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Sound Is a System Variable: Integrating Acoustic Simulation into ADAS, Vehicle Dynamics, and Powertrain Validation

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Abstract:

In Driver-in-the-Loop (DIL) simulation, system validation is still largely dominated by visual and motion feedback—while acoustic information remains underrepresented, despite being a fundamental part of human perception and system interaction.

This presentation positions sound as a core system variable, essential for realistic and reliable simulation across ADAS, vehicle dynamics, and powertrain domains.

We present the real-time integration of PreSense and CarMaker, enabling physically consistent sound synthesis directly from underlying system models. This allows acoustic effects to be dynamically linked to vehicle states, actuator behavior, and environmental conditions—fully synchronized within the simulation loop.

While the relevance spans multiple domains, a particular focus is placed on ADAS:

- Driver perception and trust in ADAS interventions (e.g. braking, steering corrections) are strongly influenced by associated acoustic cues
- Critical scenarios (e.g. emergency braking, near-limit handling) require realistic sound feedback to enable valid driver response evaluation
- Human-machine interaction increasingly relies on multimodal feedback, where sound complements visual information

Beyond ADAS, the importance extends to:

- Powertrain systems, particularly in electric vehicles, where the absence of masking combustion noise amplifies secondary noise sources (e.g. inverter switching, gear meshing), making them perceptually and diagnostically relevant
- Legal requirements (e.g. AVAS systems) introduce new sound design challenges
- Vehicle dynamics, where tire-road interaction, slip, and chassis responses generate characteristic acoustic signatures that support driver interpretation of handling limits

The presentation demonstrates that neglecting sound leads to incomplete system validation. Only the combined consideration of visual and acoustic feedback enables a holistic, system-level assessment of driver behavior, perceived vehicle quality, and functional performance—especially in the context of increasingly silent and complex electric vehicles.

The presentation demonstrates how combining visual and acoustic simulation leads to a more immersive, reliable, and development-relevant DIL experience.

It argues that **only the joint consideration of what the driver sees and hears enables true system-level validation**, especially in the context of increasingly silent and perception-sensitive electric vehicles.