PROJECT of the PEGASUS FAMILY

VERIFICATION VALIDATION METHODS

Final Event 21 / 22 November 2023

Semless Testing in Practice
Example Realizations

Stefan Otten, FZI

Supported by:

Federal Ministry for Economic Affairs and Climate Action

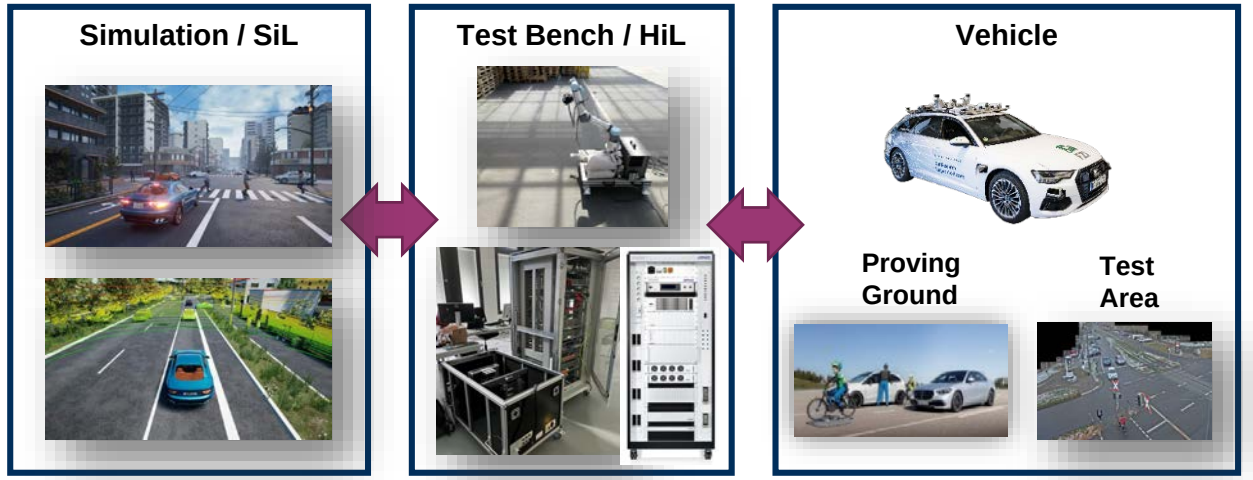
on the basis of a decision by the German Bundestag

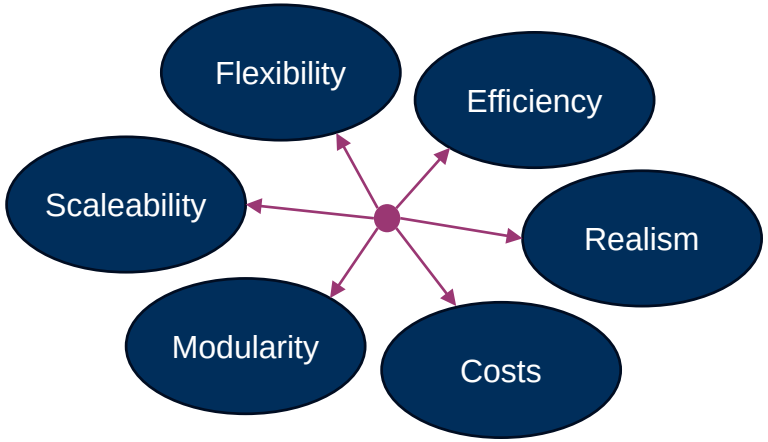
Agenda

- Test Platforms for Test Execution
- Example Realizations for Seamless Testing
  - Cross-Cutting Influence on Camera Perception
  - Seamless Scenario Based Testing in Simulation and Proving Ground
  - Fleet Monitoring and Assessment for Validation
- Overview of VVM Test Methodology Blocks

Test Platforms

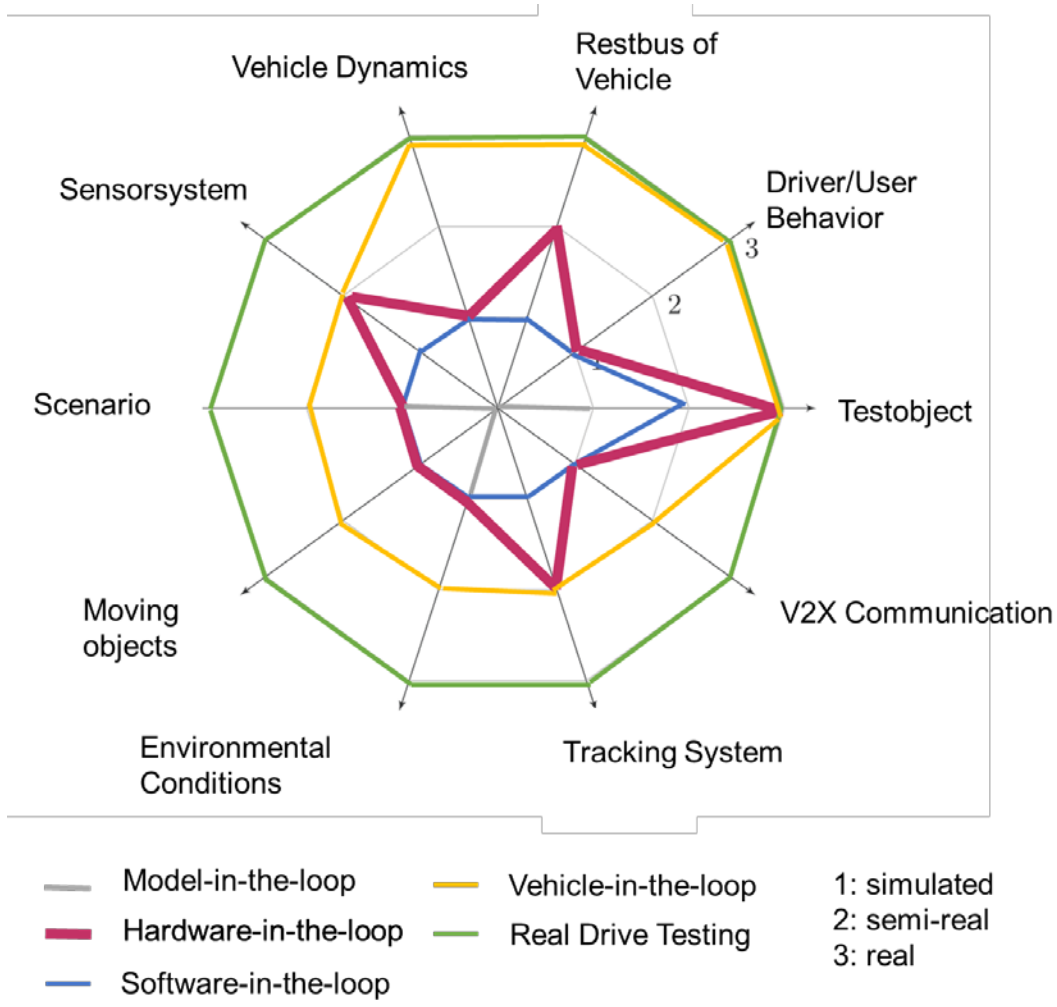
- Different test platforms must be utilized complementary for the argumentation
- Test orchestration ensures optimized usage based on:
  - Test objects, goals and scenarios
  - Target KPIs and metrics
  - Available test platforms
- Knowledge about strength / weaknesses of test platforms required



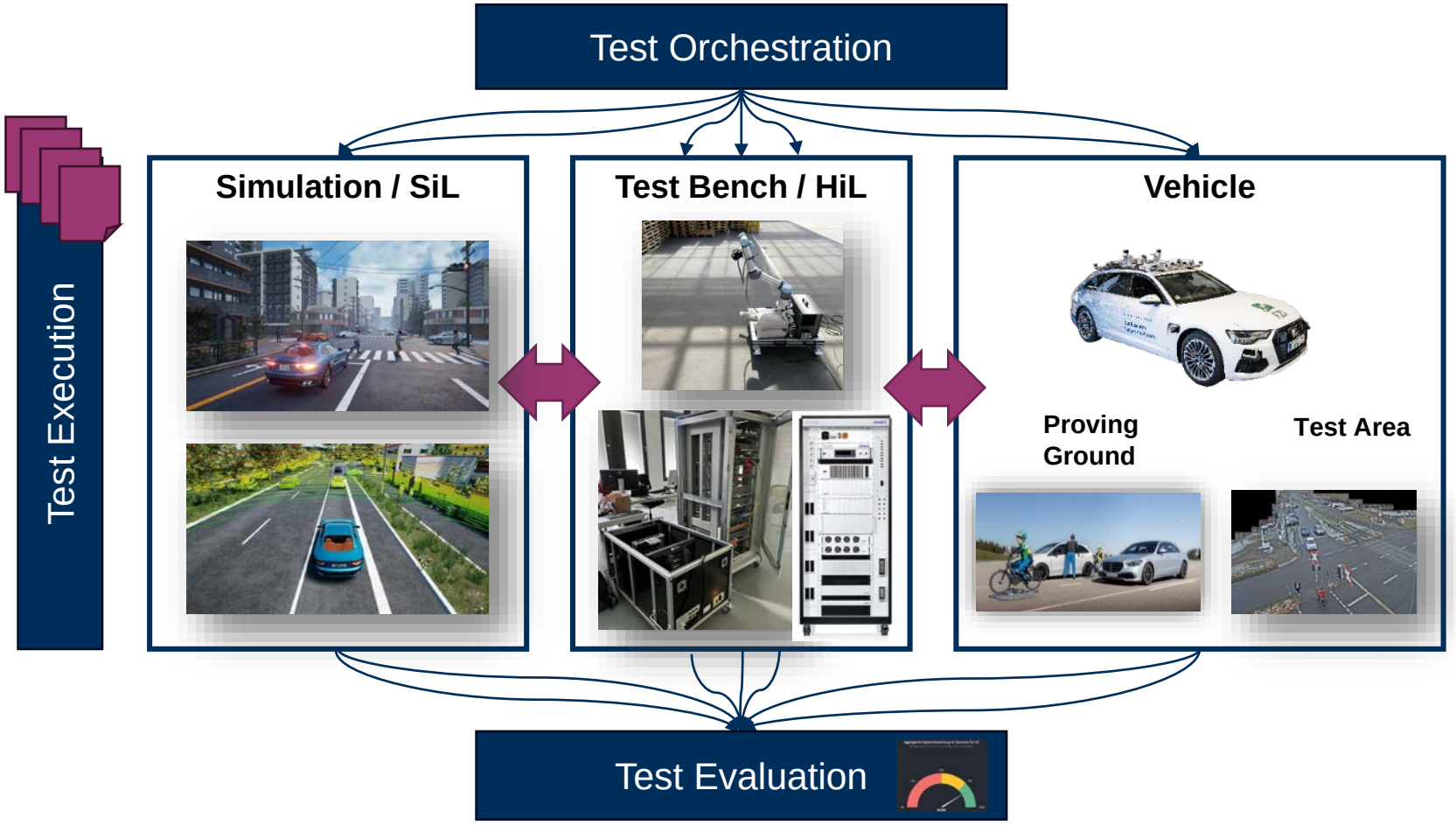


Test Platforms – Systematic Comparison

- Systematic comparison of test platforms
- Different characteristics and behaviors
- Individual choice and combination within test orchestration
- Complement, efficiency, flexibility, consistency, reuseability

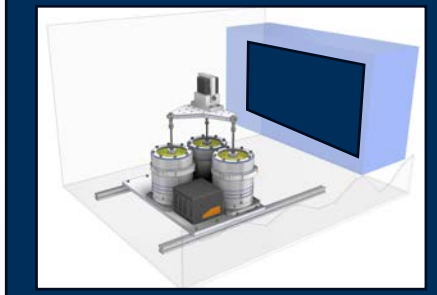


Test Execution – Example Realizations



Test Execution – Example Realizations

Example Realization 1
Cross-Cutting Influence on Camera Perception



Test Execution

Test Orchestration

Test Bench / HiL

Vehicle

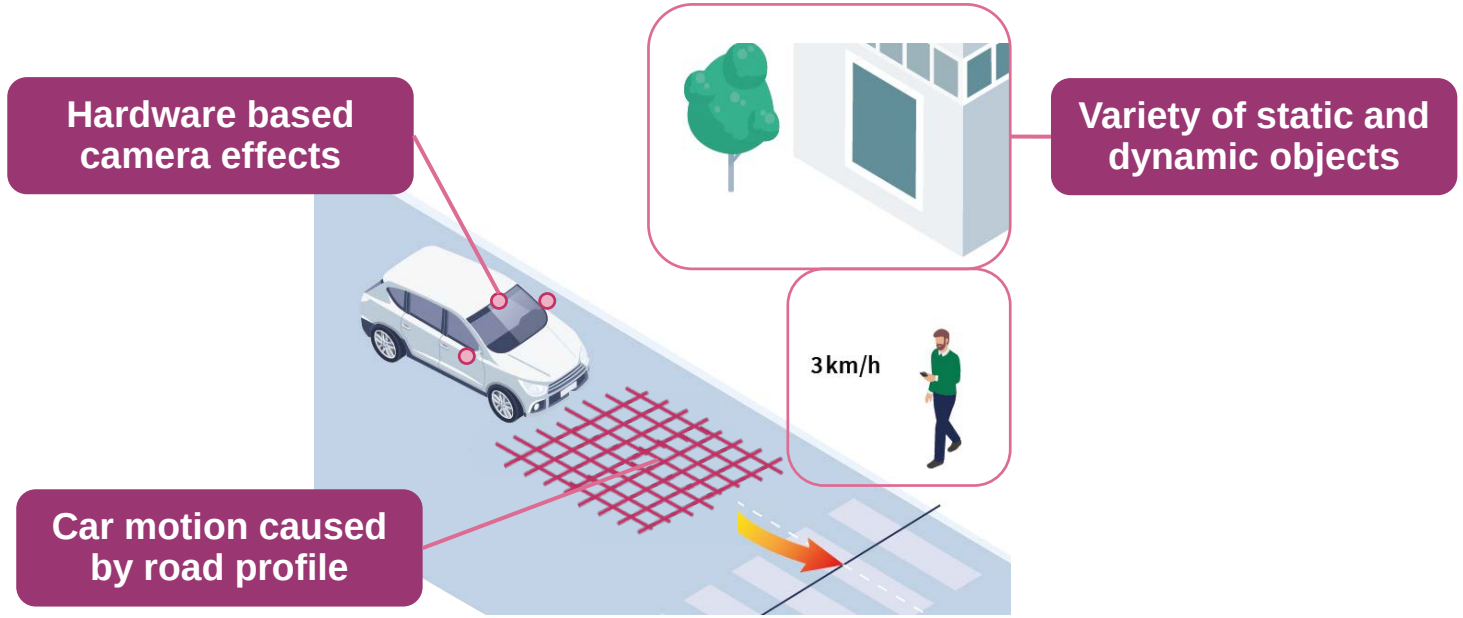
Proving Ground

Test Area

Test Evaluation

Example Realization 1 – Cross-Cutting Influence on Camera Perception

- **Top goal: Perception of moving objects**
- Target metric: Accuracy of object detection
- Scenario: Functional Use Case 2.3
- Cross-cutting influence of kinematic coupling to a specific mode of perception (camera) through systematic analysis
- Transfering causes of real driving conditions in a laboratory environment
- Complete chain of effect on a Hardware-in-the-Loop test platform



Benefit:

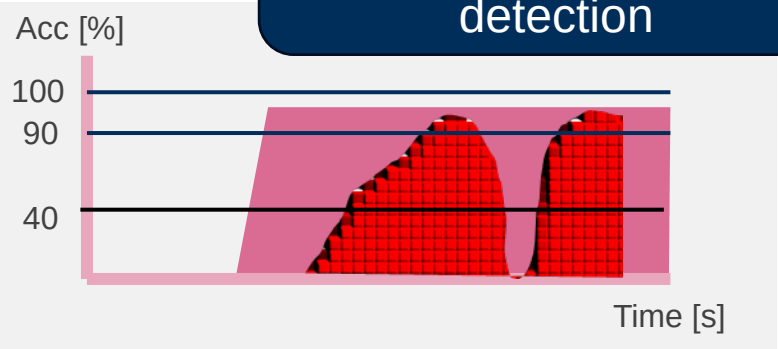
Observe and evaluate performance degradation within a simulated environment from early development phases on

Example Realization 1 – Cross-Cutting Influence on Camera Perception

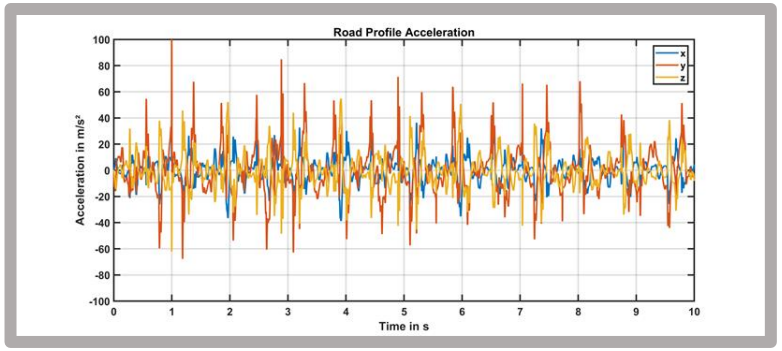
VERIFICATION VALIDATION METHODS

Target metric:

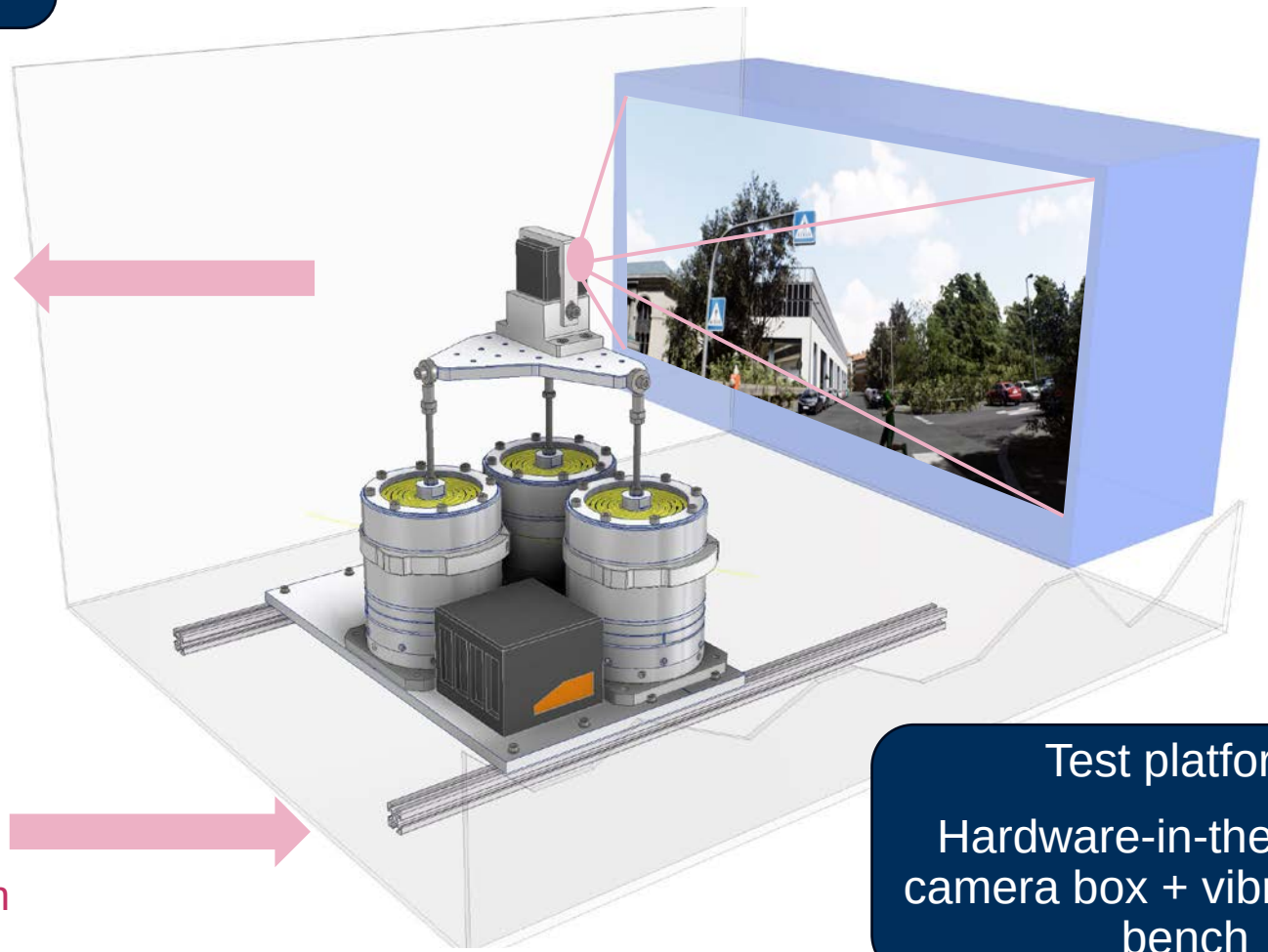
Accuracy of object detection



Automated evaluation of test results



Injection of a recorded road profile acceleration



Test platform:

Hardware-in-the-Loop + camera box + vibration test bench

Test Execution – Example Realizations

Example Realization 1
Cross-Cutting Influence on Camera Perception

Test Orchestration

Test Bench / HiL

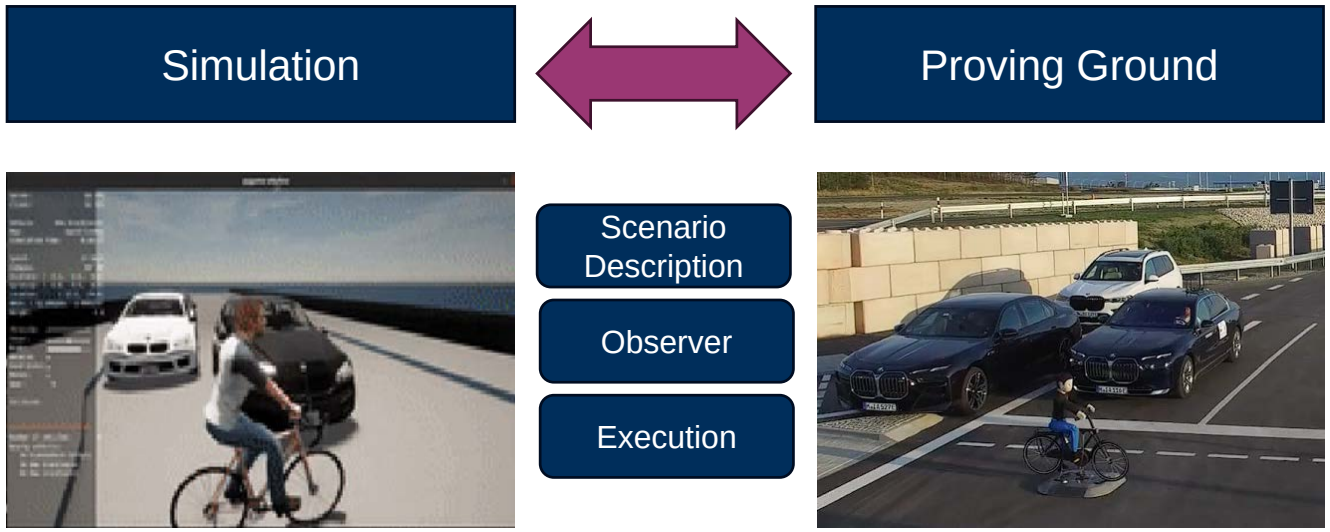
Vehicle

Example Realization 2
Seamless Scenario Based Testing in Simulation and Proving Ground

Test Evaluation

Example Realization 2 – Seamless Scenario Based Testing in Simulation and Proving Ground

- **Efficient and seamless testing on simulation and proving ground**
  - Based on using same artifacts and objects for test execution
- Realisation of logical traffic scenario by means of simulation and real world on the proving ground
- Scenarios involve interaction and coordinated motion of several actors
- Automated repetitive test execution
- Integration of certified NCAP movable targets



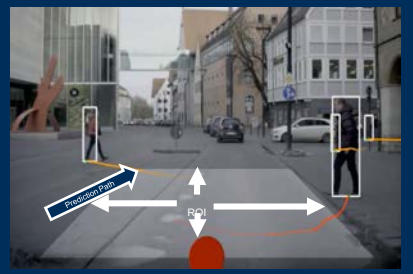
Test Execution – Example Realizations

Example Realization 1
Cross-Cutting Influence on Camera Perception

Test Orchestration

Test Bench / HiL

Example Realization 3
Fleet Monitoring and Assessment for Validation

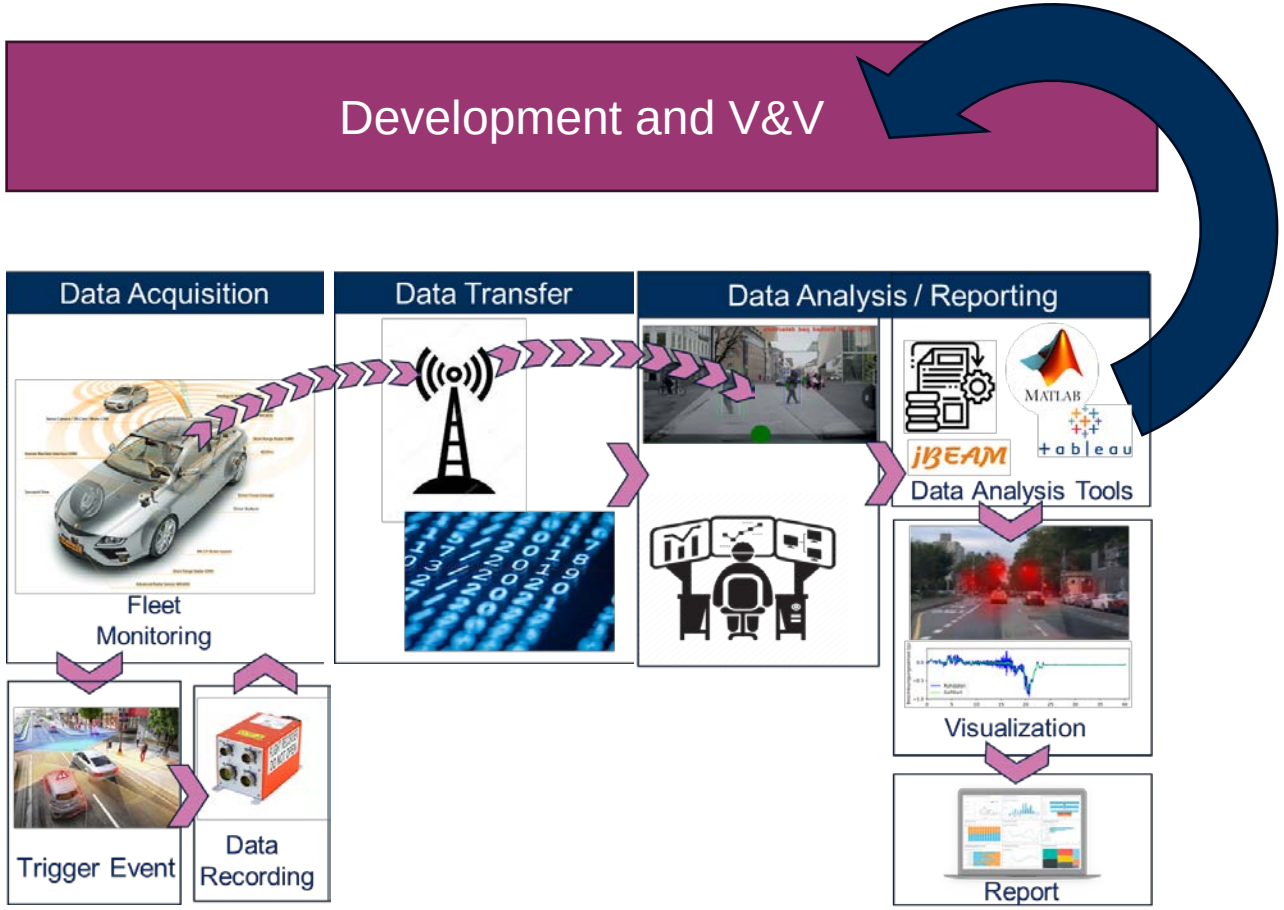


Example Realization 2
Seamless Scenario Based Testing in Simulation and Proving Ground

Test Evaluation

Example Realization 3 – Fleet Monitoring and Assessment for Validation

- **Validation approach to complement Verification**
- Support validation within the overall V&V approach by in-field monitoring in development and series phase
- Observation of traffic situations by smart monitors
- Triggering of data recording when trigger conditions are fulfilled
- Data analysis and visualisation to identify unknown and potentially hazardous scenarios
- Systematic transfer to system design and verification

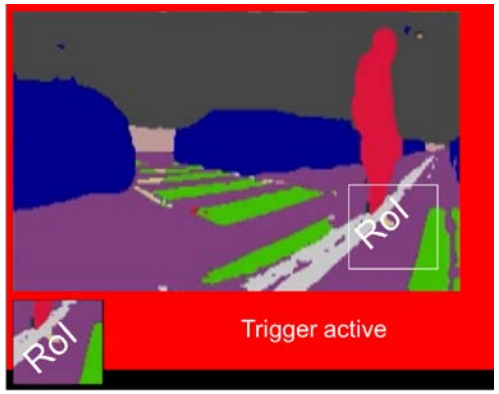


Example Realization 3 – Fleet Monitoring and Assessment for Validation

VERIFICATION VALIDATION METHODS

Idea

- A rear-facing camera that allows a view of past events is used to identify near-misses

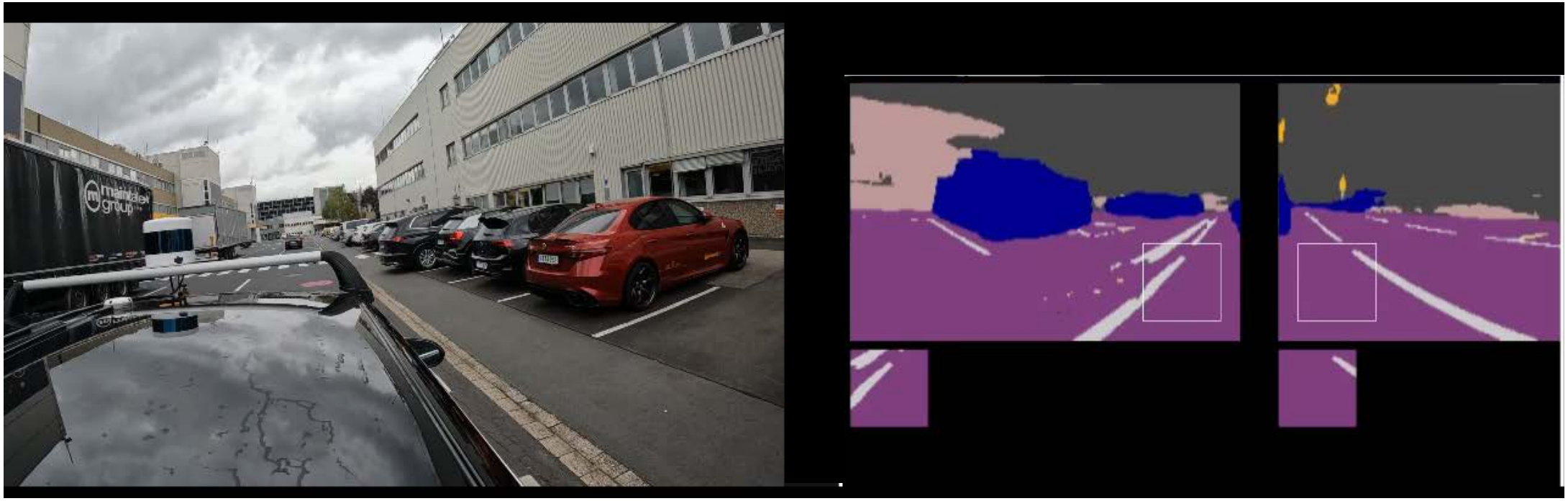


RoI – Region of Interest

- If there is a pedestrian in this area, it is assumed that a near miss has occurred and a measurement data recording is started (trigger condition)

Trigger Indicator

red – Trigger active



Exhibition Area 14 - Overview of VVM Test Methodology Blocks

VERIFICATION VALIDATION METHODS

Cross-Cutting Influence on Camera Perception

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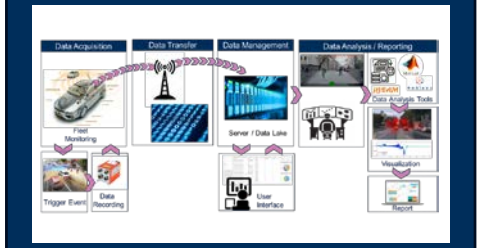
Roll-Up 14.11, 14.12, 14.13

Fleet Monitoring and Assessment for Validation



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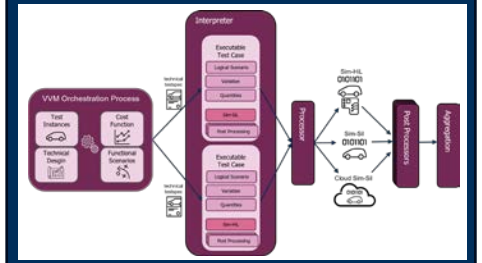
Roll-Up 14.1

Distributed and Scaleable Test Execution



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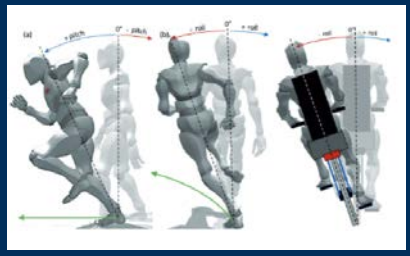
Roll-Up 14.15

Realistic Motion of Vulnerable Road Users



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Roll-Up 14.10

Digital Twin and Test Area

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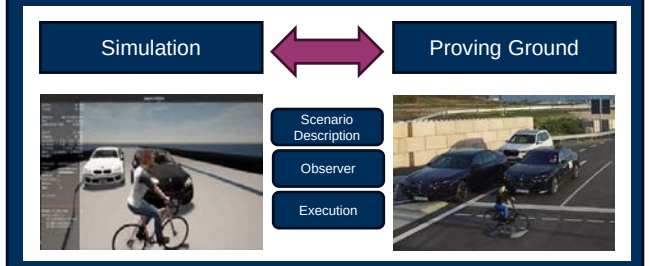
Seamless Scenario Based Testing on Proving Ground



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Validation of Simulation Models

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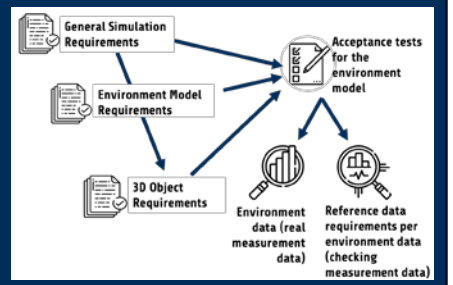

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Roll-Up 14.2, 14.3, 14.5

Integration of Vulnerable Road Users in Simulation

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Roll-Up 14.4, 14.6, 14.7

Validation of Adverse Weather Performance

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Roll-Up 14.9

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Thank you!

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PROJECT of the PEGASUS FAMILY

VDA LEITINITIATIVE

A project developed by the VDA Leitinitiative
autonomous and connected driving

Supported by:

Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag