VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

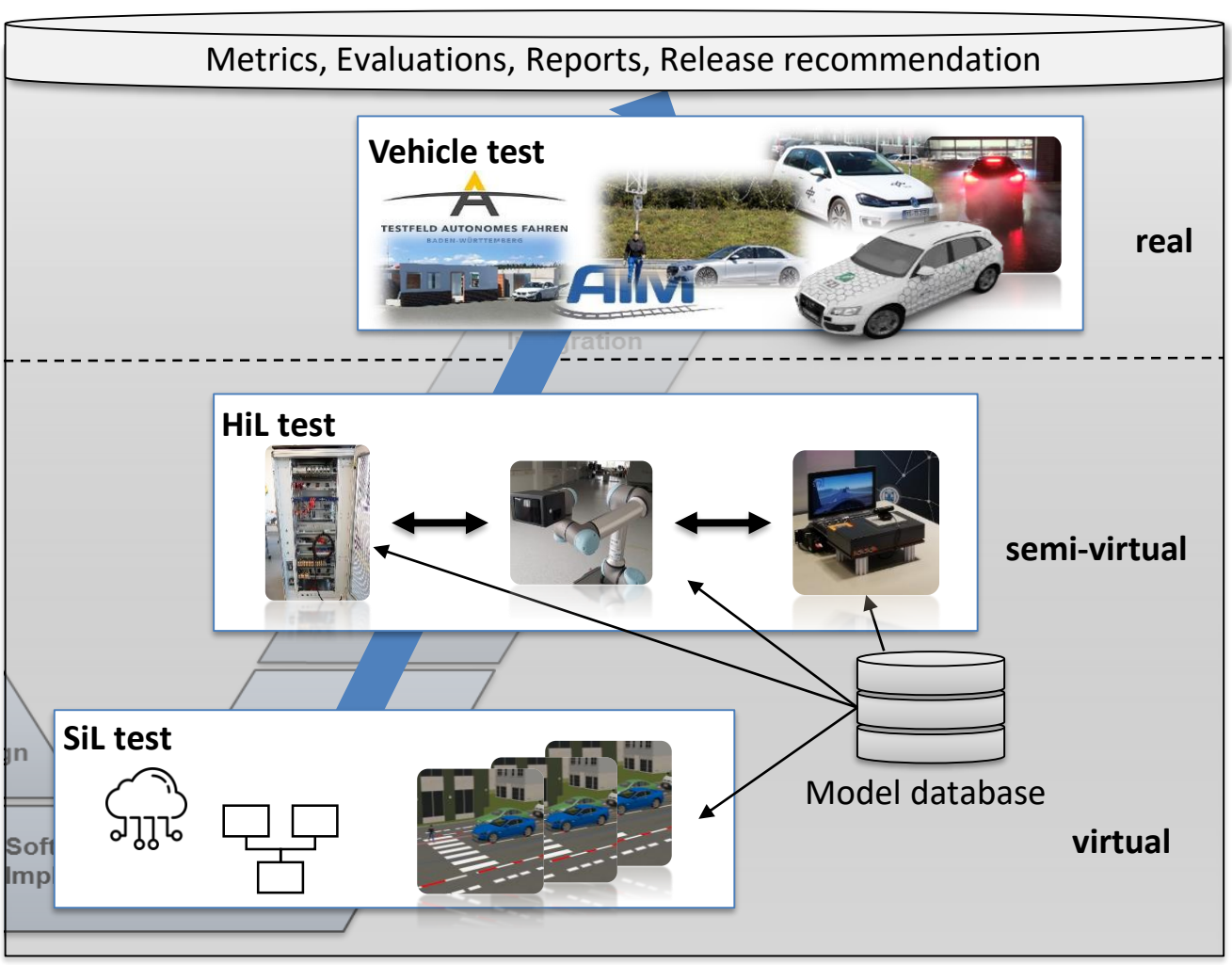
TOWARDS SEAMLESS TESTING OF URBAN SCENARIOS IN THE SIMULATION AND ON THE PROVING GROUND

Vision and Goals

Erik Fox, AKKA; Thomas Otto, BMW; Christian King, Julian Fuchs, FZI

Vision:

- Test instances support a **comprehensive and seamless test process**
- Ensure **consistency** of test assets along the validation tool chain
- Enable the **distribution** of tests to different test instances like the simulation and the proving ground
- **Standardize** test descriptions to support the transferability



Goals:

- Use standardized formats and interfaces (like OSI, FMU, OpenScenario or OpenDrive)
- **Interchangeability** and **reuse** of simulation models in different test instances
- Generate **comparable** and **aggregatable** test results
- Build test instances that **complement** each other

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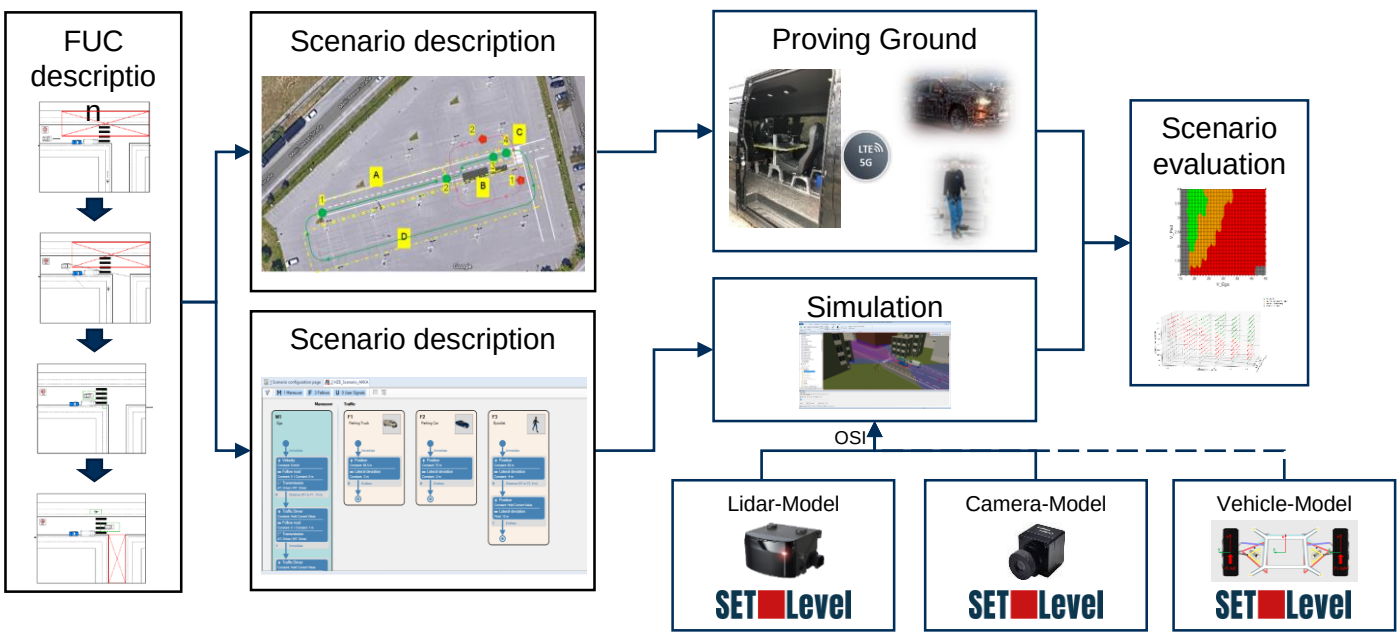
Prototypical implementation for a logical scenario

Erik Fox, AKKA; Thomas Otto, BMW; Christian King, FZI; Julian Fuchs, FZI

Scope of the prototype

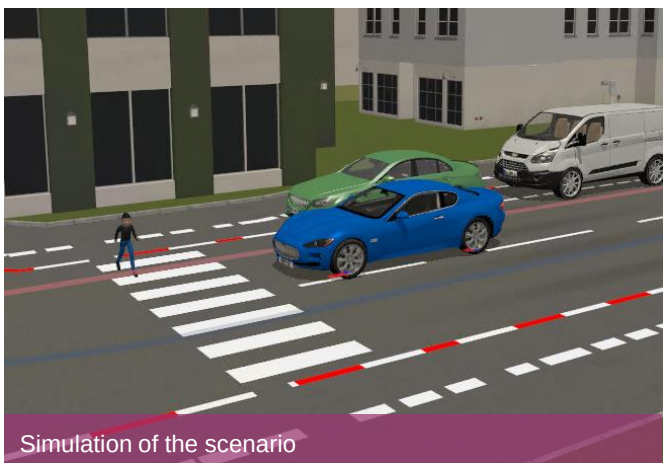
- Demonstration of a logical scenario in the simulation and on a automated proving ground
- Use the same parametrization and test description for both test instances
- Analysis and comparison of results



Considered Logical scenario:

- Contains a straight passing of a T-crossing with a pedestrian crossing
- Parked vehicles on the roadside
- Special concern: occlusion of the pedestrian through parking vehicles


Proving Ground Test


Simulation of the scenario

Challenges of the prototype in relation to the common evaluation

- **Time synchronization of the measurement data**
- **Transformation of the measurement data coordinate systems**
- **Availability of in-vehicle measurements and external ground truth data**

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Requirements related to the interchangeability of the test platform

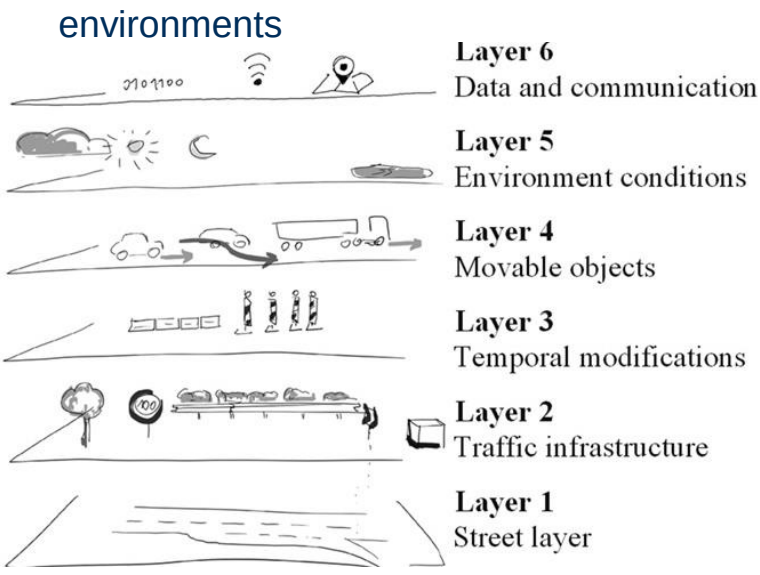
Erik Fox, AKKA; Thomas Otto, BMW; Christian King, FZI; Julian Fuchs, FZI

General requirements

- **Validation of the test environment** for comparability
- **Standardize documentation** for a common aggregated assertion
- **Common assertion** as a contribution to the test aim

Scenario requirements

- Structuring of the scenarios in **6-layer Pegasus model**
- Standardized **OSI interfaces for exchanging model** parts between environments



6-layer Pegasus model

Bock et al. 2018

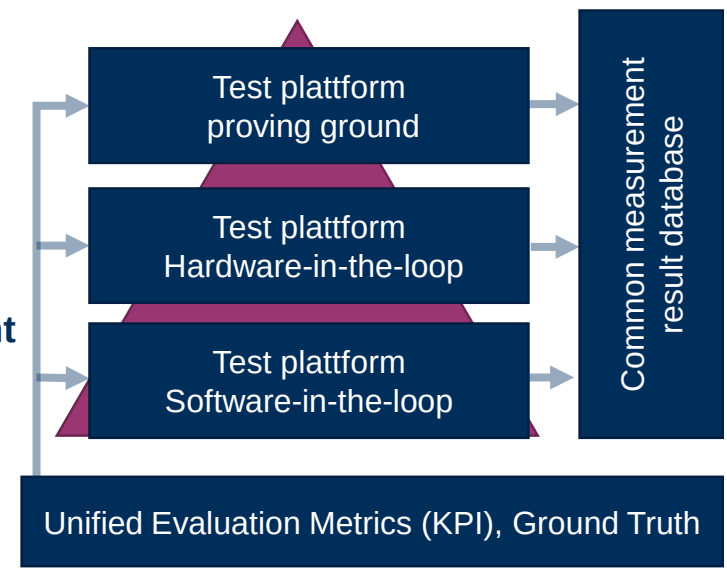
Specification of GPS, V2X communication, etc.

Standardization via OpenScenario to specify a comparable scenario

Standardization via OpenDrive to specify a comparable scenario

Evaluation requirements

- Unified **Evaluation Metrics** (KPI)
- Access to **comparable measured values**
- Comparison with reference **(ground truth)**
- Return and storage of **measurement results** (signals, test results, unique identification, ...) from test platform
- Uniform and standardized **data exchange format**



Assessment requirements

- Development of a **selection catalog for orchestration**
- **Allocation of the test cases** based on the capability of the test platform and the test aim
- **Reproducibility** of test cases independent of the test platform
- Determination of **limitations, strengths and weaknesses of the test platform**

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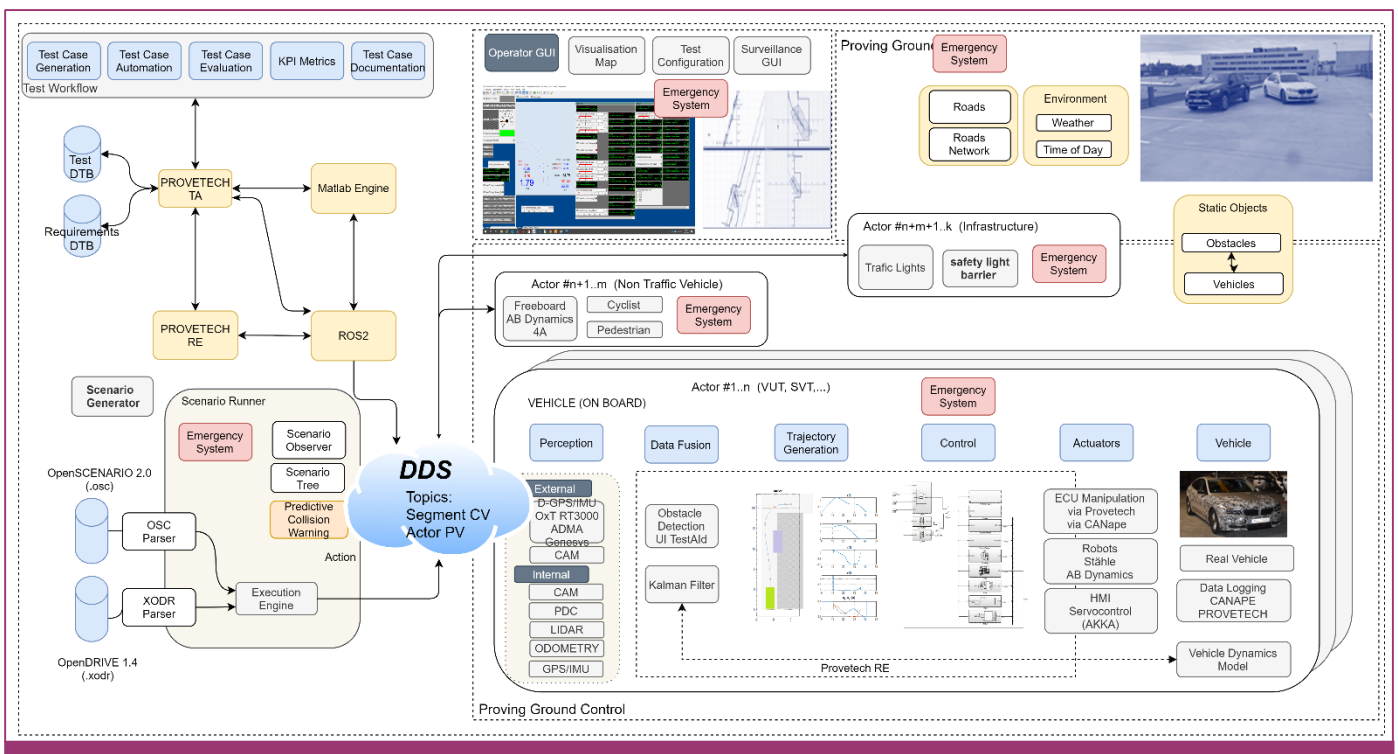
Control Center for seamless testing of scenarios on proving grounds

Erik Fox, AKKA; Thomas Otto, BMW; Christian King, FZI; Julian Fuchs, FZI

Focus

- Comparability of test results within the **seamless testing philosophy**
- Automated test operation for **reproducibility**
- **Central control layer** for all objects within test scenarios (vehicles, targets, test site infrastructure)
- Monitoring and **security** layer
- Infrastructure for **data management**

Architectural concept of the central control layer



Architectural concept for prototypical realization

Technological approaches

- **ASAM Open X standards** as basic formats for scenario description for simulation and real test.
- Further elements to ensure **seamless testing** e.g. trajectory planning based on ASAM scenario description.
- **Data Distribution Services** (within ROS2 Framework) to Ensure synchronicity and data consistency between objects within test scenarios.
- **Communication** for transferring data to objects within test scenarios via WLAN (later mobile technologies)
- **Safe testing** with state-of-the-art security features e.g. trajectory-based monitoring (geofences)

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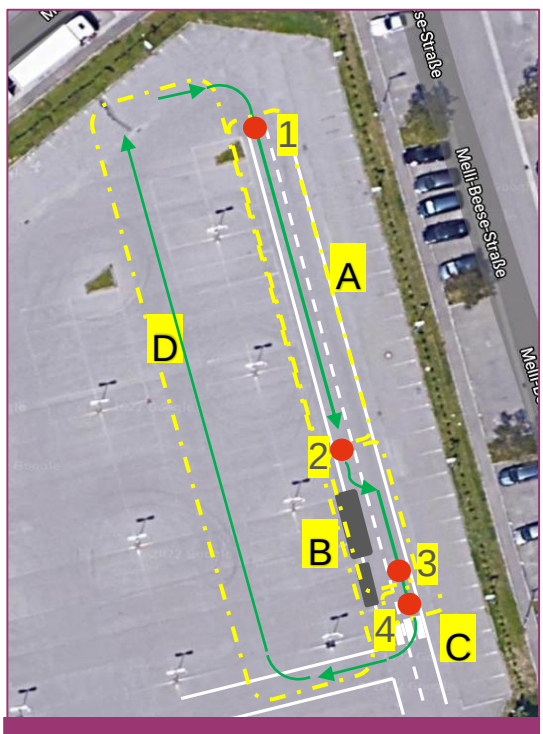
Added values

- Same metrics between simulation and real test enable mutual comparability
- Multi-vehicle operation and parallel operation of multiple test campaigns
- Automated vehicle operation with in vehicle interfaces (ECU manipulation) and/or external robotics

Description of video for FUC 2.3

- Video of the prototypical implementation of the FUC 2.3 in real testing
  Description of test sequences and individual activity areas



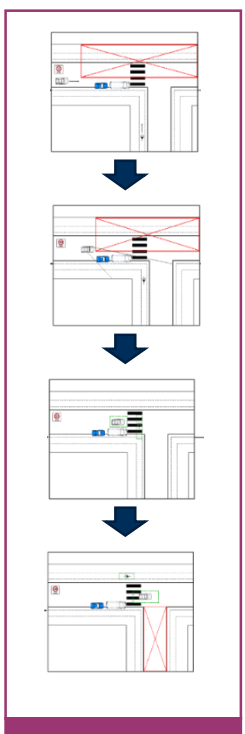
Description of implementation FUC2.3

A Start and acceleration area
1 Starting point
Acceleration and constant speed

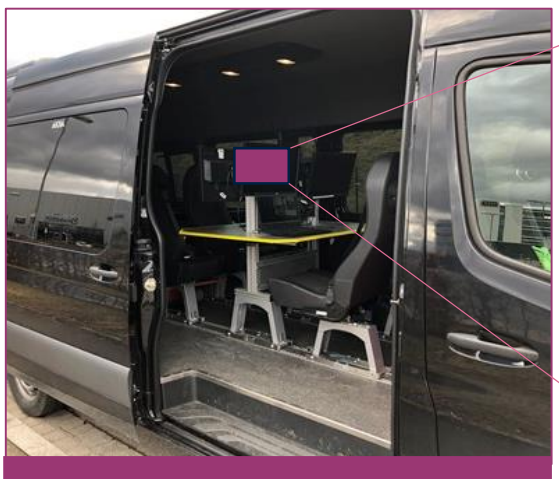
B Swerving area
2 Start lane change and straight ahead driving
In each case with constant speed

C Braking area
3 Braking point. Detection of pedestrian
4 End point. End of FUC 2.3.

D Return area
Automated return to the starting point



FUC 2.3



Mobile control center

Surface control center

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