AVL List GmbH

Virtual approach to ADAS/AD safety testing and validation

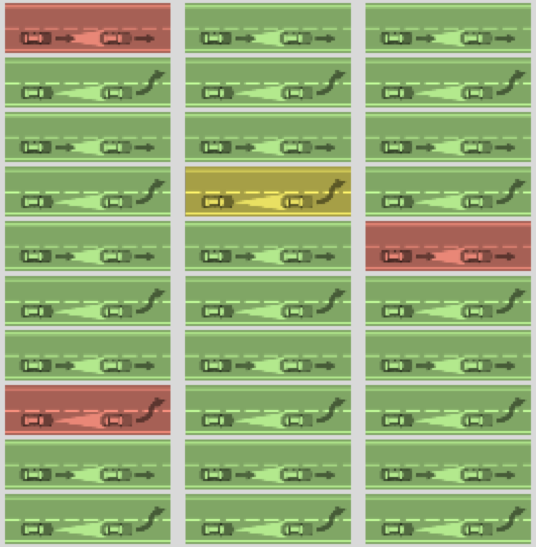
Advanced Simulation Technologies

J. Balic, F. Koenigsson

Vehicle Validation Cascade

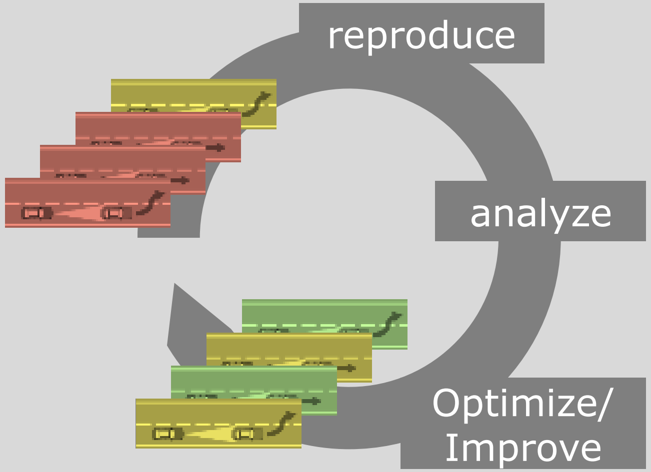
Simulation

Scale Testing of Variants
(Vehicle Configurations and Scenarios)



Virtual TESTING

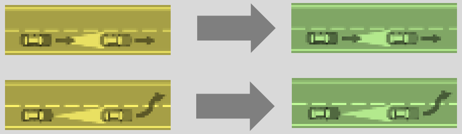
Integrate, Analyze and Improve



+ specific test cases which cannot be done in simulation

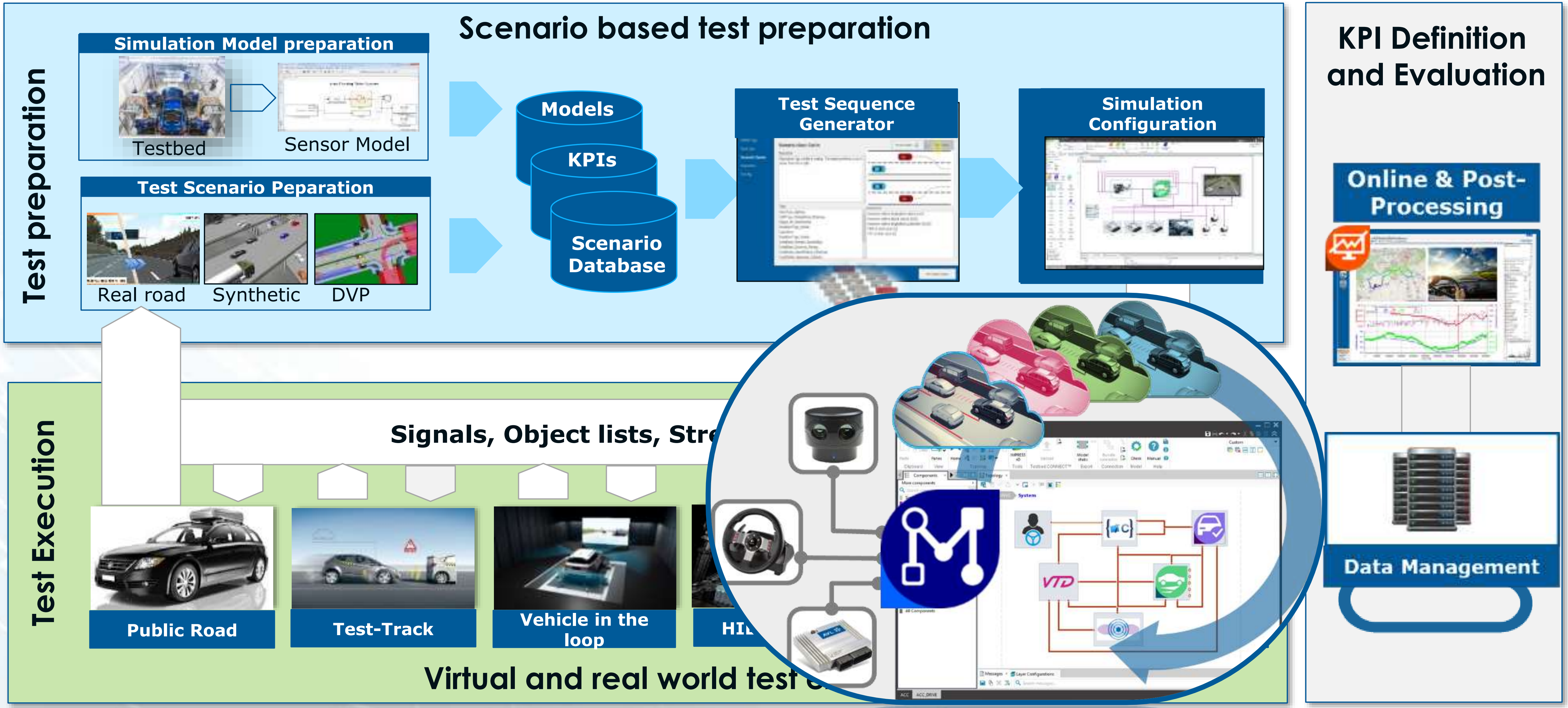
Proving Ground | Real World

Finalize and Confirm



+ specific test cases which cannot be done in simulation and/or Virtual Testing

AVL's Scenario based ADAS/AD Development and Validation Framework



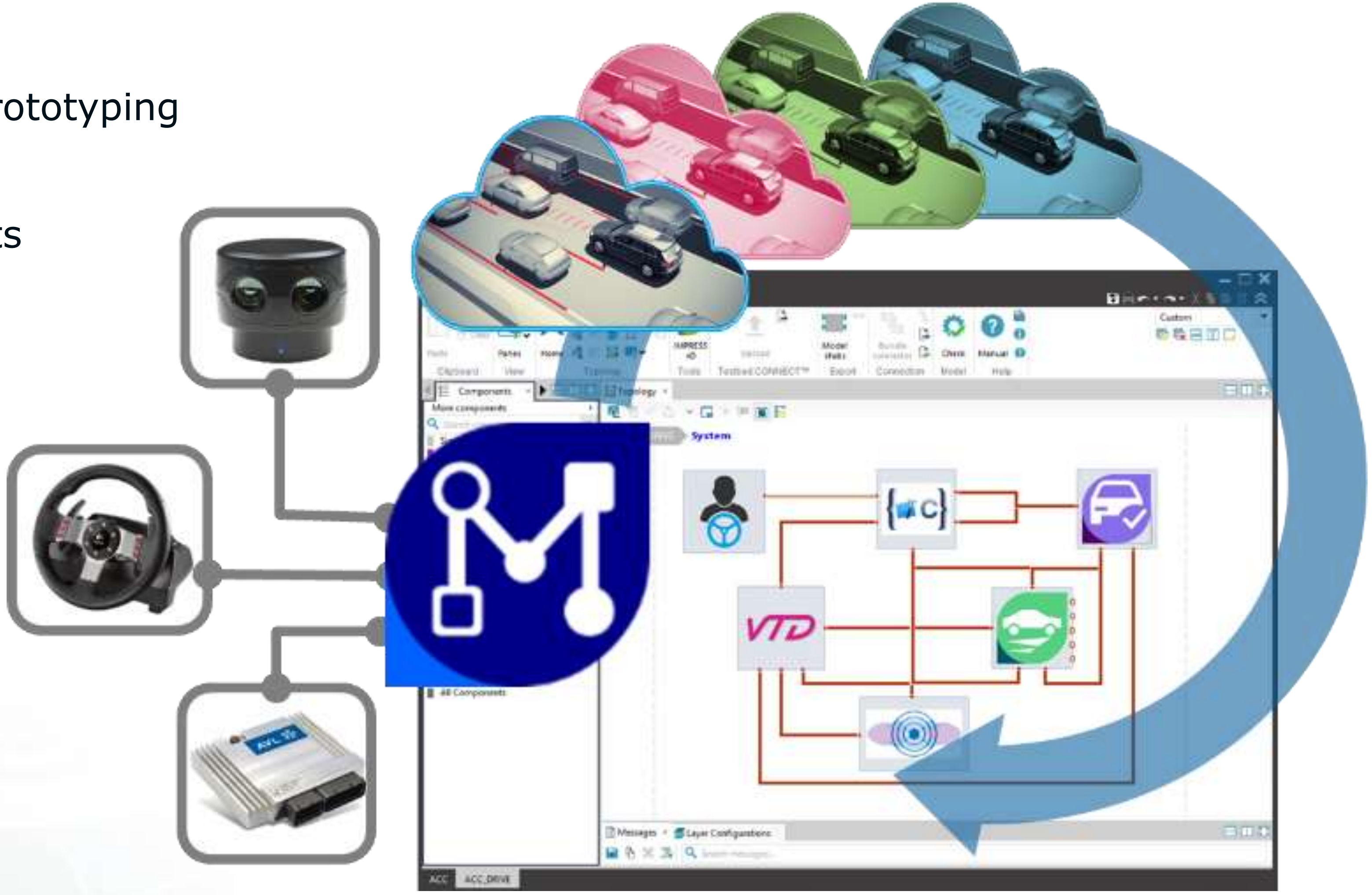
ADAS/AD MiL Integration Platform

AVL Framework:

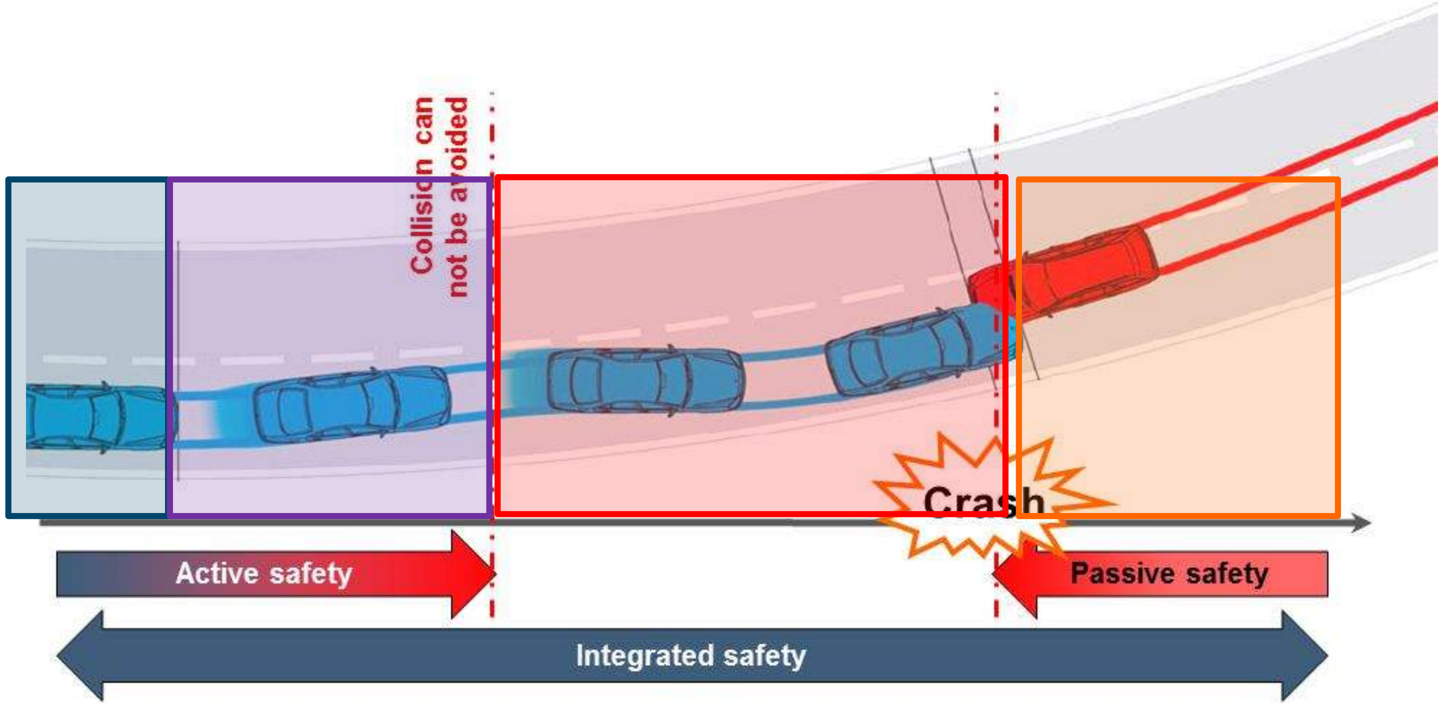
- Ready-to-use MiL platform for rapid prototyping
- Accurate and fast vehicle models
- Integration of sensors and control units
- Large scale DOE optimization
- Scenario based validation in the cloud

Use cases:

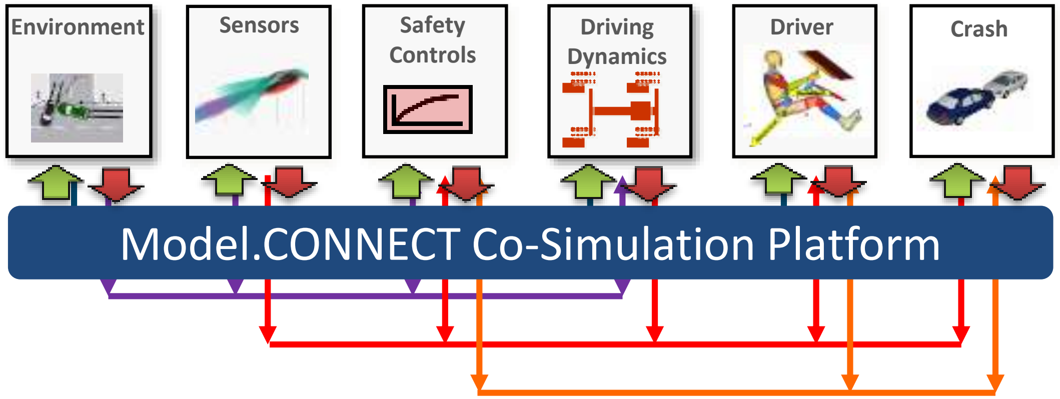
- Lane keeping/changing assistant
- Predictive and adaptive cruise control
- Platooning
- Parking assist
- Traffic jam assist
- Active Safety etc.



Example: “Safety Tool Chain”



Co-simulation representation



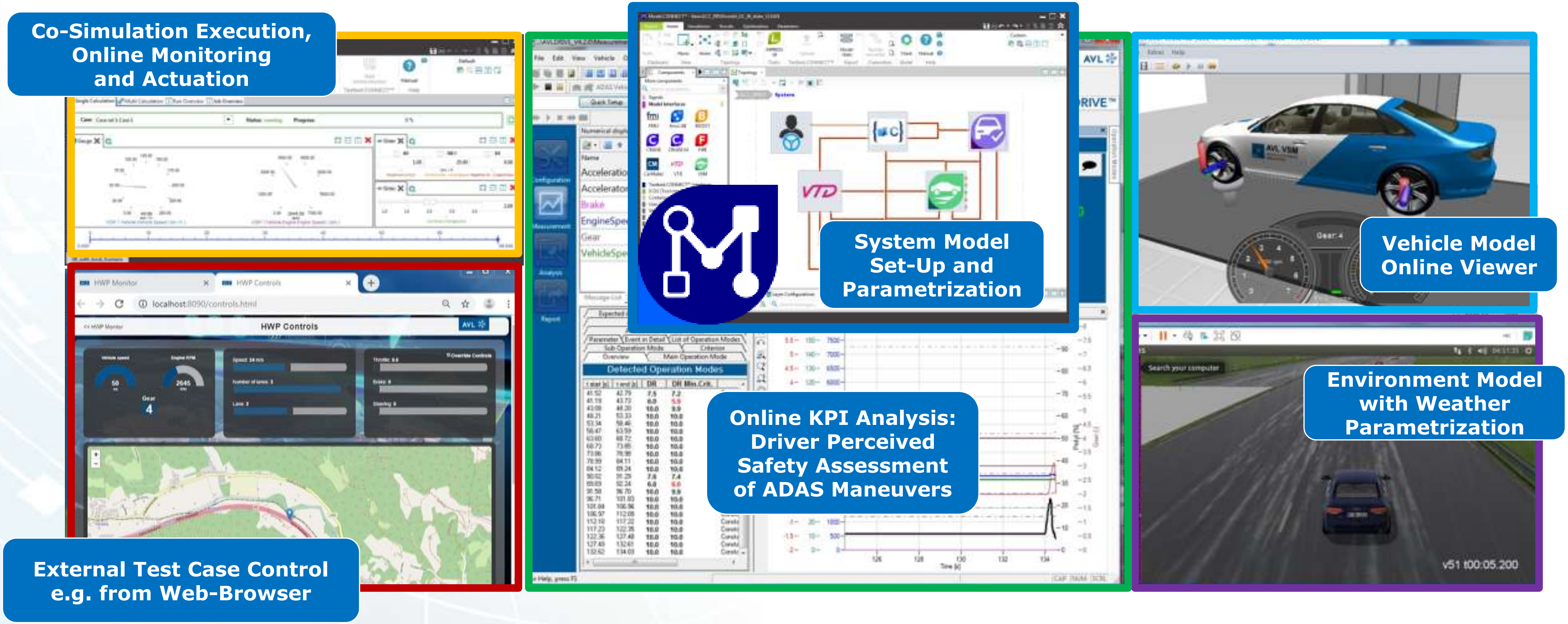
Embedded in CI/CD process

Continuous Integration

Continuous Deployment

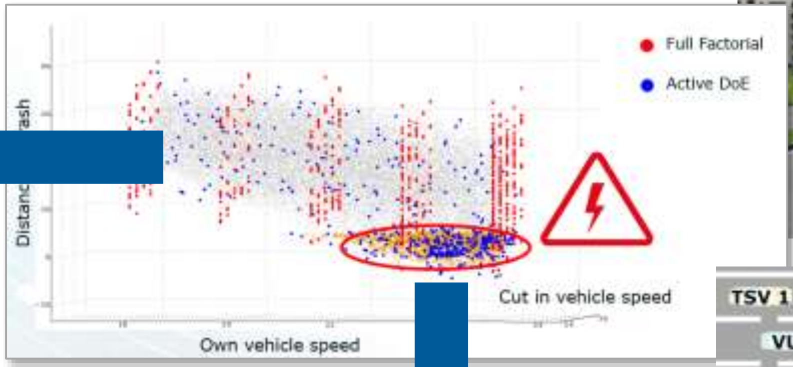
AVL Demonstrator
Virtual Testing - Highway Pilot

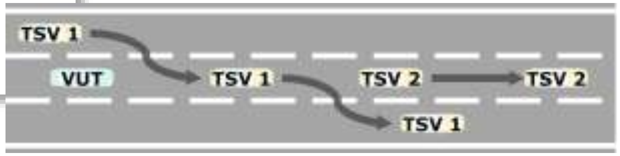
- Co-simulation of AVL VSM, VTD Vires and AVL Drive for Highway Pilot Application



Critical Scenarios Testing for ADAS
USE CASE: Cut In – Cut Out

660 years





Active DoE

Factor 40

16 years

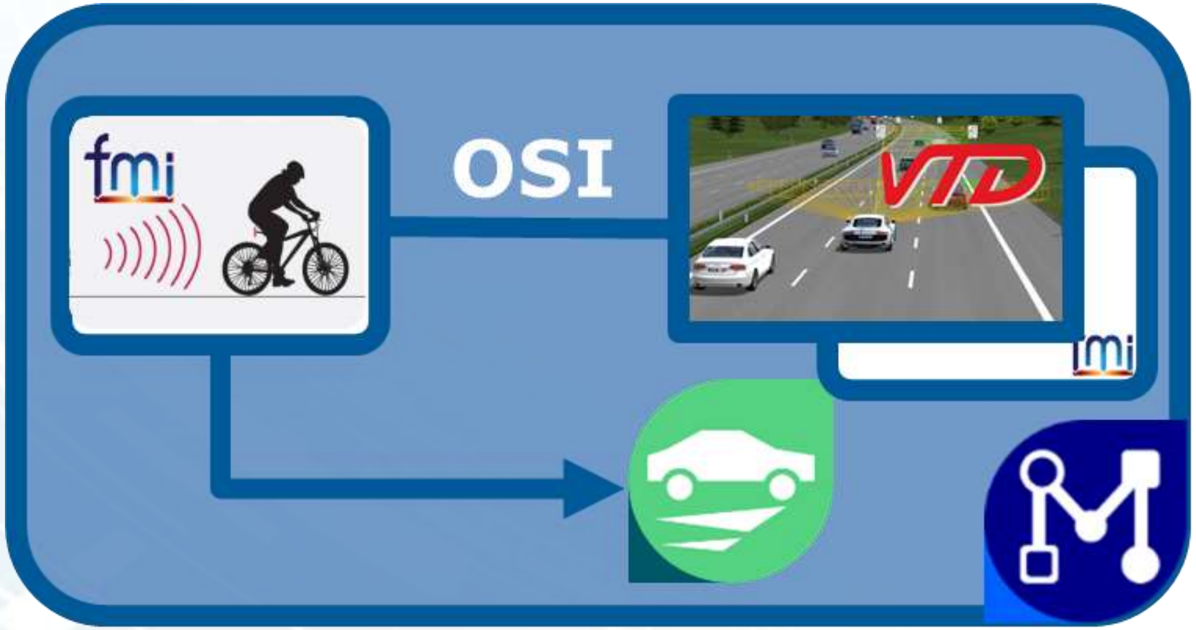
Model.CONNECT™

Factor 1000

1 week

Sensor Model and Hardware Integration

Open Simulation Interface (OSI) for sensor model integration

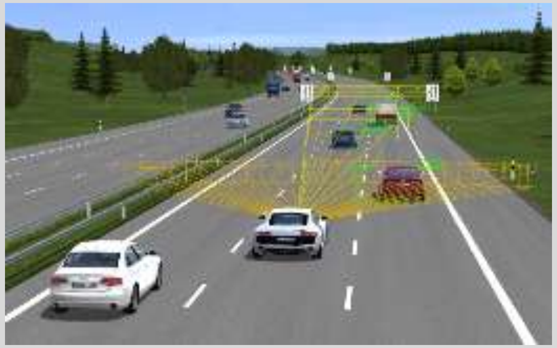


Examples: HiL and CAN Bus Sensor integration

Vehicle Validation Cascade

Simulation

- + fast, flexible and cheap in operation, there are already ESC homologation
- – processes in simulation is only as good as the model(s)



4 tests: < 1 min

AVL DRIVINGCUBE™

- + close to real operation, chassis dynos are already established for homologation (emissions)
- – limited in terms of lateral dynamics

4 tests: ~10 min

Proving Ground

- + very close to the real operation
- – expensive, high effort, less repeatability

4 tests: ~1 day

The most efficient validation will be done by those who will use the best combination!

The AVL DRIVINGCUBE™...

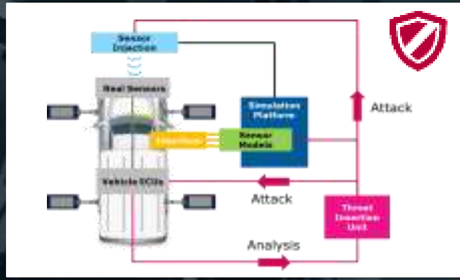
...as vehicle integration lab

Different functions and perceptions must be evaluated at a certain time in the vehicle.

The DRIVINGCUBE is the only test environment for reproducible and repeatable test on vehicle level!

... for security testing

Hacking attacks to evaluate the security of the vehicle must also be performed during operation of the vehicle. Do you want to try an attack on a highway at high speed?



... to reproduce critical scenarios and tests

Critical Scenarios (in general or determined out of simulation) must be analyzed on vehicle level in a reproducible way.

... as most efficient test instance for a lot of use cases

For vehicles of category M_1, N_1

Speedrange		*>130 km/h*
Maximum value for the specified maximum lateral acceleration		3 m/s²
Minimum value for the specified maximum lateral acceleration		0.3 m/s²

Different uses cases in validation and also homologation can not be executed efficiently in other test instances (e.g. ECE 79: LKA above 130km/h)

AVL DRIVINGCUBE™
Top-Level Use Cases

vehicle integration and collaboration lab

- before going on the real road all functions and perceptions must be integrated in the vehicle and validated
- Evaluating malfunctions requires a collaboration of the involved engineers on the vehicle
- It is not efficient to cover all these test on a proving ground

reproduce test cases from simulation on vehicle level

- Simulation will be used to scale testing of AD/ADAS systems (different vehicle variants, different scenarios and test cases)
- Interesting resp. critical scenarios must be reproduced and investigated in an test instance with a higher fidelity
- reproducing the tests on the proving ground is hard to perform

safe validation instance for safety critical test

- In the validation process there are a lot of critical and dangerous scenarios and test cases
- If those have to be validated with the integrated vehicle in the loop, proving ground and of course the real road is not safe enough

Most efficient test instance for a lot of use cases

- Some test cases must be performed with the integrated vehicle in the loop (to test the behavior and functions on system level)
- A lot of use cases cannot be performed in an efficient way on the proving ground or the real road (e.g. lane keeping)

safety and security testing with driving vehicle

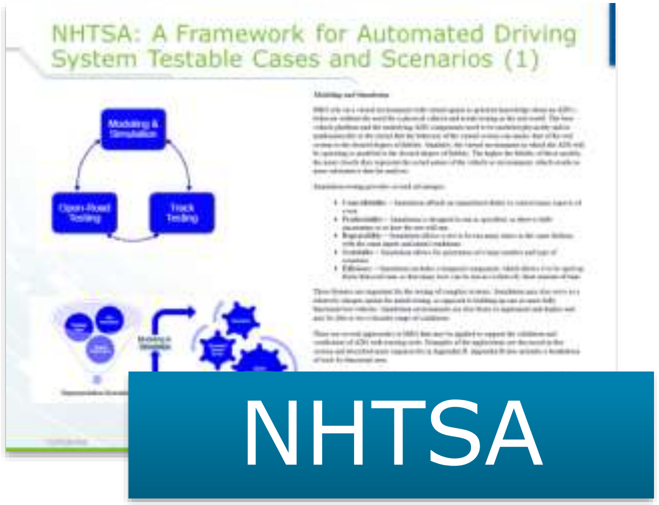
- During safety and security testing the behavior of the vehicle is manipulated also during operation (cyber attack, broken cable, malfunction of sensor, etc.)
- Safety and security testing requires the integrated vehicle
- Testing this on proving grounds or real roads is too dangerous

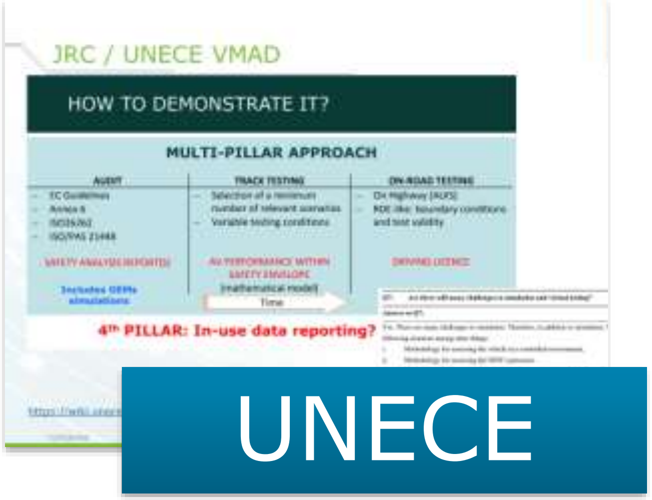
Contribution to generate simulation models

- Simulation will be used to scale testing of AD/ADAS systems (different vehicle variants, different scenarios and test cases)
- Simulation requires validated models of the vehicle dynamics, efficiency, etc. (depending on the use cases)
- Test beds are predestined to determine model parameters

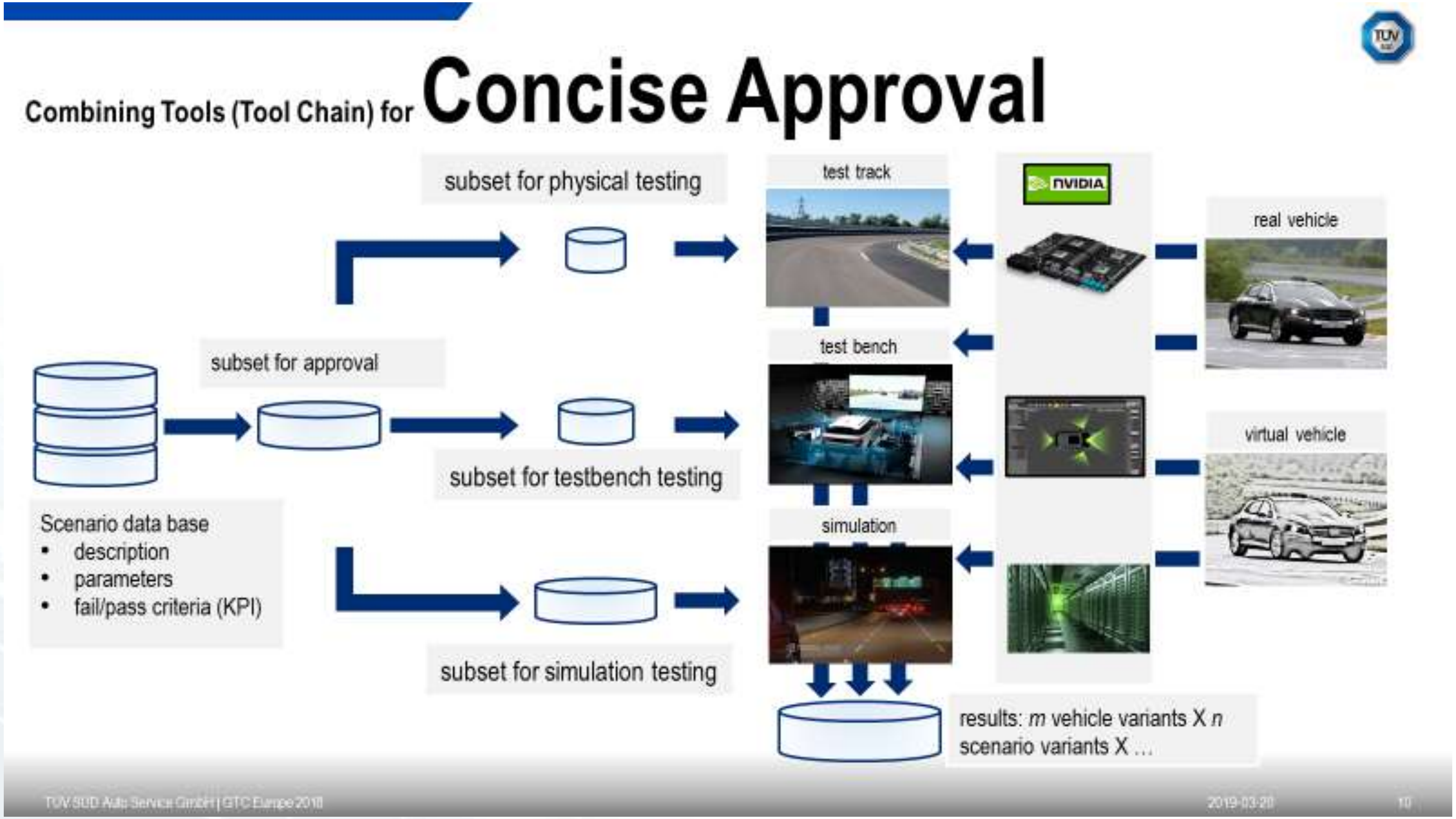
Homologation for ADAS/AD

- Clearly unreasonable to perform the homologation using only real world testing.
- Instead, homologation of ADAS/AD will be performed in both the real world and the virtual world.
- Three pillar approach is recognized as main approach from several key stakeholders:
  - Virtual testing
  - Physical testing(track, ViL)
  - Real world testing



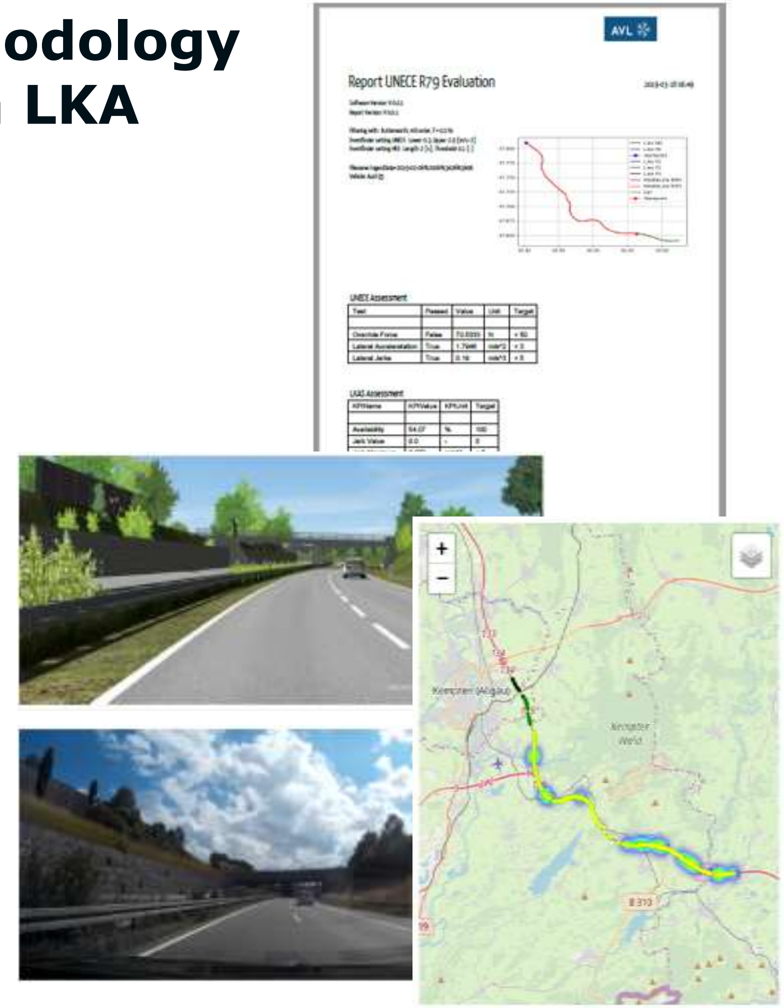


Homologation Approach from TUEV SUED



Introduction and Background Joint Project with OEM based on ENABLE-S3 results

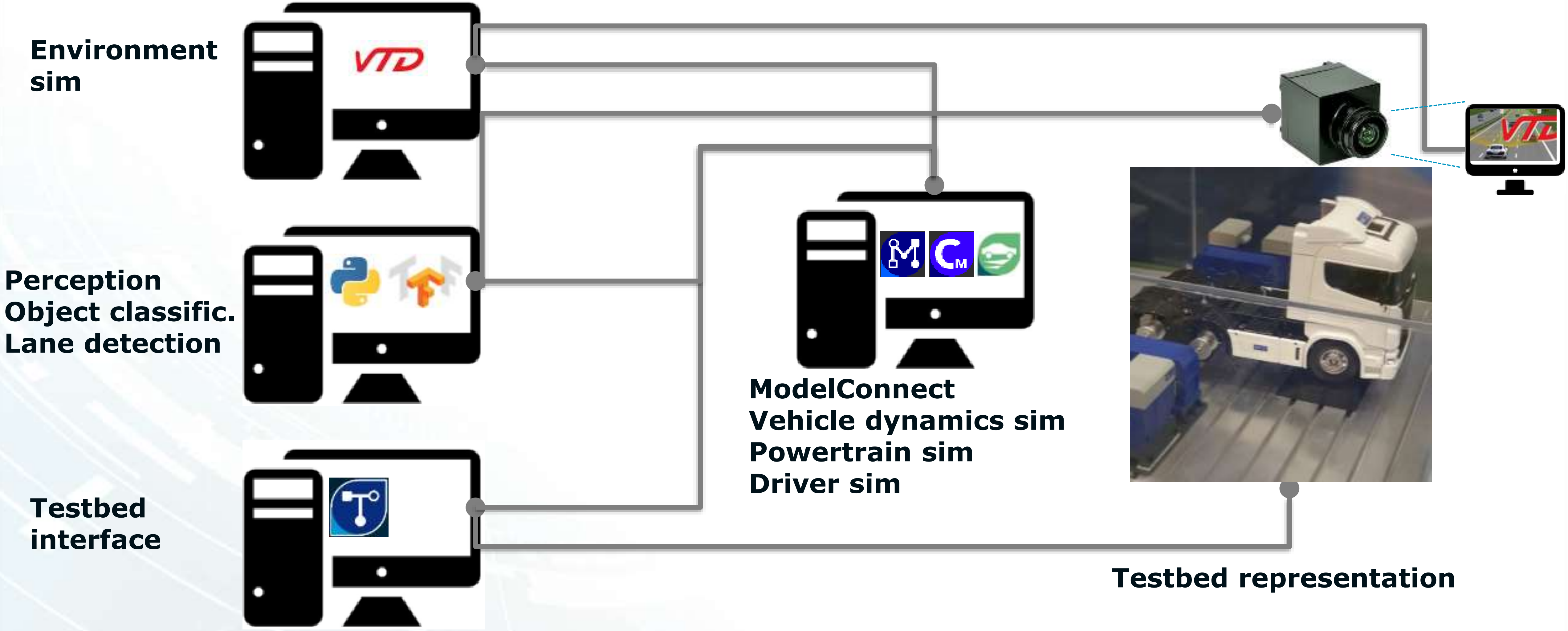
Project Goals: Develop/apply a **tool chain and methodology** for **virtual-based homologation of a LKA based on UN Regulation R79**



Project Setup:

OEM:	Use case and vehicle + vehicle model
	Execution of physical and virtual tests
Partner:	Virtual-based homologation methodology KPIs & criteria for model validation & LKA assessment
AVL:	Tools for virtual testing and simulation, incl. Vehicle-in-the-Loop testbed
	Integration of simulation models
	Tools for evaluation and reporting

AVL Mini Driving Cube



AVL

Current use cases

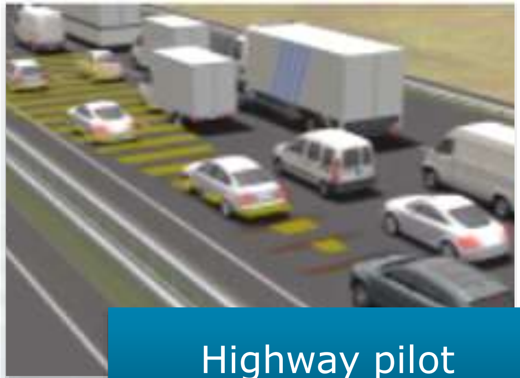
AEB Validation & Homologation

Prototype Vehicle safety commissioning

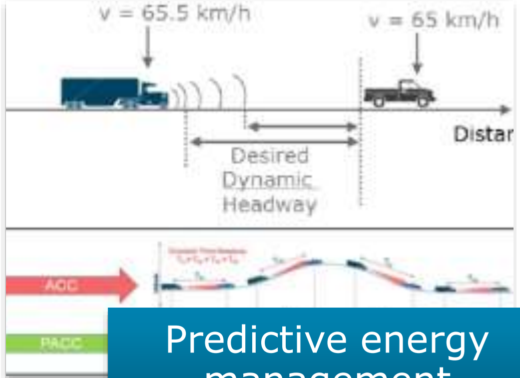
Cyber security

LKA/LDW

Platooning



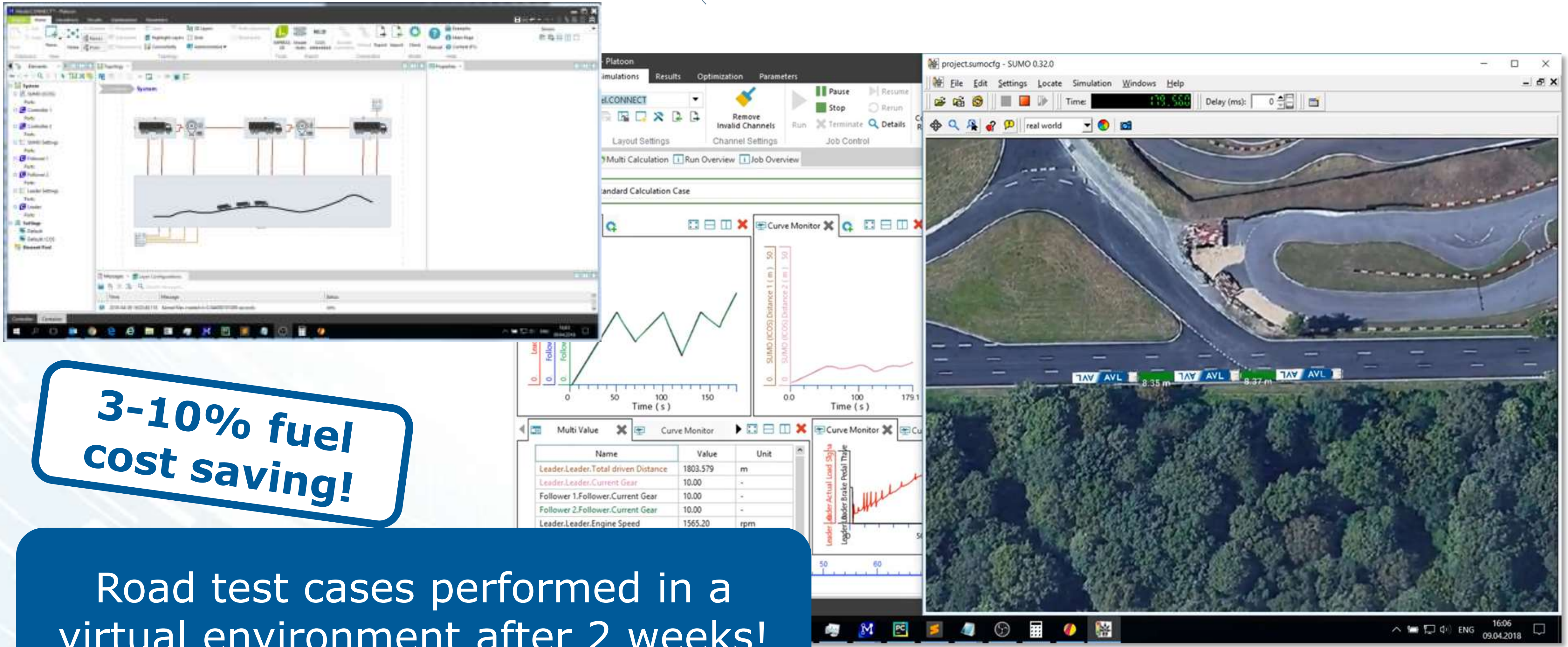
Highway pilot



Predictive energy management

Benchmarking

Project Reference (2018): Platooning



3-10% fuel cost saving!

Road test cases performed in a virtual environment after 2 weeks!