VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

EMPIRICAL SIMULATION VALIDATION

Comparing proving ground and simulation data of a SAE Level 4 System

Hardi Hungar, Gerald Temme; DLR

Goal:

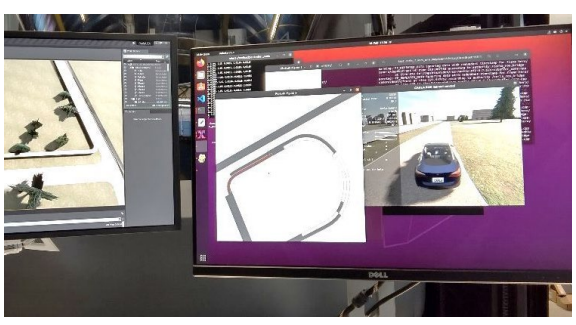
Evaluation of the empirical realism of simulation data by comparison with a SAE4 system in the loop

Automation controlling a research vehicle on proving ground

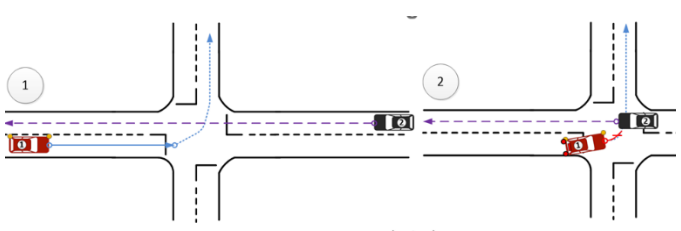
Method:

Comparison of gathered simulation data with reference data from reality (proving ground):

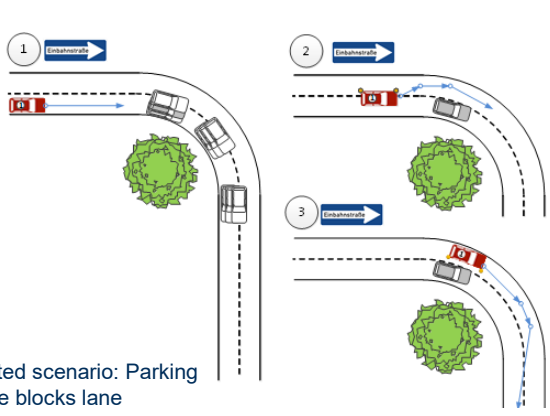
- Use of same SAE4 Automation and parametrization for System Under Test (SUT)
- Addressing same scenarios
- Faithful OpenDRIVE modeling of proving ground environment environment
- Replay of movement of traffic based on measured data on proving ground



Automation operating within a simulation framework
(SET Level development)



Selected scenario: Left turn with oncoming vehicle



Selected scenario: Parking vehicle blocks lane

Pre-study performed in Q4 2021:

- Recorded 56 data sets within two selected scenarios in both environments
- In-the-loop test of all involved components as a preparation of a main study Q4.2022
- Ongoing improvement of data analysis regarding quality of simulation

Satellite image of proving ground in **reality**
Source: Google Maps

Model of proving ground within **simulation**
Format: OpenDRIVE

www.vvm-projekt.de Twitter @vvm-project LinkedIn VVM Project

Projektpartner

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

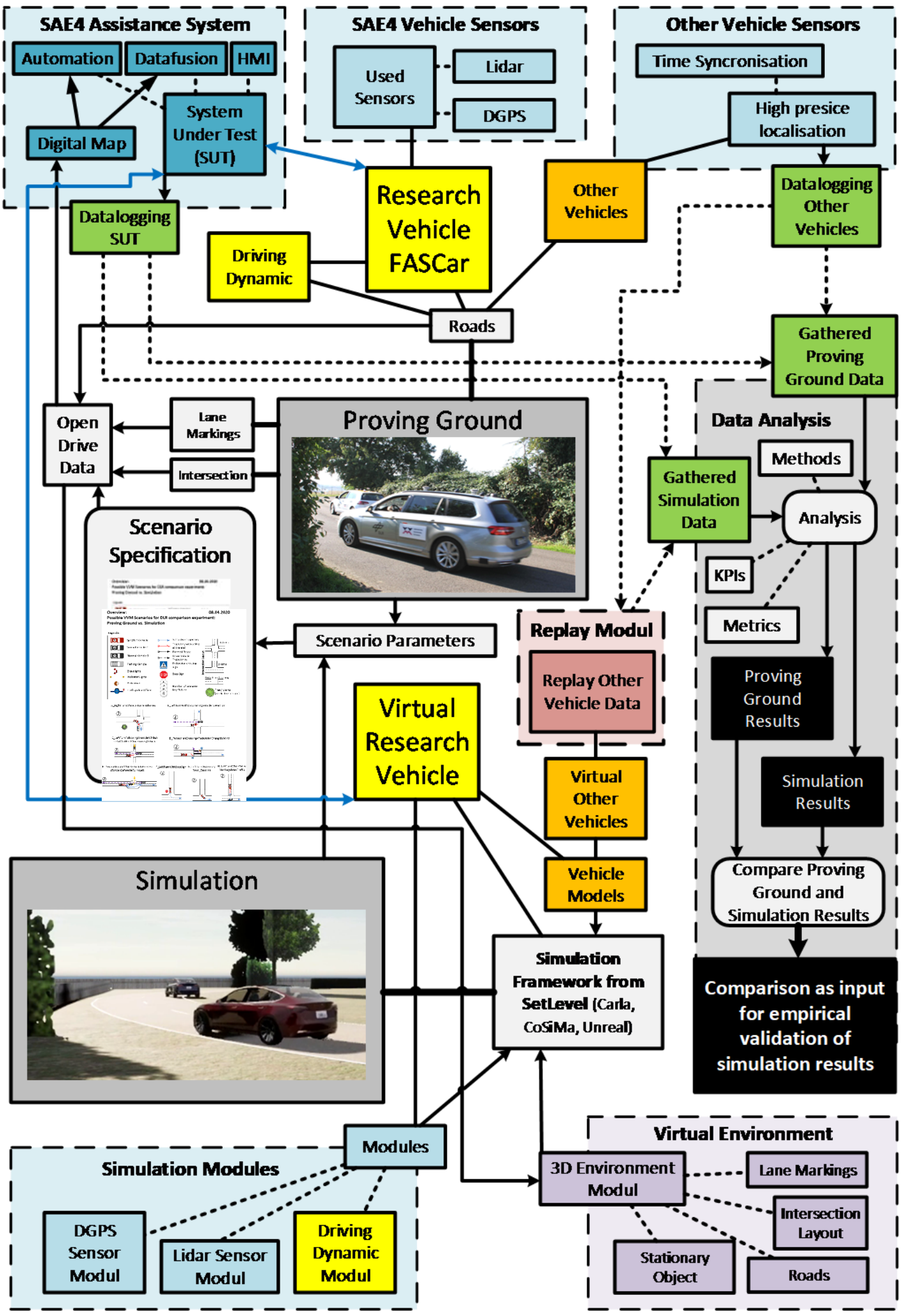
VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

EMPIRICAL SIMULATION VALIDATION

Comparing proving ground and simulation data of a SAE Level 4 System

Overview diagram of involved components and their relations to gather comparable date on proving ground and simulation



www.vvm-projekt.de Twitter @vvm-project LinkedIn VVM Project

Projektpartner

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

VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

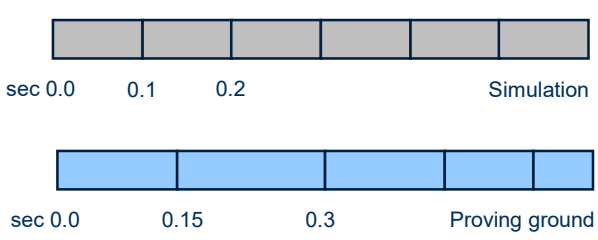
EMPIRICAL SIMULATION VALIDATION

Comparing proving ground and simulation data of a SAE Level 4 System

Data Analysis Phases

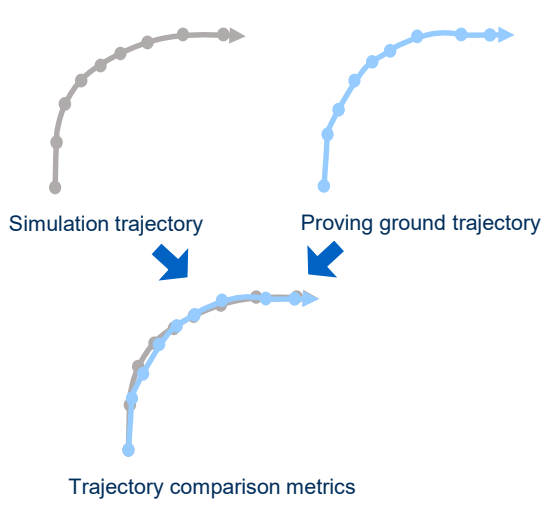
1. Data alignement

- Data format transformation into comparison form
- Elimination of measurement-systematic discrepancies



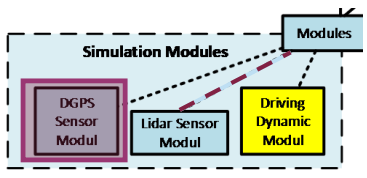
2. Discrepancy analysis

- Definition of comparison metrics
- Detection of discrepancies on
  - Trajectory level
  - Internal system level
  - Component level
- Discrepancy source analysis
  - Environmental modeling
  - Component models
  - Composition (co-simulation) artefacts
  - …



3. Simulation improvement

- Eliminate detected simulation deficiencies
- Re-simulation



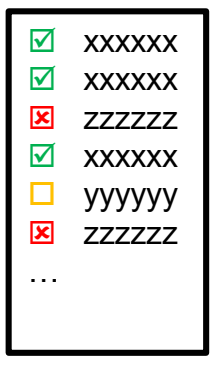
Component and composition improvements

4. Analysis iteration

- Iterated discrepancy analysis

5. Validation Report

- Comparison verdict
  - Qualified simulation validity statement
- Lessons learned
  - Experiment setup and conduct
  - Analysis methods and results



www.vvm-projekt.de Twitter @vvm-project LinkedIn VVM Project

Projektpartner

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