

Application of the NVH simulator in product development and its future integration into virtual development

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Introduction - The NVH Simulator

What is it?

- Tool that enables customers and developers to virtually drive a vehicle, thereby replaying the vehicle interior sound with the highest accuracy

How does it work?

Record NVH data



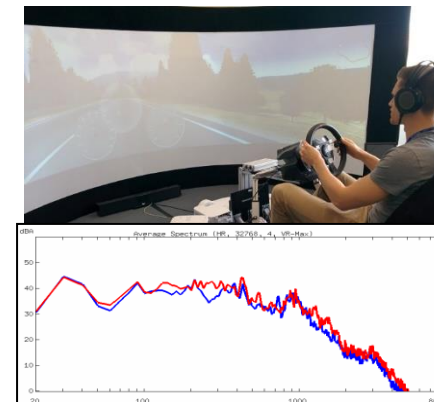
- Audio data
- Performance model

Post process data



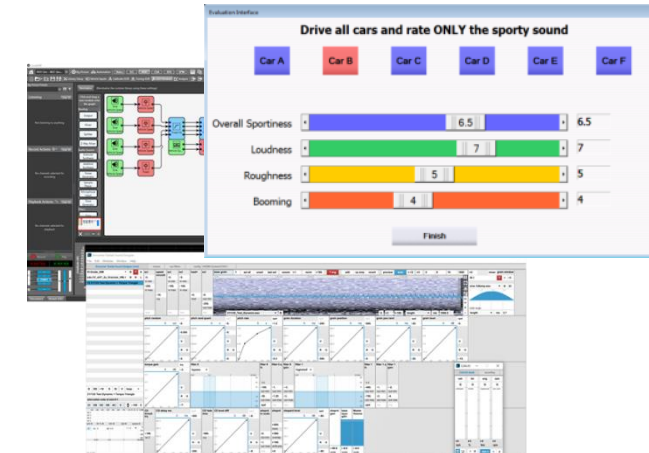
- Decompose data
- Re-synthesise

Assemble & validate vehicle model



- Robust model

Sound design & customer evaluation



- Evaluate in real driving conditions

Introduction – Driving simulator

Standalone NVH Simulator



Dedicated NVH simulator for efficient development

Ease of use:

- + Quick and easy vehicle performance model
- + Quick implementation of changes
- + Less immersion / less training required for drivers

Static driving Simulator



Integrate NVH simulator into static driving simulator

Enhance driver immersion:

- + Environment much more realistic
- + Simultaneous evaluation of multiple attributes

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Application in product development

Active Sound System Integration

What is Active Sound?

- Electronic system that generates simulated driving sounds based on vehicle parameters

How does it work?



- Engine speed
- Throttle position
- Engine torque
- Vehicle speed



Sound module:

- Vehicle data is processed
- Desired sound is calculated

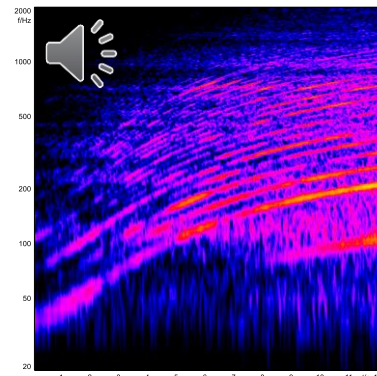


Active sound is radiated in vehicle interior by loudspeaker system or sound actuator

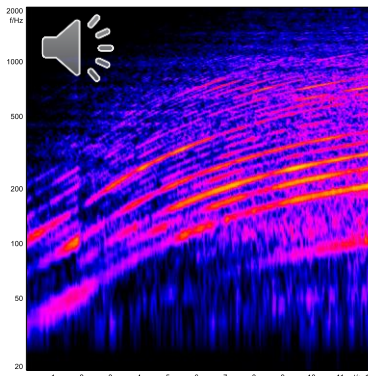
Result:



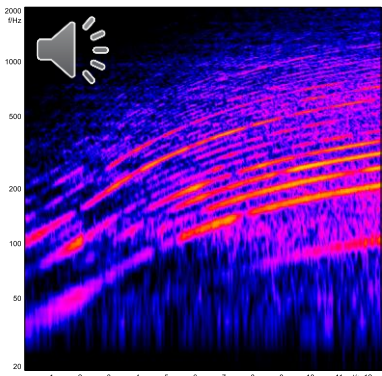
3 Driving Modes



Normal



Sport



N Mode

Application in product development

Active Sound System Integration

Why integrate the development into the NVH simulator?

- To create the „right“ sound for the target vehicle, **extensive** sound tuning
- Jury evaluations are necessary due to subjective nature

Benefits of using simulator with H-i-L

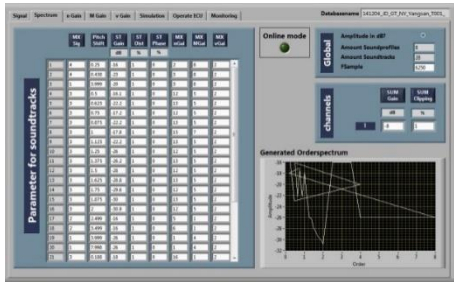
- Quick creation of sound concepts created with the production ASD system
- Significant cost & time saving compared to developing in vehicles
- Low time requirements on development vehicles
- Efficient customer evaluations
 - Cost & time saving
 - Remove influence of brand image
 - Remove influence of other driving characteristics
- Direct transfer of sound concepts to real vehicle for quick verification

Application in product development

Active Sound System Integration – H-i-L

Hardware requirements

Sound design SW



ECU



Actuator



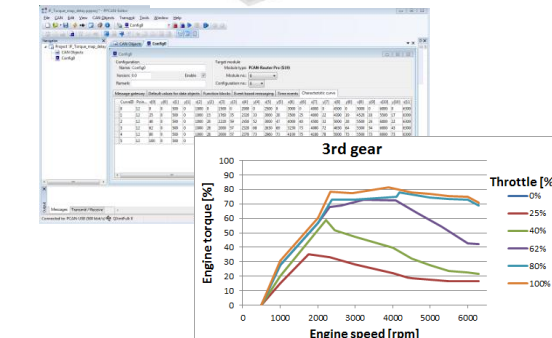
Audio mixer



Driver input



CANBUS



Other considerations

FRF measurements

- Measure response function from input source to drivers ear



Easy integration into real vehicle after development in NVH simulator

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Application in product development

Development process

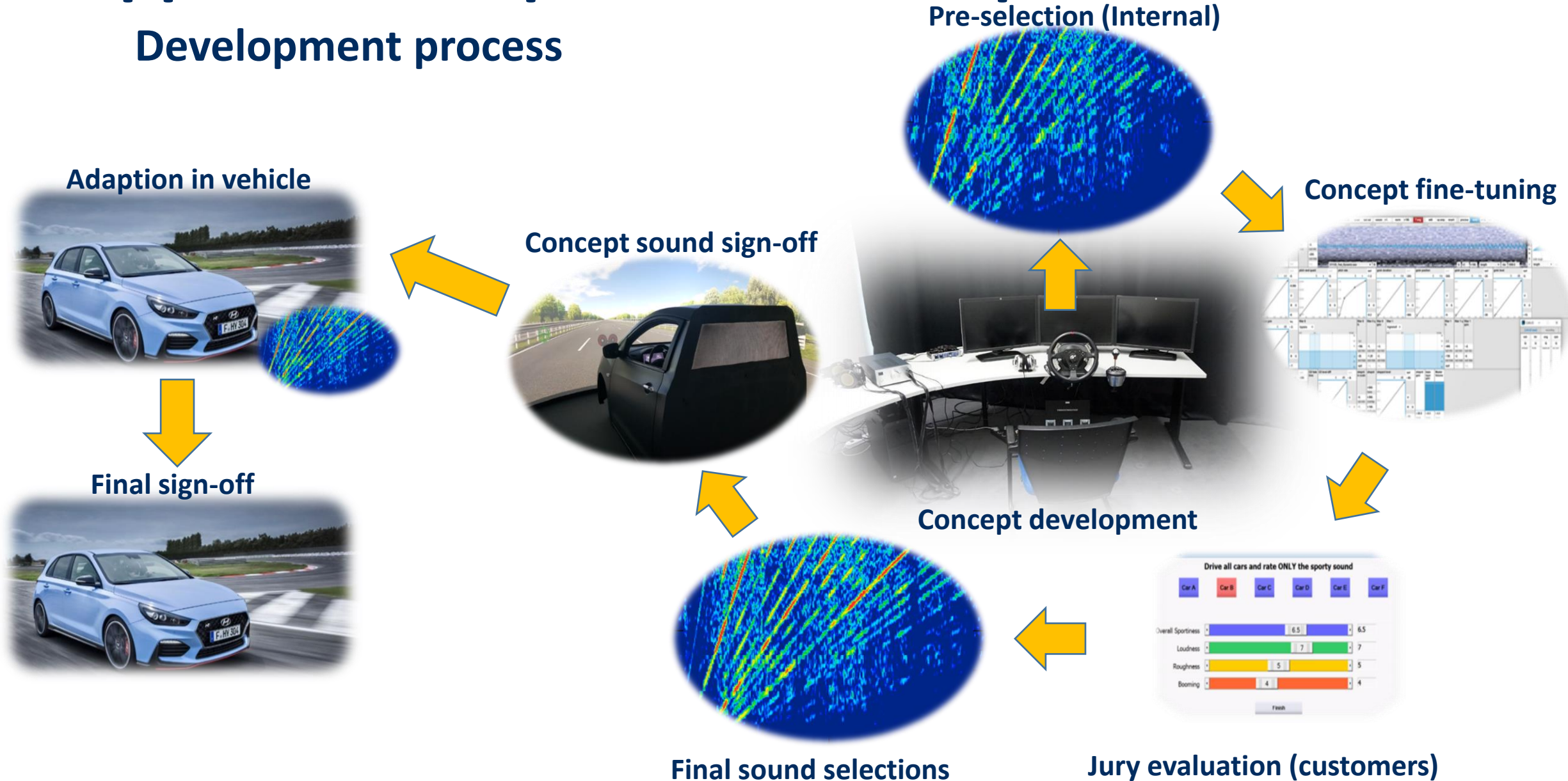


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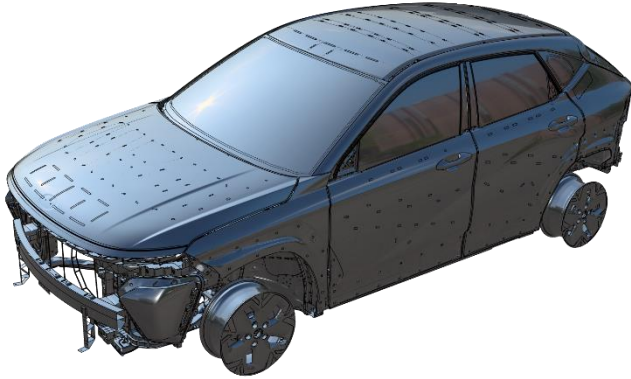
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Future integration into Virtual Development

Virtual Development

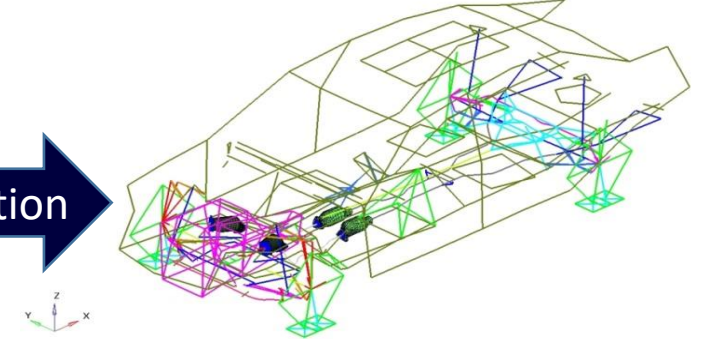


- Re-design and analyze parts in CAE
- Insert CAE results in NVH simulator for sound & vibration replay
- Hybrid models: mixed test & CAE based

Vehicle Measurements Constant & Impact



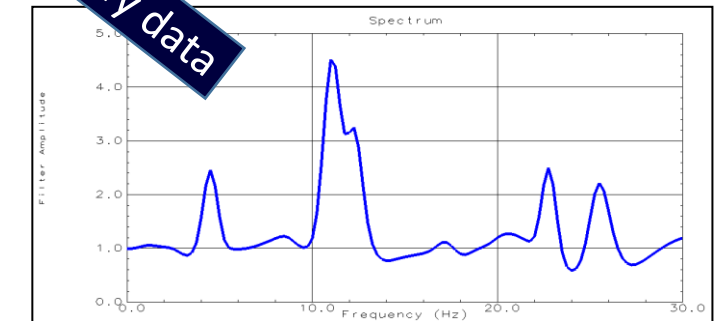
CAE Model



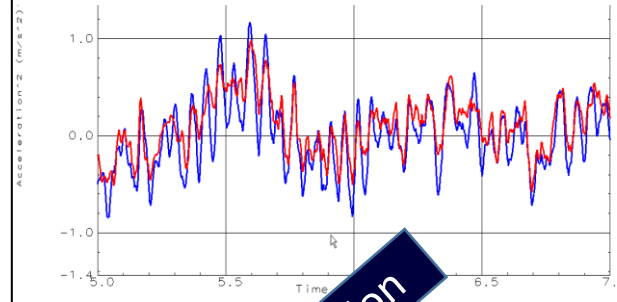
Modifications e.g. Engine Mounts



Modify data



Measured & Modified Data



Evaluation



$$[\text{Filter matrix}] = \left[\begin{array}{c} \frac{(\ddot{a}(\omega) \text{ Revised Specification} / \text{excitation force})}{(\ddot{a}(\omega) \text{ Base Specification} / \text{excitation force})} \end{array} \right]$$

Thank you for your attention.