Sciences and Technology (NUST), Islamabad in 2022. He is currently working as a Research Associate at Technische Universität Ilmenau, Germany. He is engaged in Virtual Verification and Validation (VVV) of Automotive Radars at Thuringian Centre of Innovation in Mobility (ThIMO). He is pushing boundaries for advanced scenario description and improving degree of realism in Over-the-air Vehicle-in-the-loop (OTA-VIL) test systems.

Lukas Ostendorf is a doctoral researcher at the Institute for Automotive Engineering at RWTH Aachen University, focusing on Vehicle Intelligence and Automated Driving. He previously earned a master's degree in Automation Engineering and a bachelor's degree in Mechanical Engineering at RWTH Aachen. His research centers on automated driving perception, with emphasis on multimodal sensing and 4D radar. In the 4-CAD project, he works on 4D-radar-based object detection, datasets, and evaluation metrics. His goal is to develop robust perception algorithms that leverage different kind of sensor information to enhance sensor fusion, environmental understanding, and the safety of automated vehicles.