PROJECT of the PEGASUS FAMILY

VERIFICATION VALIDATION METHODS

Mid-Term Presentation 15 / 16 March 2022

Test technologies and infrastructure for the Verification and Validation of AD Systems

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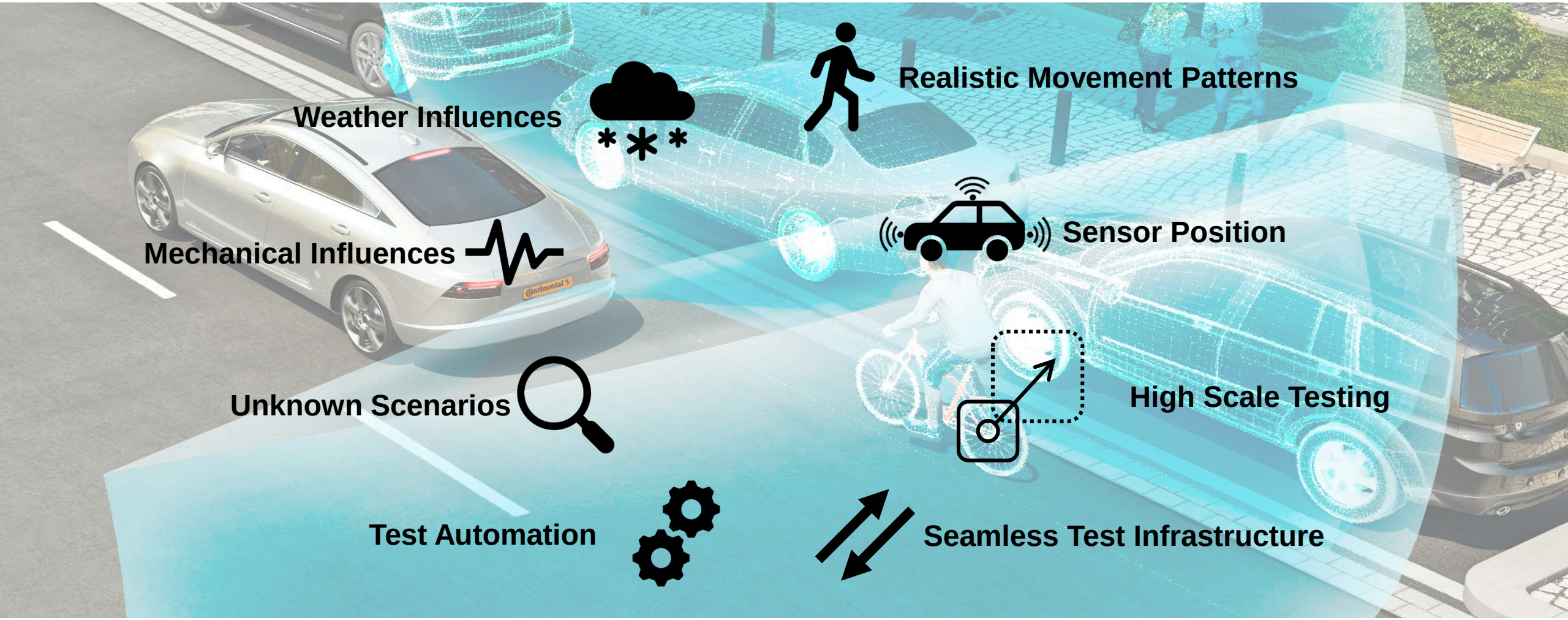
on the basis of a decision by the German Bundestag

Agenda

- Overview of available test instances within the project
- Presentation of two ongoing research activities
- Summary and upcoming challenges

Upcoming demands for test infrastructure



Available test vehicles within V&V methods

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German Aerospace Center (DLR)

- Test vehicle equipped with a prototypical **SAE4** automation system
- Addressing specific driving scenarios on a **proving ground**

Research Center for Information Technology (FZI)

- Test vehicle equipped with a prototypical **SAE4** automation system
- Addressing specific driving scenarios on a **proving ground** and in **public test areas**

Continental AG

- Test vehicle equipped with an in-service monitoring and reporting system
- Addressing specific driving scenarios in **public traffic**

Proving grounds and public test areas within V&V methods

- Three closed **proving grounds** with different focus areas are available in the project
  - **Mercedes Benz**: Demonstration of real movement patterns of pedestrians and cyclists
  - **BMW**: Automation of proving ground tests
  - **DLR**: Comparison of scenarios in the simulation and the proving ground

- Tests can be carried out in public traffic on two **test areas**
  - Providing a **ground truth** for perception through installed reference sensors
  - Testing in real urban scenarios at research intersections in **Braunschweig** (AIM) and **Karlsruhe** (TAF)

AIM

TESTFELD AUTONOMES FAHREN
BADEN-WÜRTTEMBERG

Test benches and test technologies within V&V methods

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AD HiL – test bench

- Focus on testing a chain of effects for an AD-System

Lidar HiL – test bench

- Testing of different installation positions of LIDAR sensors
- Recording of measurement data

Mechanical HiL – test bench

- Reproduction of mechanical vibration conditions on sensitive hardware
- Enable replay of recorded vibrations or coupling with simulation environments

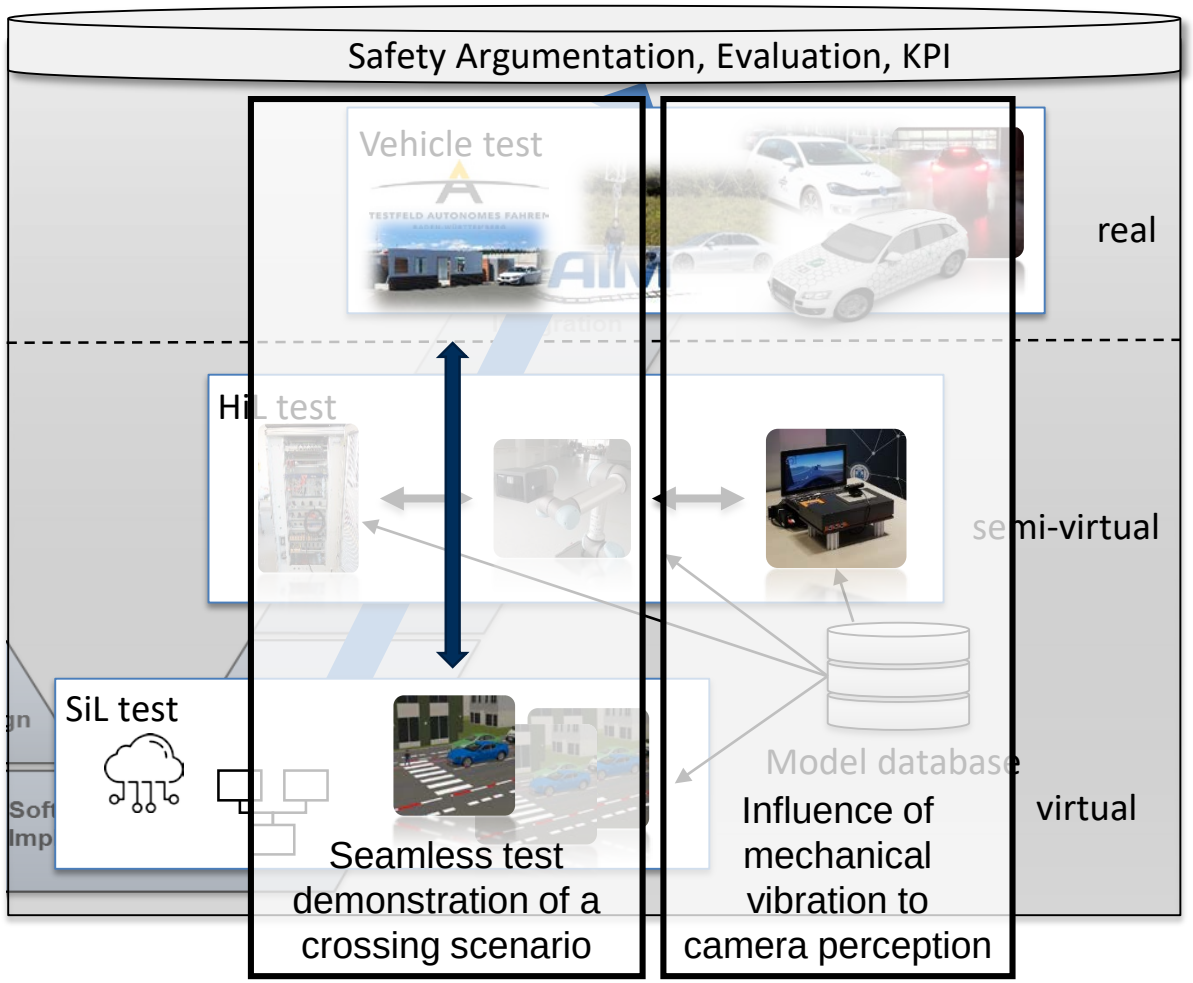
Various SiL – test benches

- Sensor realistic simulation
- Scalability of the simulation
- Co-Simulation
- Use of sensor models from SetLevel

Weather chamber and spray maker

- Generation of reproducible weather conditions
- Mobile spray generator, usable on the proving ground

Towards seamless testing



Vision

- Test instances support a **comprehensive** and **seamless** test process
- Enable the efficient **distribution** of **tests**

General prerequisites

- Use **standardized** formats and interfaces
  - OSI, FMU, OpenScenario, OpenDrive
- Provide the same **metrics** and **measurands**
- Ensure **comparability** of measurements
  - Simulation models cover all required effects
  - Validated simulation models
- Enable **transferability** of models

Prototypical execution of a pedestrian crossing scenario

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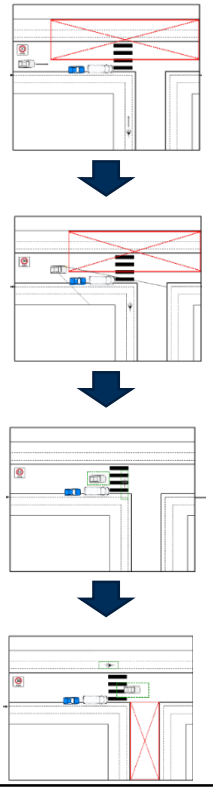
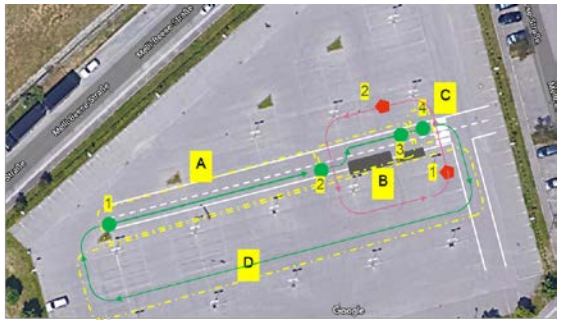
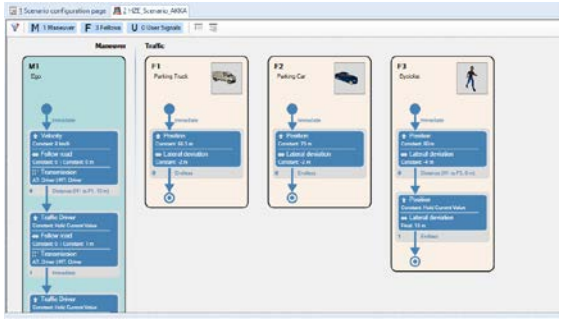
Logical scenario description



Concrete scenario description



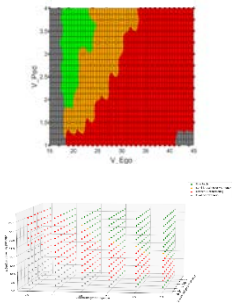
Concrete scenario description



Proving Ground

Simulation

Scenario evaluation



OSI

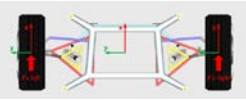
Lidar-Model

SET Level

Camera-Model

SET Level

Vehicle-Model



SET Level

Automatic scenario execution in the simulation and on the proving ground

Simulation in MotionDesk

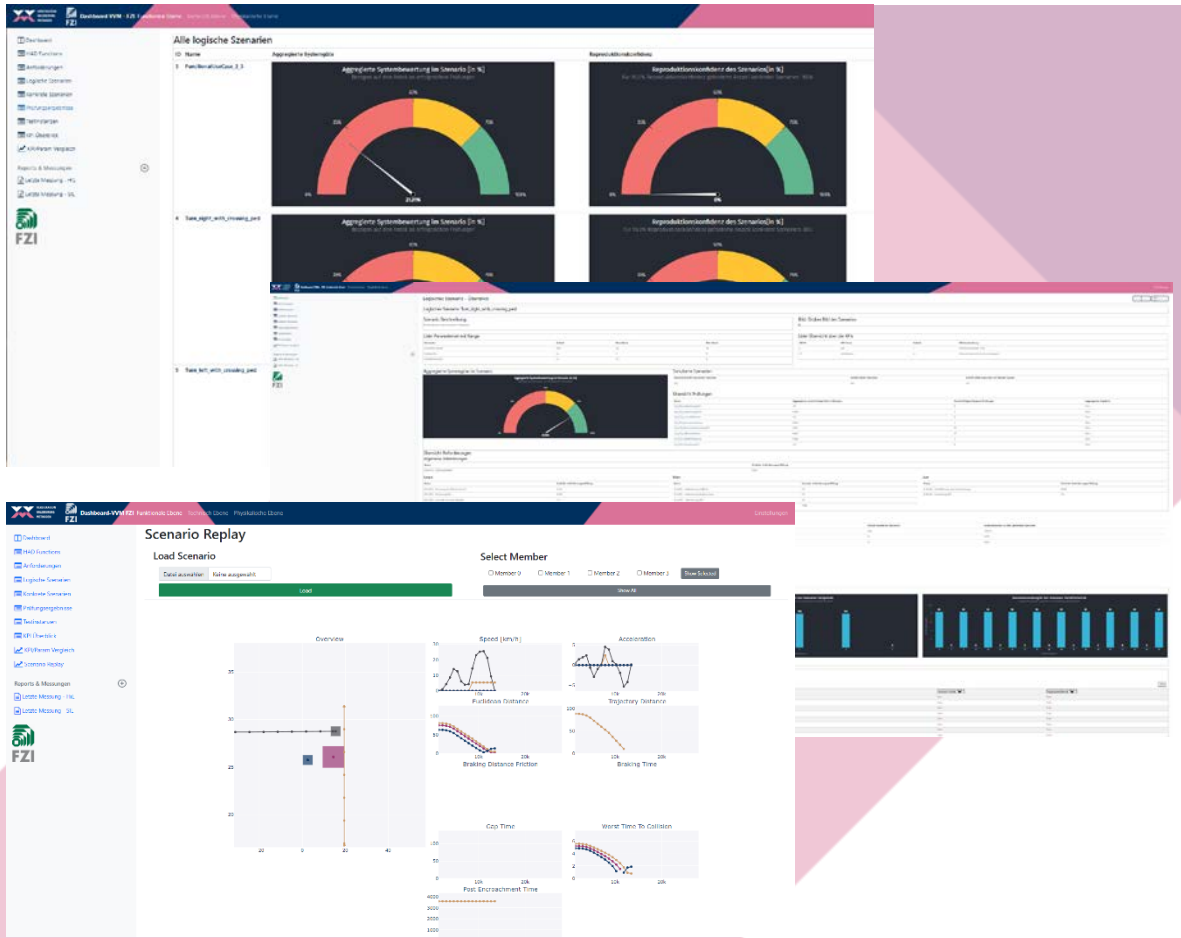
Proving ground

Automatic scenario execution in the simulation and on the proving ground

Simulation in MotionDesk

Proving ground

Aggregation and visualization of test results to ensure seamless testing



- Storage of test results from different test instances in a common database
- Aggregation of test results
- Development of a dashboard for the visualization of the aggregated results
  - Overview of all logical scenarios
  - Consideration of system performance in a logical scenario
  - Detailed analysis of concrete scenarios

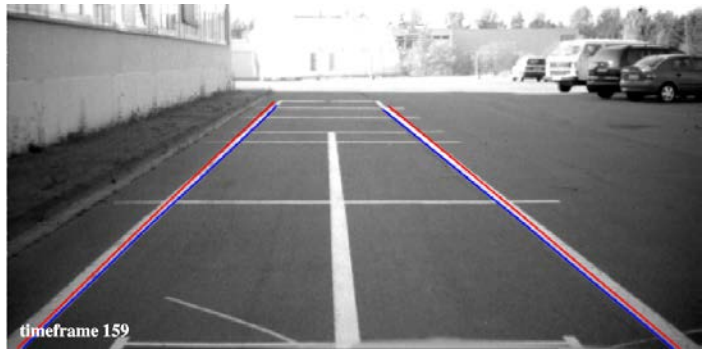
Camera-in-the-loop vibration test

- Raise of new concerns
  - ***Mechanical vibrations must not influence object-based image recognition***
- Mechanical vibrations are…
  - caused by vehicle's movement,
  - characterized by amplitudes and frequencies,
  - well understood and modeled in simulation models.
- Up to now, the impact of vibrations on image processing can only be examined during in-vehicle driving test

Disturbances due to camera movement

Rolling shutter effect

Motion blur

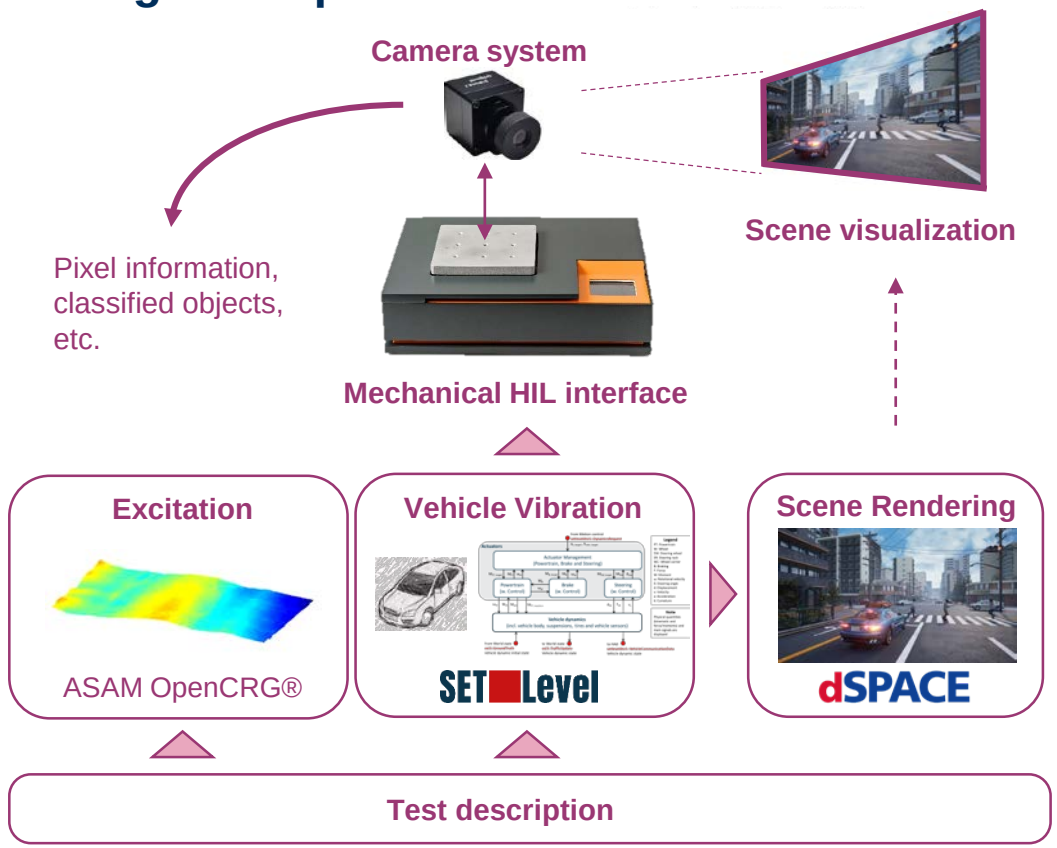


Deviations in object classification

Camera-in-the-loop vibration test

- How to realize a camera-in-the-loop environment for vibrational testing?
  - Make use of existing simulation models
    - Road surface ASAM OpenCRG®
    - Vehicle dynamics and vibration behavior
    - Scene rendering and visualization
  - Excite camera by **mechanical Hardware-in-the-loop interface**
  - Feedback and assessment of…
    - Pixel information, classified object lists, closed-loop stability, robustness, …

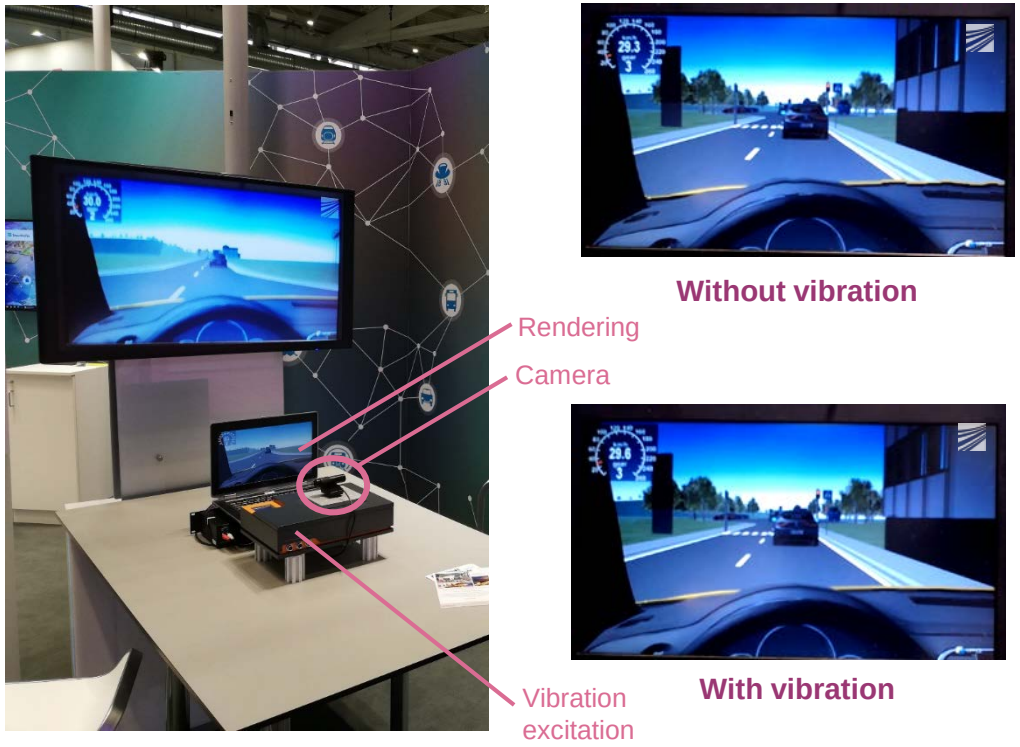
Test rig concept



Camera-in-the-loop vibration test

- Camera-in-the-loop vibration testing will…
  - serve the **refinement** and **separation of concerns** regarding camera-based object classification regarding vehicle vibrations.
  - **enable sensitivity analyses** with respect to camera installation position, vibration isolation measures and excitation scenario.
  - help to **quantify quality criteria** for both pixel information and object classification.
  - **bridge the gap** between simulation and in-vehicle testing.

Mock-up of vibration test rig



Summary and upcoming challenges

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Summary:

- Overview test instances within VV-Methods
- Showed two prototypes
  - Seamless test demonstration of FUC2.3
  - Influence of mechanical vibration to camera perception

Upcoming challenges:

- Further development of test instances to ensure the transferability of tests
- Integration into an test orchestration framework to evaluate the test process
- Prove validity of new developed test instances

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Thank you!

Jonathan Millitzer, FHG

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VDA Leitinitiative
autonomous and connected driving

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