A Novel Testbench for Development, Calibration and Functional Testing of ADAS/AD Functions and Active Safety Systems

virtual vehicle

Enabling future vehicle technologies

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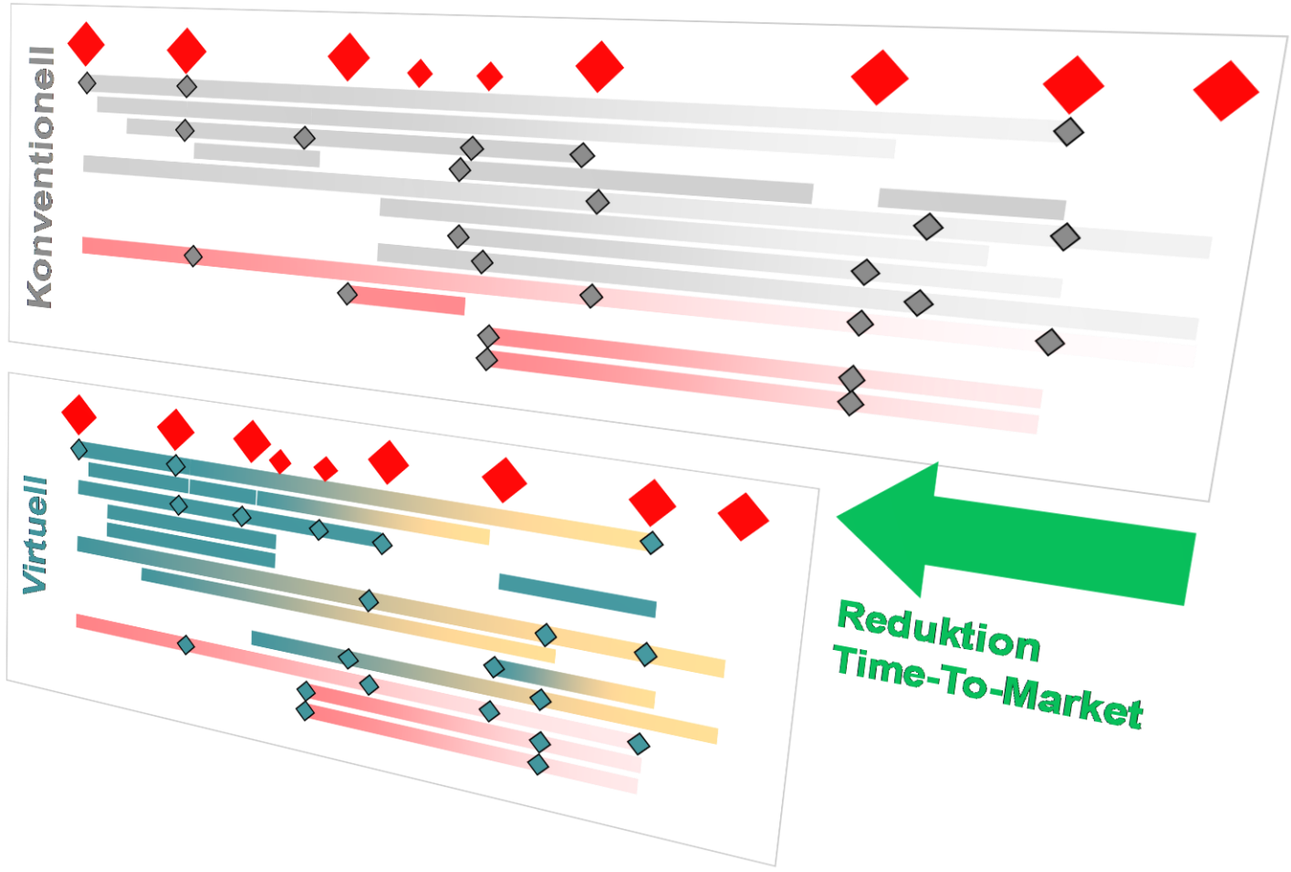
Presentation Outline

- Challenges in vehicle and ADAS/AD system development
- Autonomous/Automated Driving Trend
- ADAS System overview
- Efficient functional development of ADAS/AD systems
- ADAS/AD Demonstrator Vehicle
- A novel steerable rolling test bed (DÜRR X-Road Curve)
- ADAS function development and tuning case-study based on the DÜRR X-Road Curve
- Possible extensions and applications of the proposed solution

Challenges in Vehicle Development (1/3)

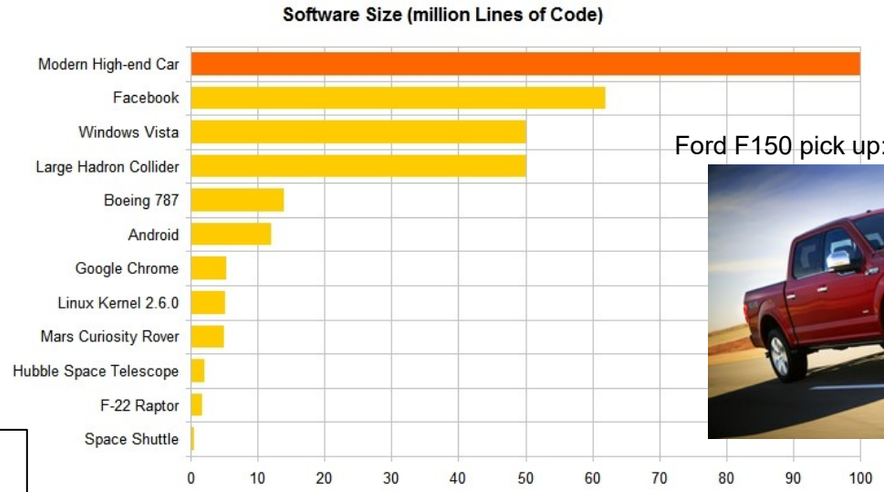
- Shorter development time (time- and cost pressure)



- ✓ Reduced number of hardware prototypes (i.e. virtualization)
- ✓ Dealing with software/hardware updates

Challenges in Vehicle Development (2/3)

- Shorter development time (time- and cost pressure)
- Strongly increasing complexity (derivates, functions, …)

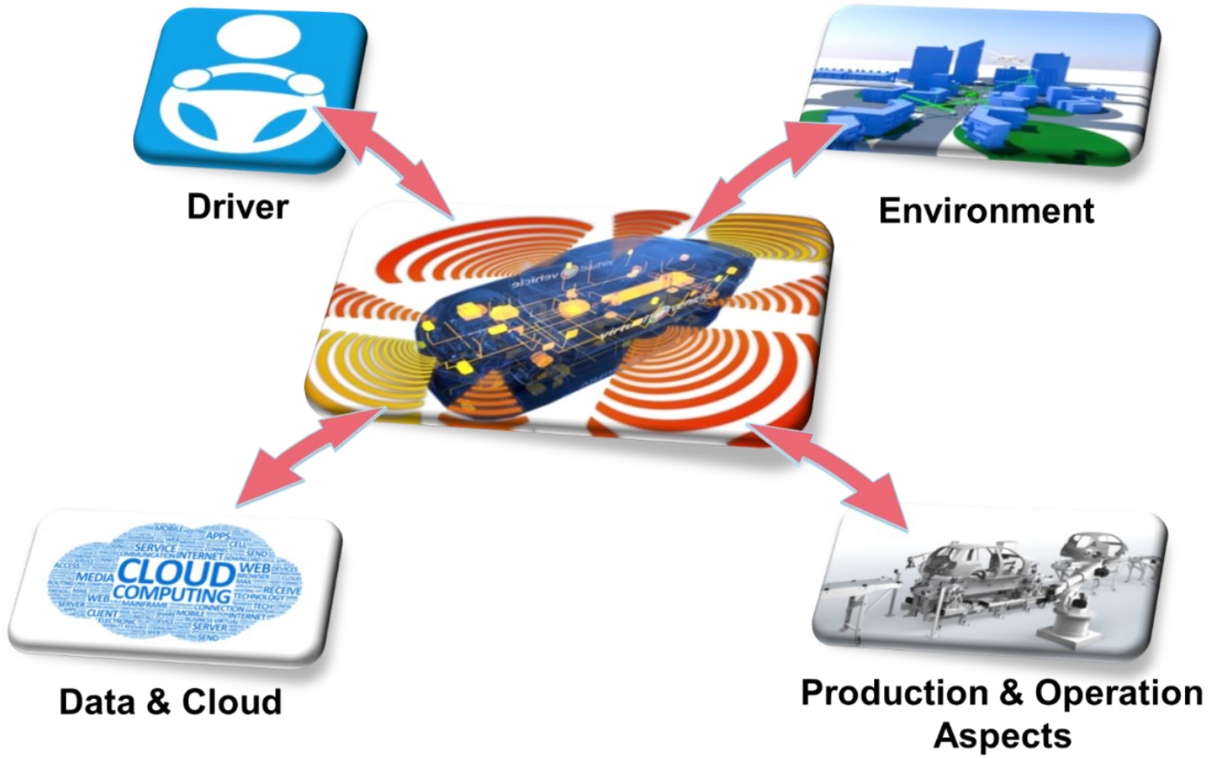


Ford F150 pick up: 150 mio. lines of code

- ✓ (Complex) technologies must work correctly, completely and consistently in any situation
- ✓ Approval of technologies critical (complete testing of systems?)

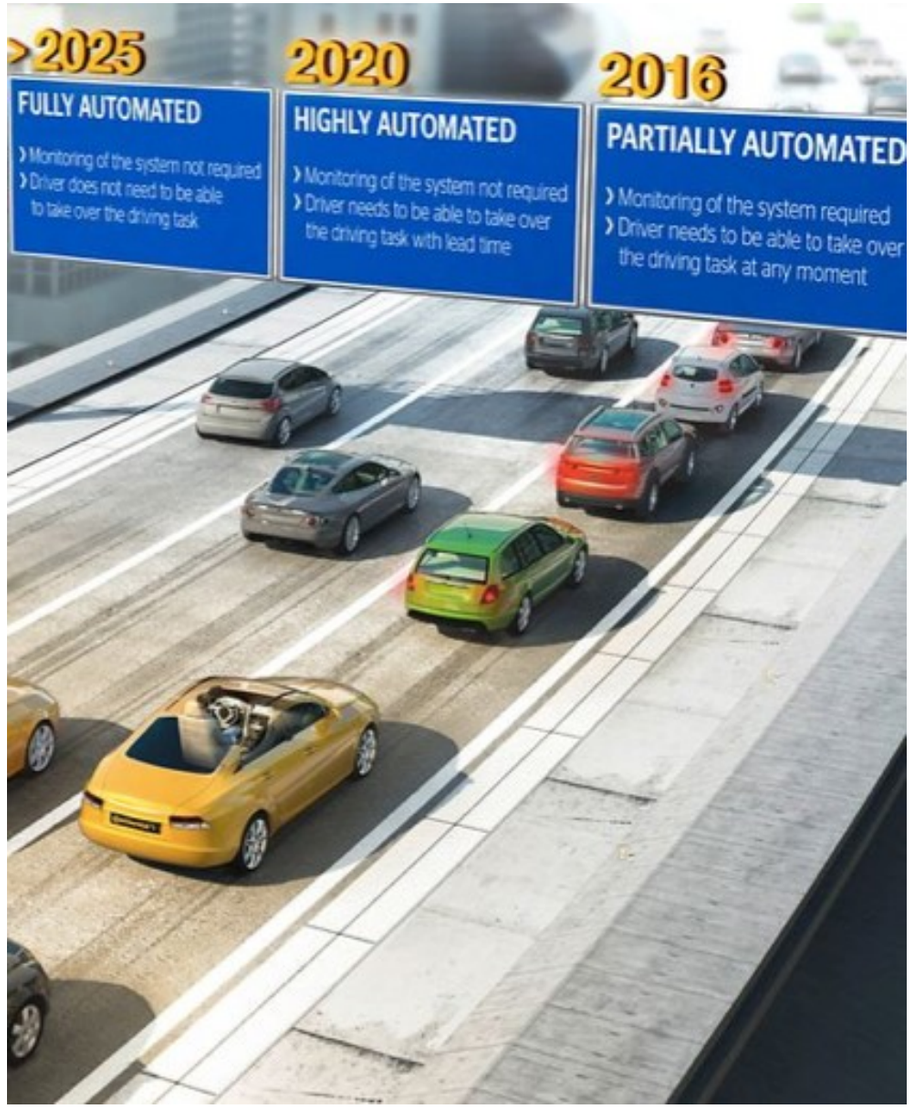
Challenges in Vehicle Development (3/3)

- Shorter development time (time- and cost pressure)
- Strongly increasing complexity (derivates, functions, …)
- Increasing “context”

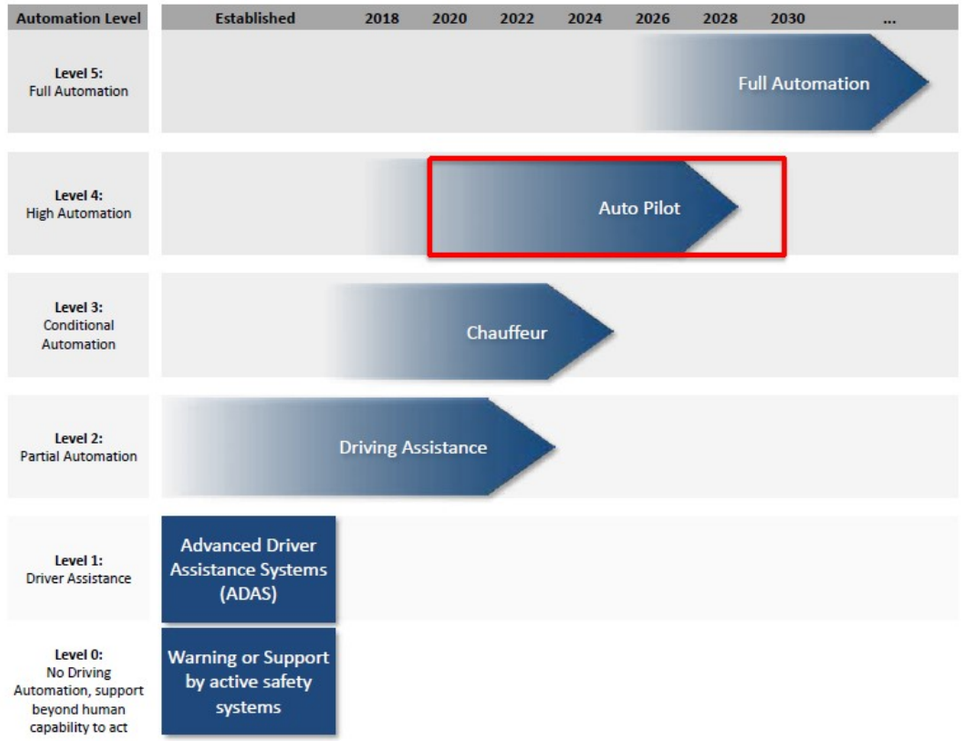


- ✓ Interaction with environment
- ✓ Multi-disciplinary development (mechanics, electronics, software engineering, chemistry, …)
- ✓ Consideration of „human factors“

Automated/Autonomous Driving Trends



- Automated driving will change mobility dramatically
- Virtual development will be relevant for „reasonable“ development time
- Virtualization in testing is expected to play a bigger role for approval and homologation



Levels of Automation (SAE Level 0-5)

Level 0: No Automation (warning of driver)
e.g. acoustic/haptic warning, display etc.

Level 1: Driver Assistance (e.g. break assistant etc.)
driver assistance system of "either steering or acceleration/deceleration"

Level 2: Partial Automation
Combined driver assistance system (e.g., Adaptive Cruise Control (ACC), Lane Keeping Assistant (LKA), or traffic jam assistant: road measurement and/or distance measurement)

Level 3: Conditional Automation
Relevant driving tasks by system, driver ready to take over

Level 4: High Automation
All driving tasks by system, limited roadway and environmental conditions (e.g. highway)

Level 5: Full Automation
All driving tasks in all situations by system ("no steering wheel/pedals"): autonomous driving

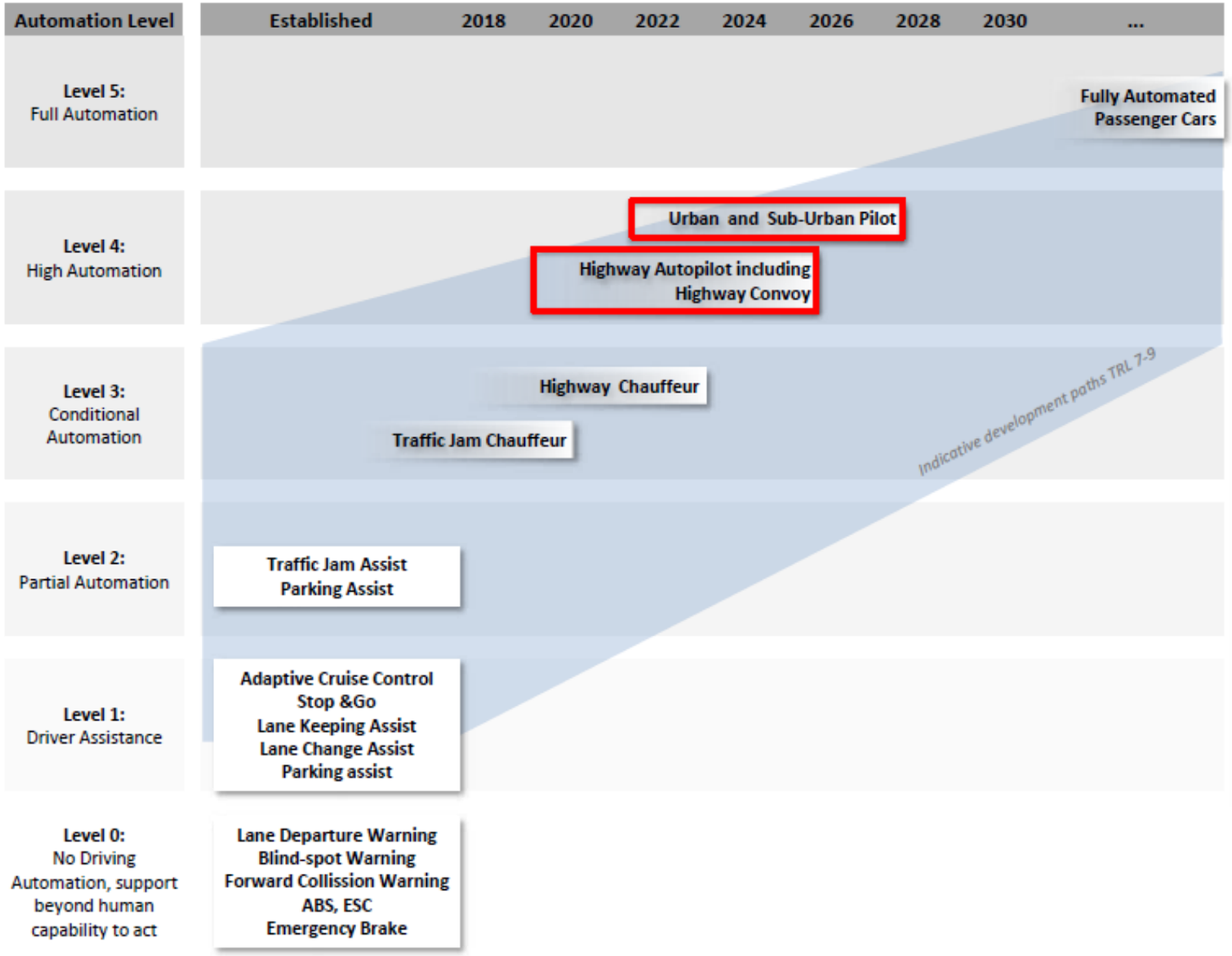
Monitoring: human driver

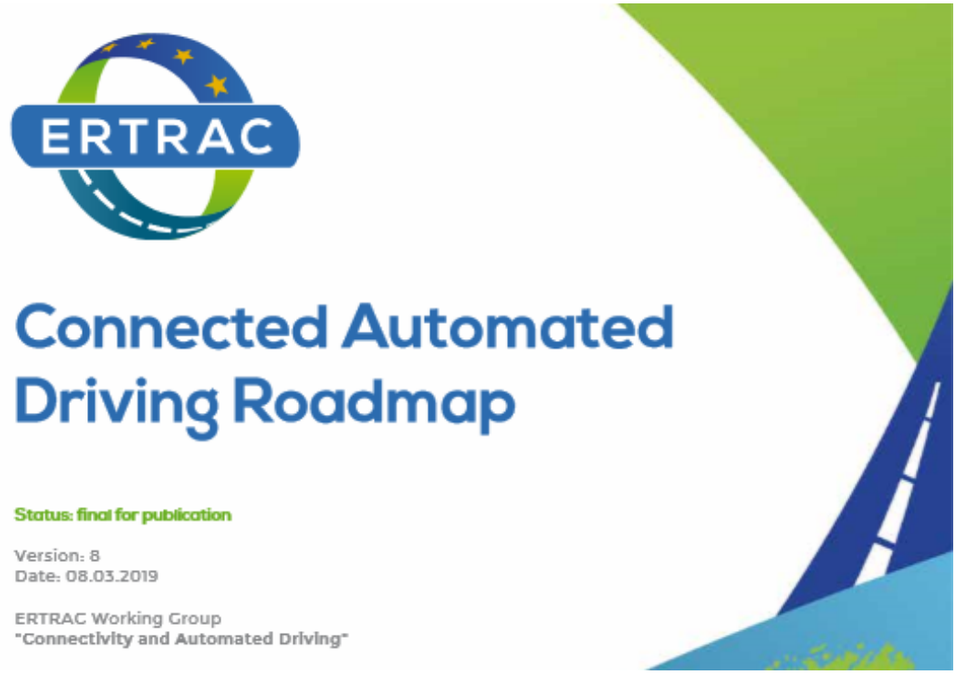
Monitoring: system

Quelle: AVL

Wording:
Automated driving ≠ Autonomous driving
Levels of automation 0 to 5

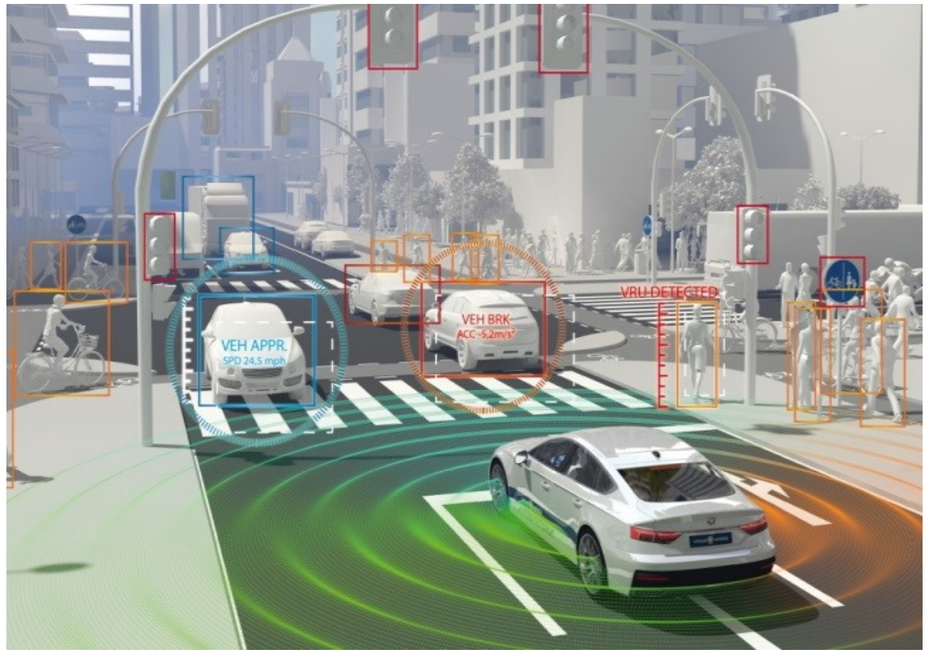
Automated/Autonomous Driving Roadmap



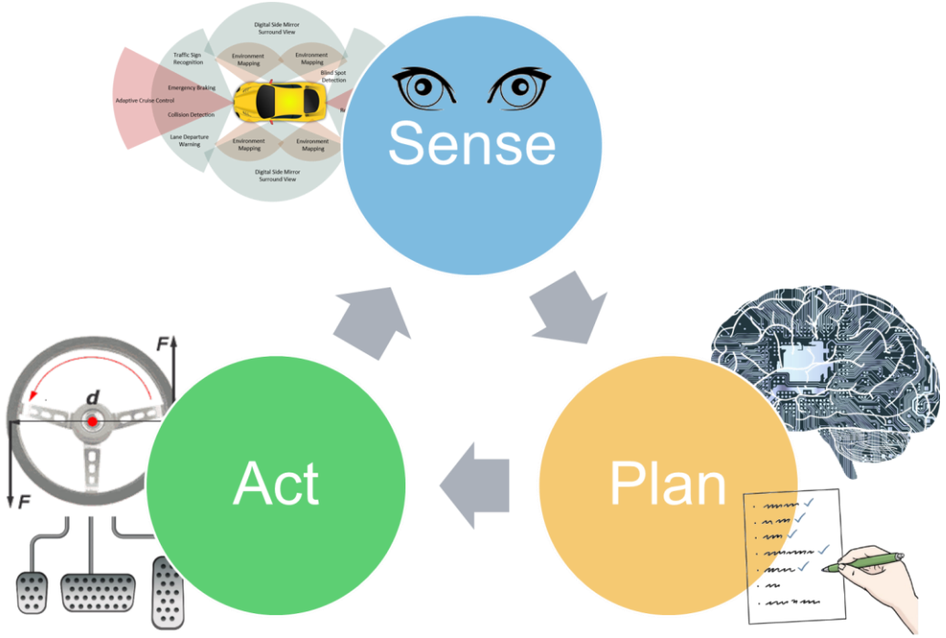


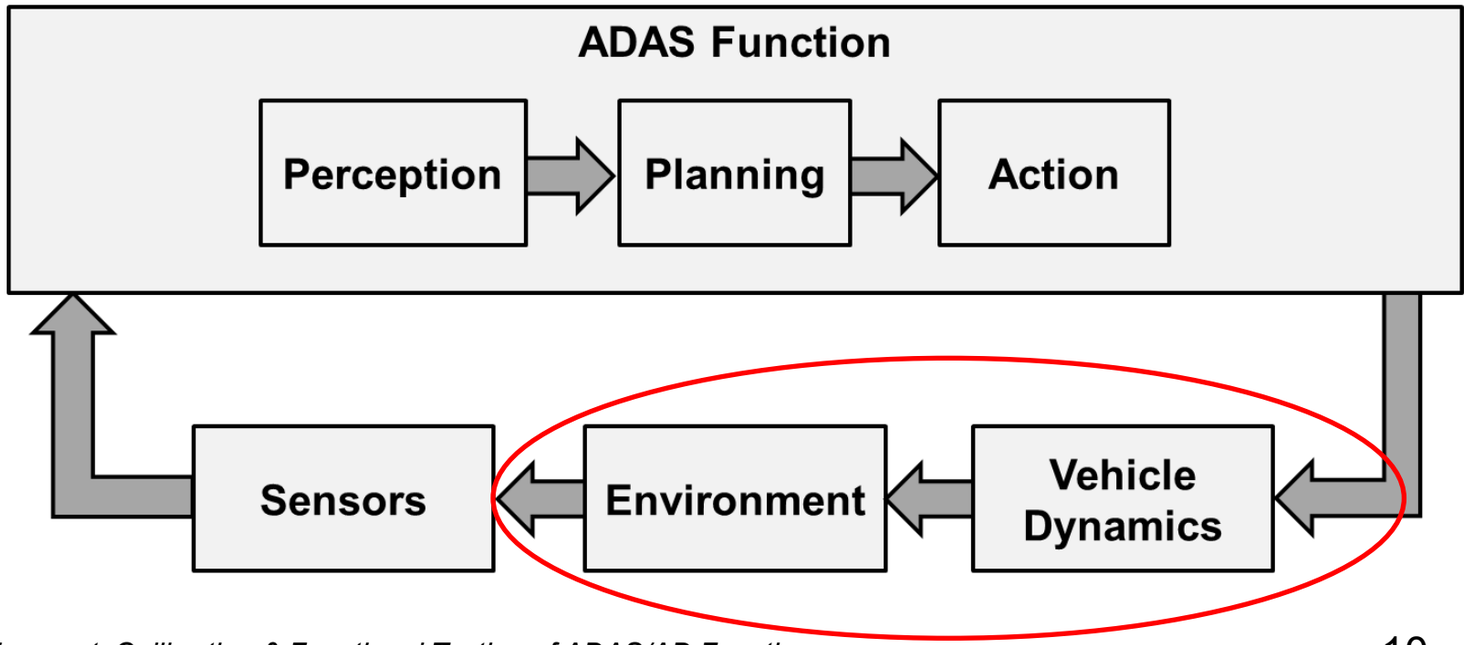
Automated Driving Research Challenges

- Embedded control and software functions (functional safety)
- Real-time sensor fusion
- Sensor self-diagnostics and fail-operational architectures
- Dependable computing and reliable vehicle control (strong multi-core expertise in both SW and HW)
- Traffic simulation (micro, macro) / infrastructure integration
- AI in both function development and vehicle operation
- Validation based on real driving scenarios (e.g. real-time co-simulation)

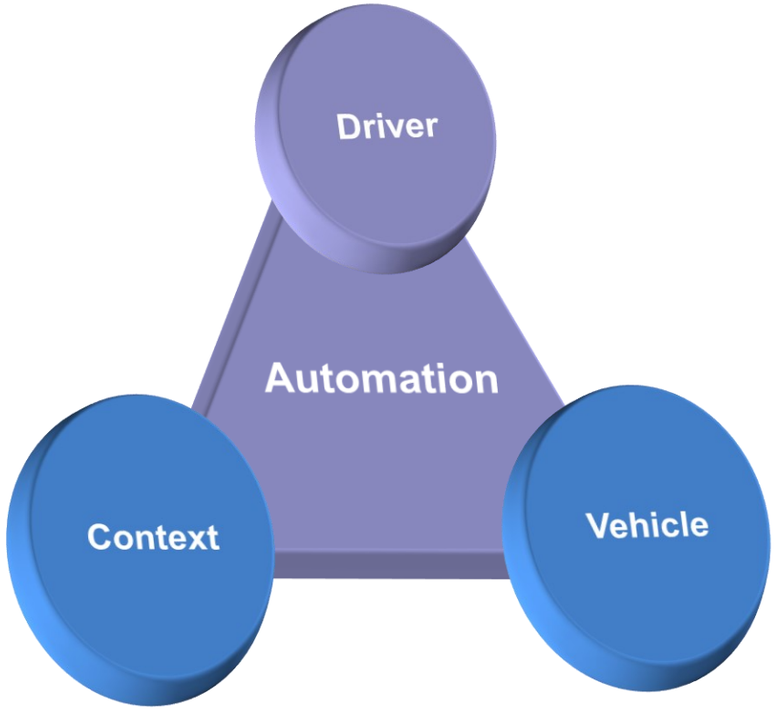


ADAS/AD Simulation Infrastructure





Automated Driving System View



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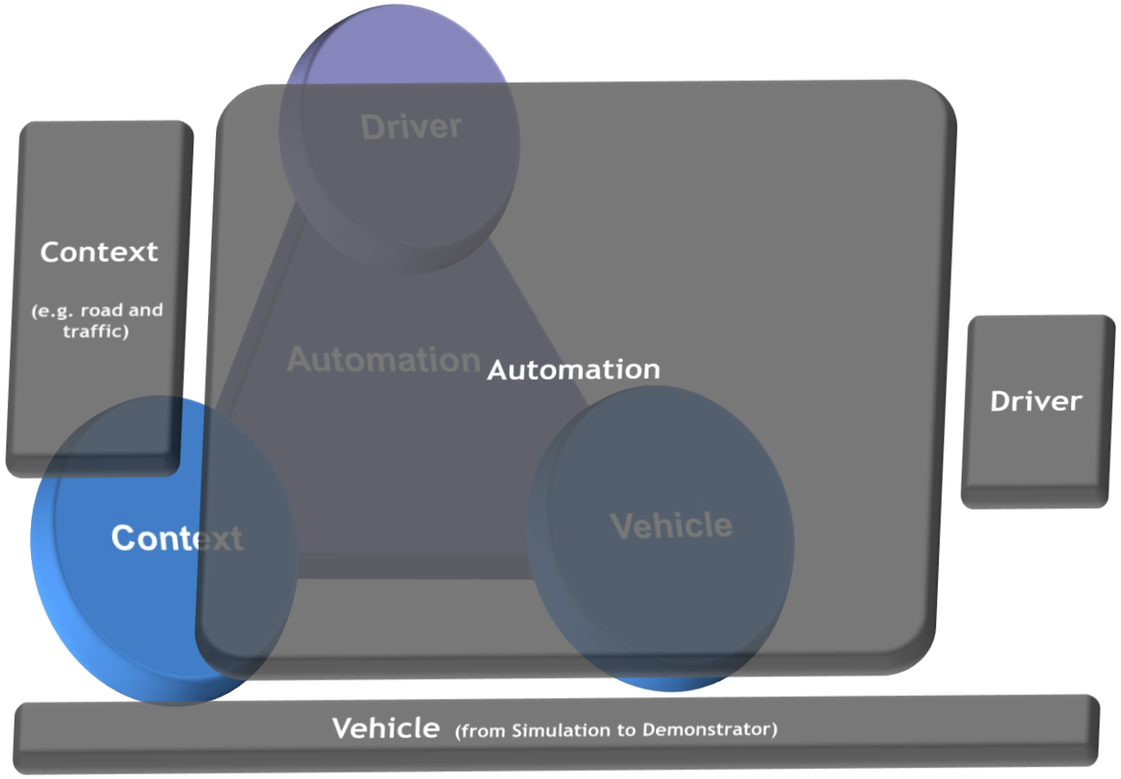
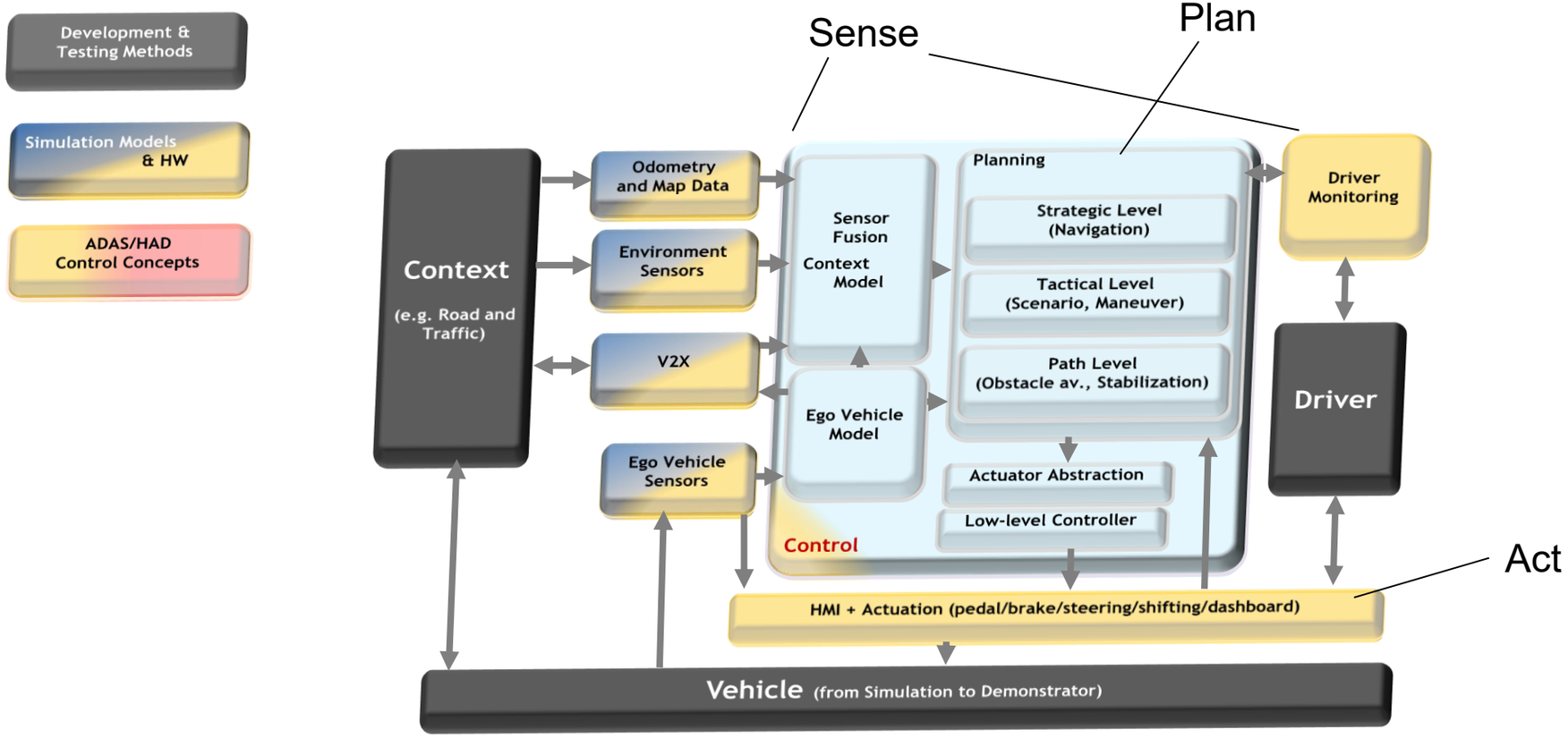


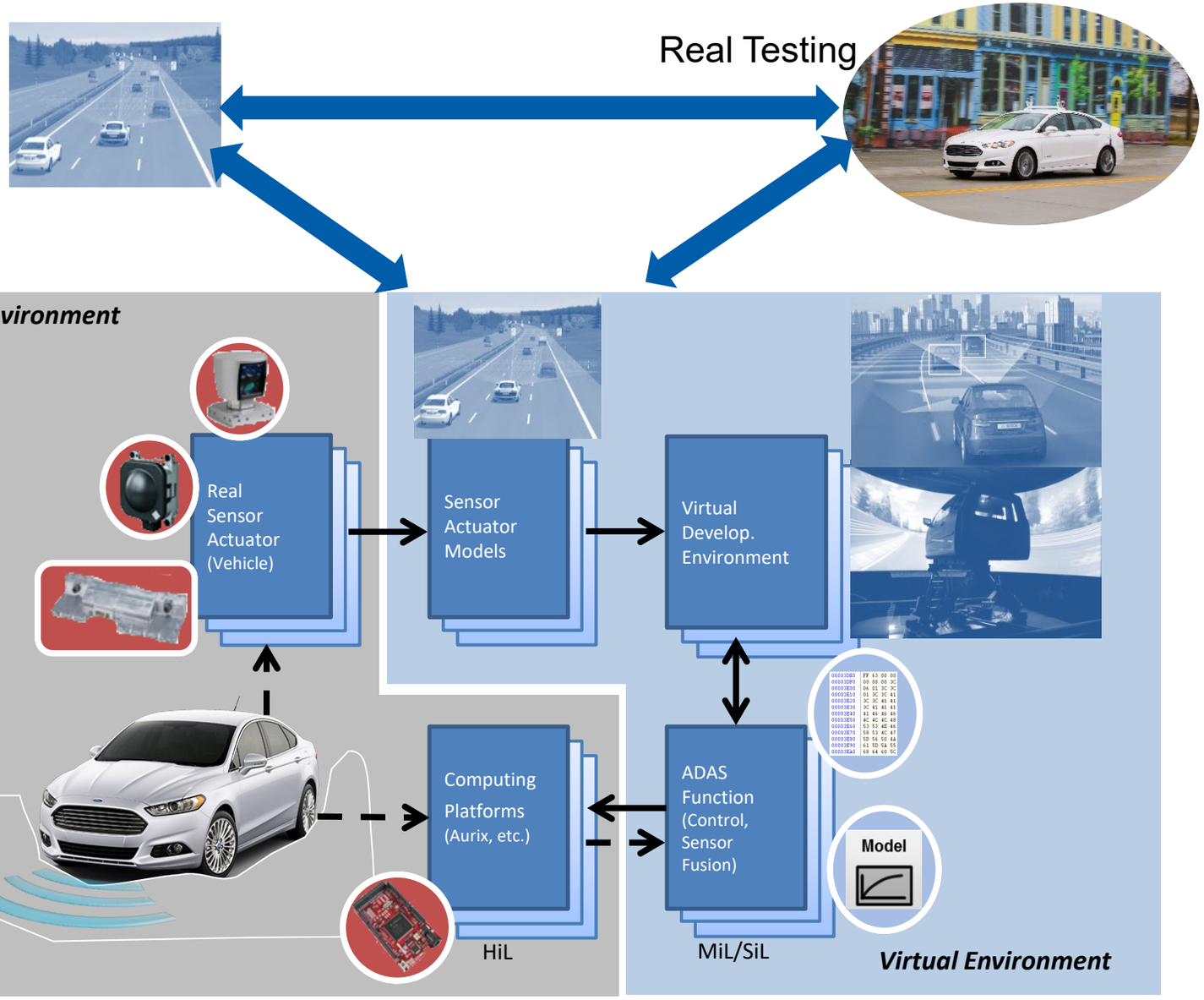
Automated Driving System View



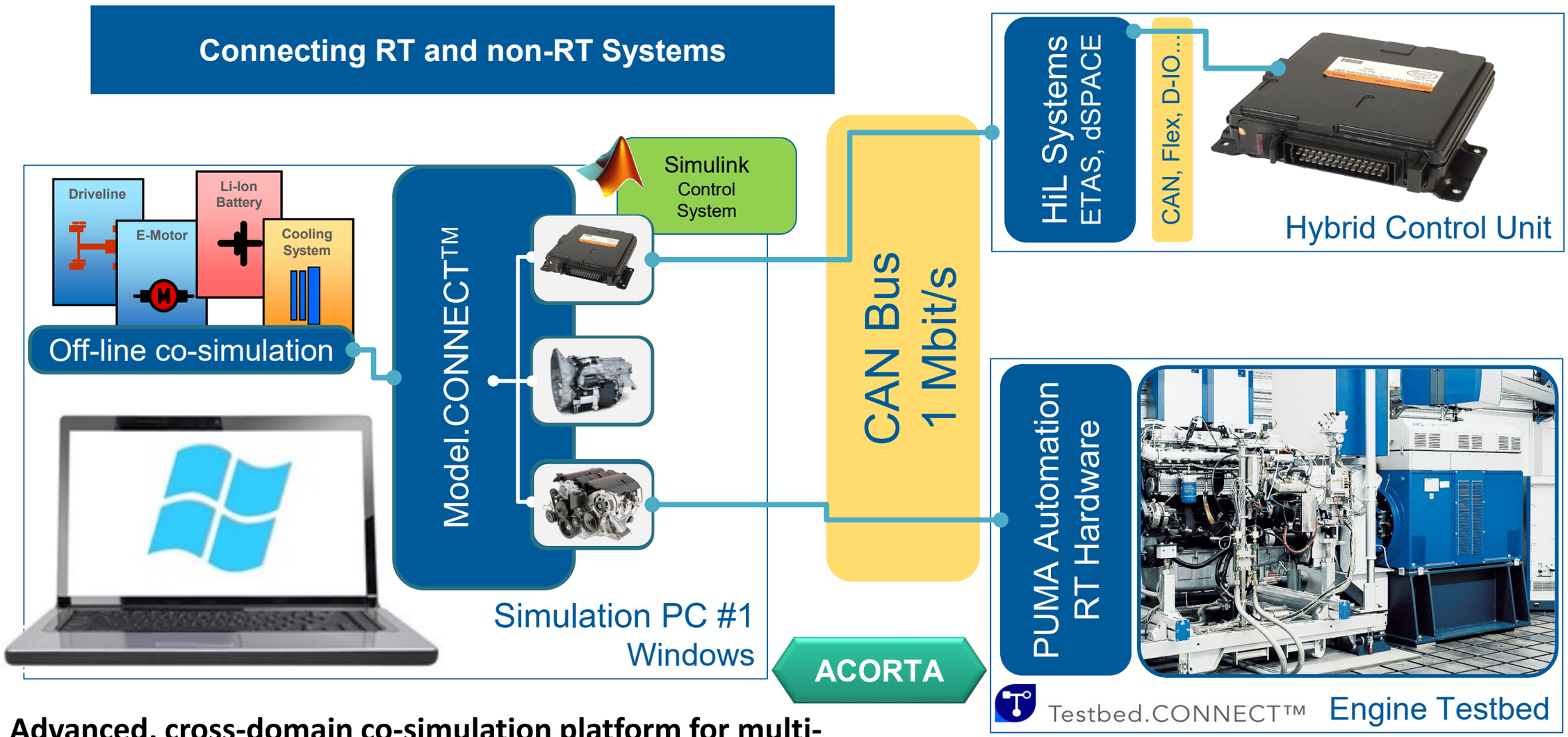
Novel Testing Approaches

Conventional Methods

Novel Concepts



Connecting RT and non-RT Systems



Advanced, cross-domain co-simulation platform for multi-disciplinary engineering

ViF-Automated Drive (AD) Demonstrator

- ***Drive by wire:***

  DataSpeed ADAS Kit:
  drive, brake, steer, visualize by wire

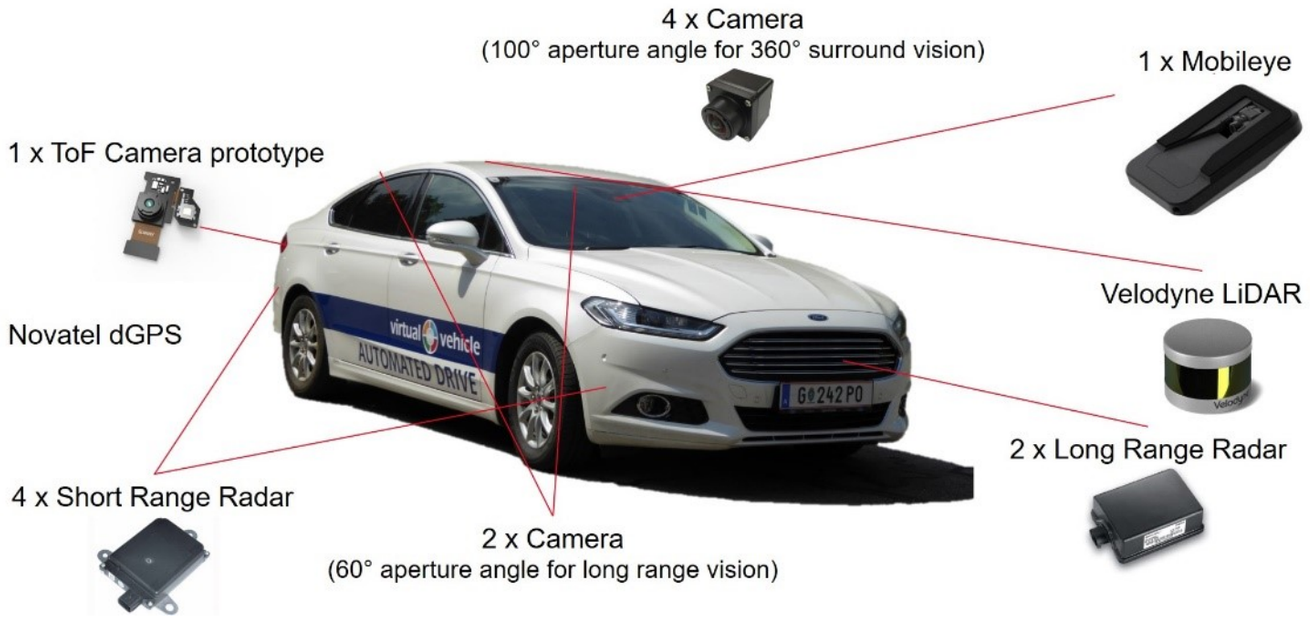
- ***Sensors:***

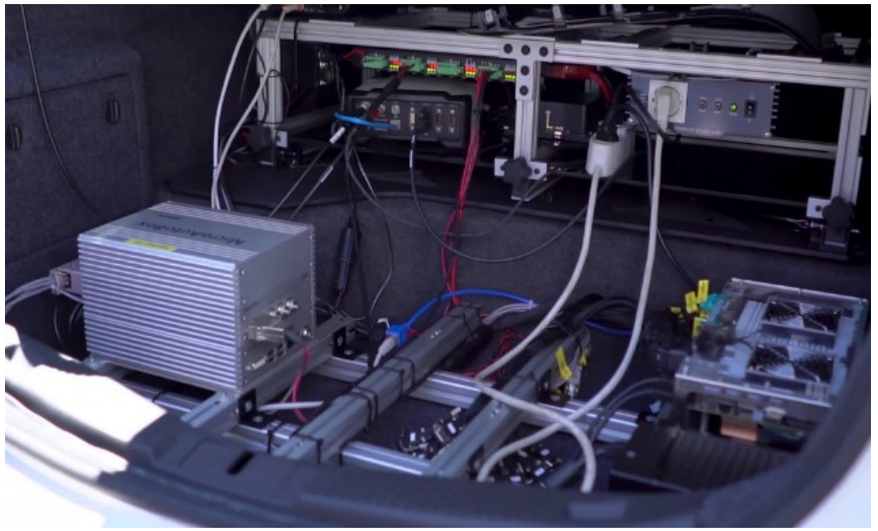
  Cameras, ultrasonic sensors, inertial sensors, RTK-GPS, Radars, Lidar(s), ToF…

- ***Interfaces:***

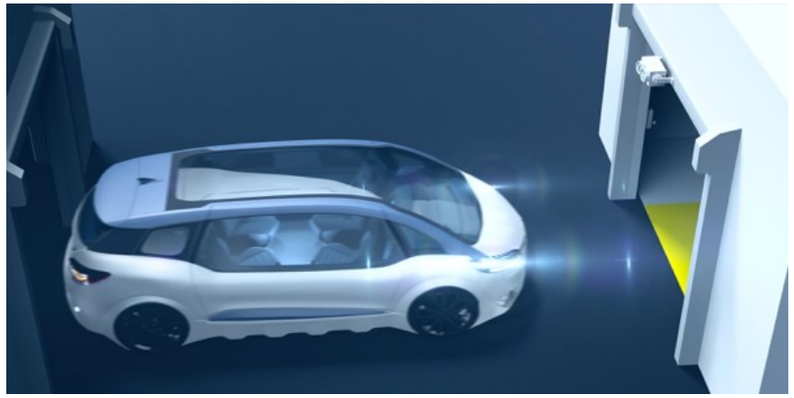
  HMI touch display, CAN,
  ROS (Robot operating System) Kinetic
  Nvidia Drive PX/2 (Ubuntu 16.04)
  dSPACE MicroAutoBoX II
  PC (Win/Linux)

- ***Applications:***
  - ❑ *Measurement (sensor data acquisition, sensor fusion)*
  - ❑ *Development and test (ADAS/AD)*
  - ❑ *Energy management (hybrid car)*
  - ❑ *Proving ground platform*





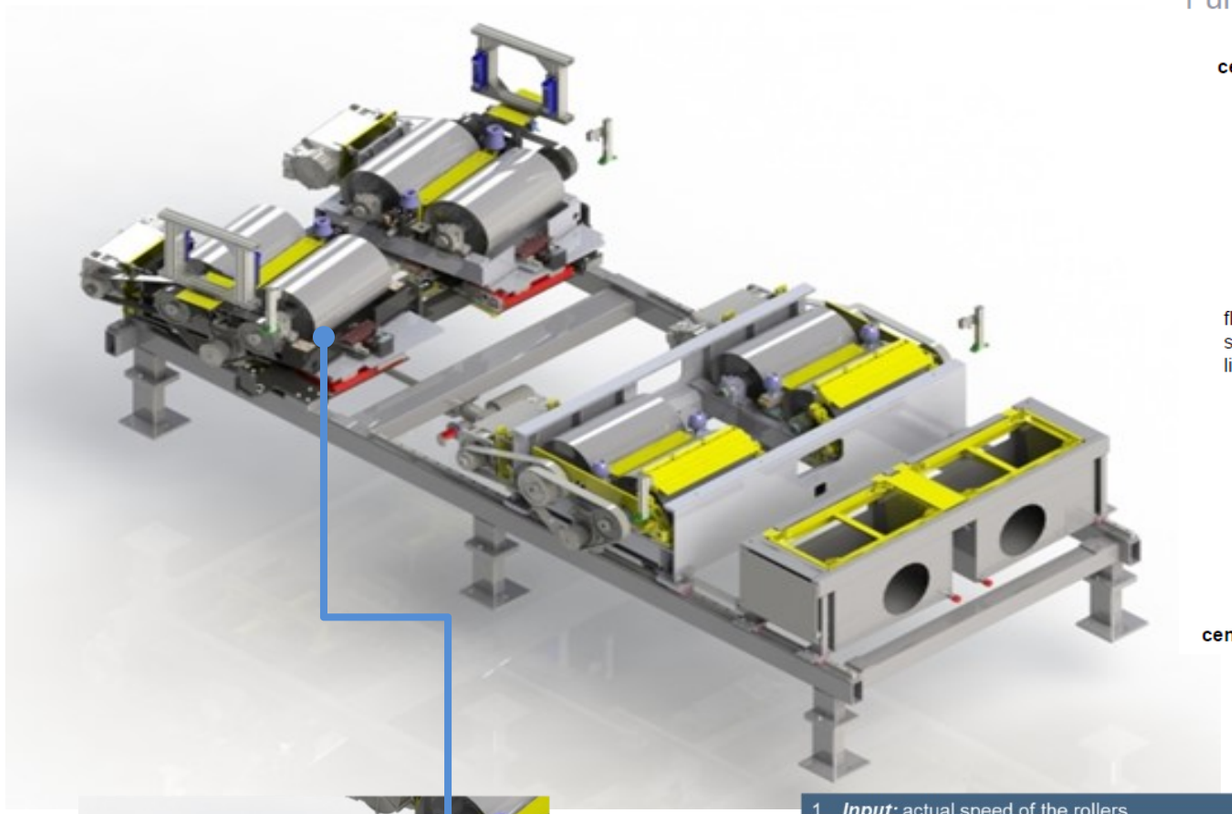
A novel steerable rolling test bed (DÜRR X-Road-Curve)

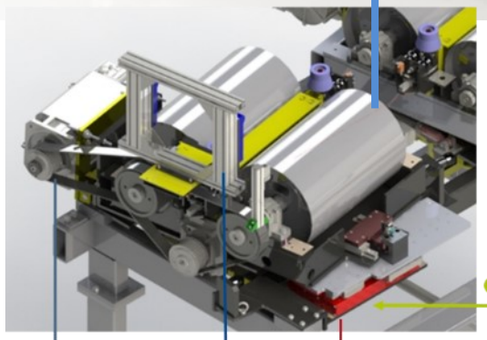


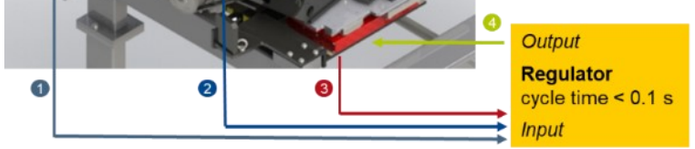
Technische Daten x-road curve	
Prüfgeschwindigkeit	130 km/h mit Lenkmöglichkeit 170 km/h ohne Lenkmöglichkeit
Max. Lenkeinschlag	+/- 10° an der Vorderachse
Typische Motorzugkraft	3700 N / 6000 N abhängig von der Antriebstechnik

- Evolution from End-of-Line rolling test bench systems (i.e., chassis dynamometers)
- X-road curve, is a rolling test bench where the vehicle is able to be kept fully automatically in the middle of the test bench and test without a driver, and to carry out tests with steering functions
- In addition to the classical tests of a chassis dynamometer with roll/brake and ABS testing, dynamic functional tests for autonomous vehicles, such as driving behavior in typical traffic situations, can also be carried out

A novel steerable rolling test bed (DÜRR X-Road-Curve)







1 ***Input:*** actual speed of the rollers

motor performance roller drive: 41 kW in case of S1 operation

2 ***Input:*** actual position & angle from tyre to rollers

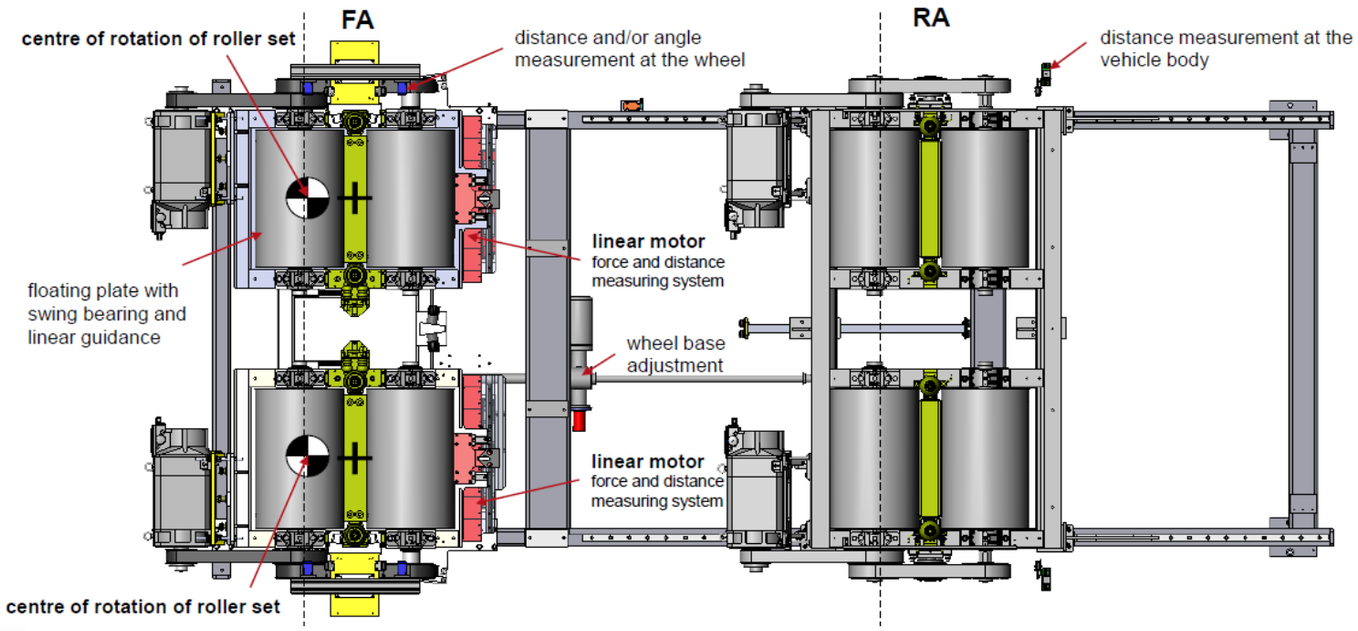
measurement system line laser:
accuracy < 0.1 mm, measuring frequency: ~ 170 Hz

3 ***Input:*** actual position of the linear motors (angle of the rollers)

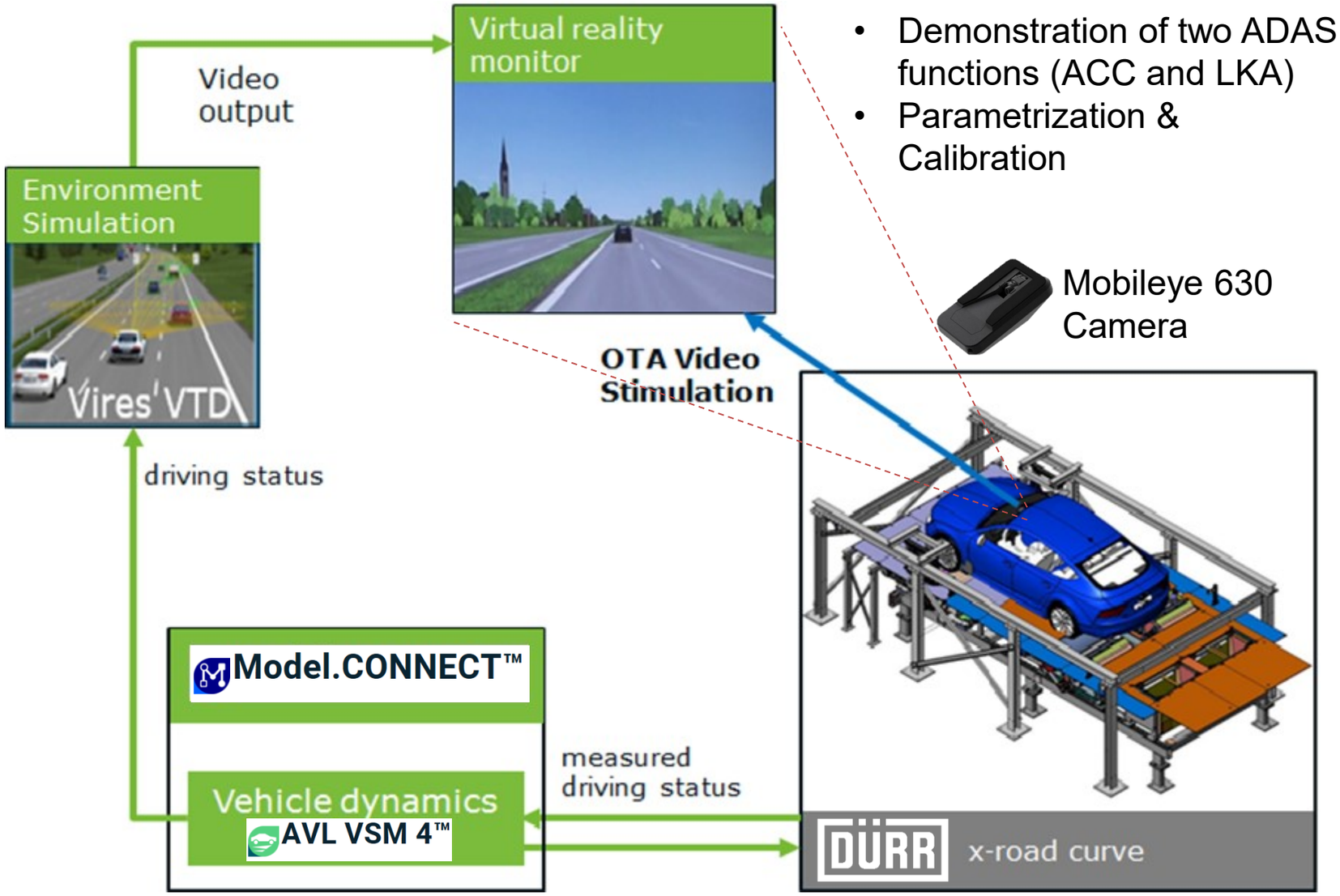
linear motor:
max. force: 4500 N
max. speed: 1m/s
max. stroke: ± 200 mm
→ max. steering angle: ±10°

4 ***Output:*** nominal position of the linear motors

Function and control principle



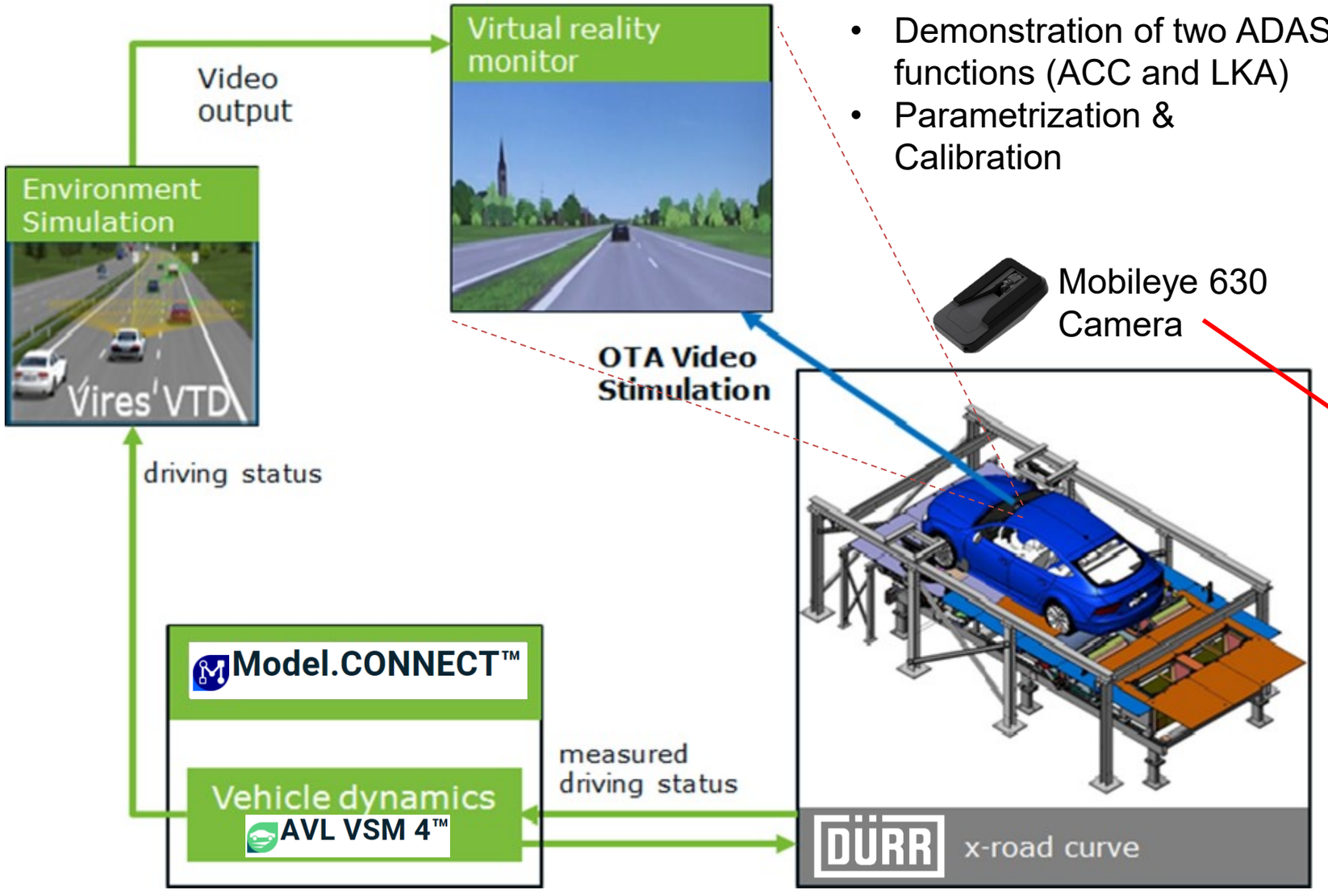
Demo Use Case: ADAS function Calibration



- Demonstration of two ADAS functions (ACC and LKA)
- Parametrization & Calibration

Mobileye 630 Camera

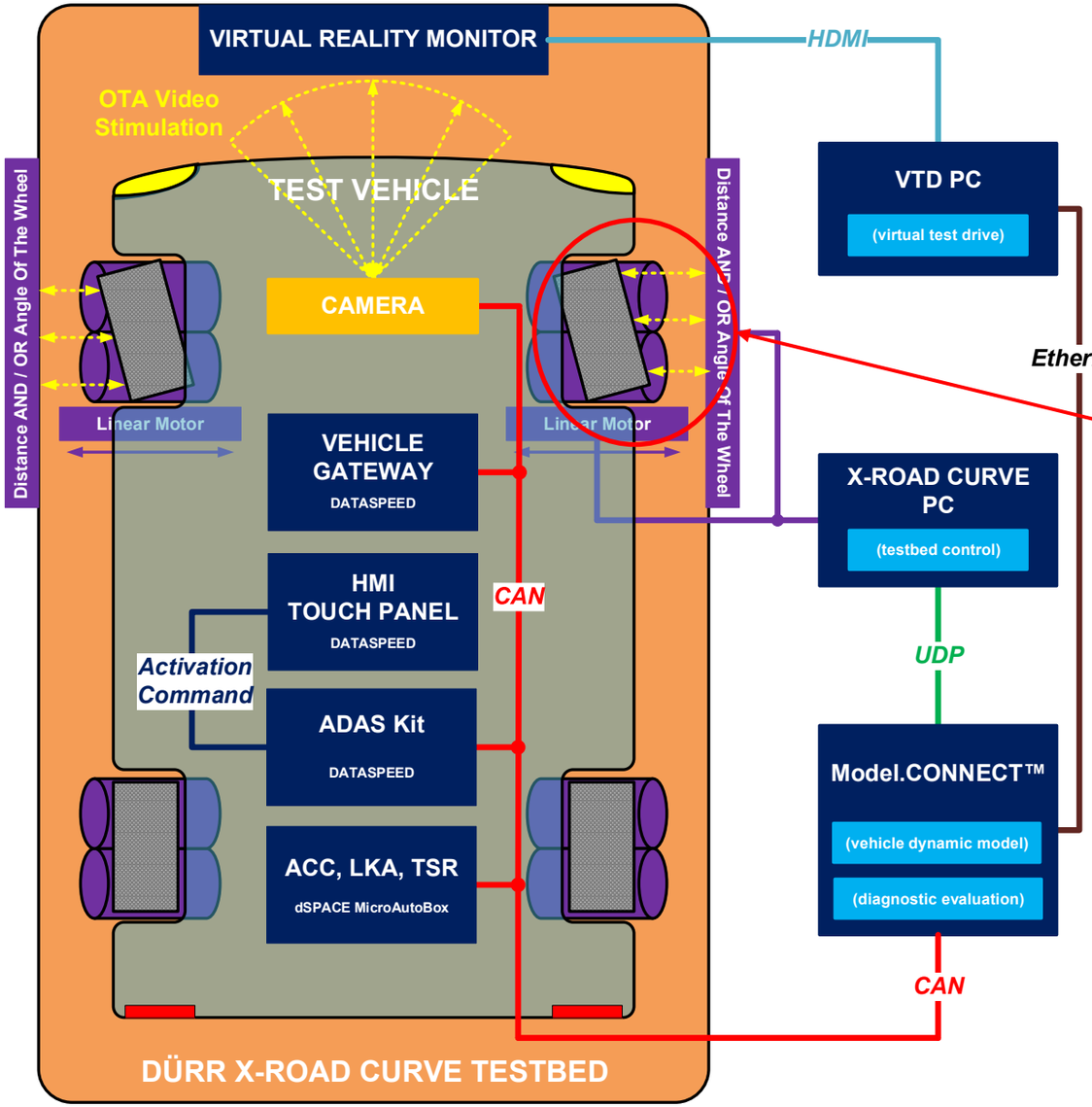
Demo Use Case: ADAS function Calibration

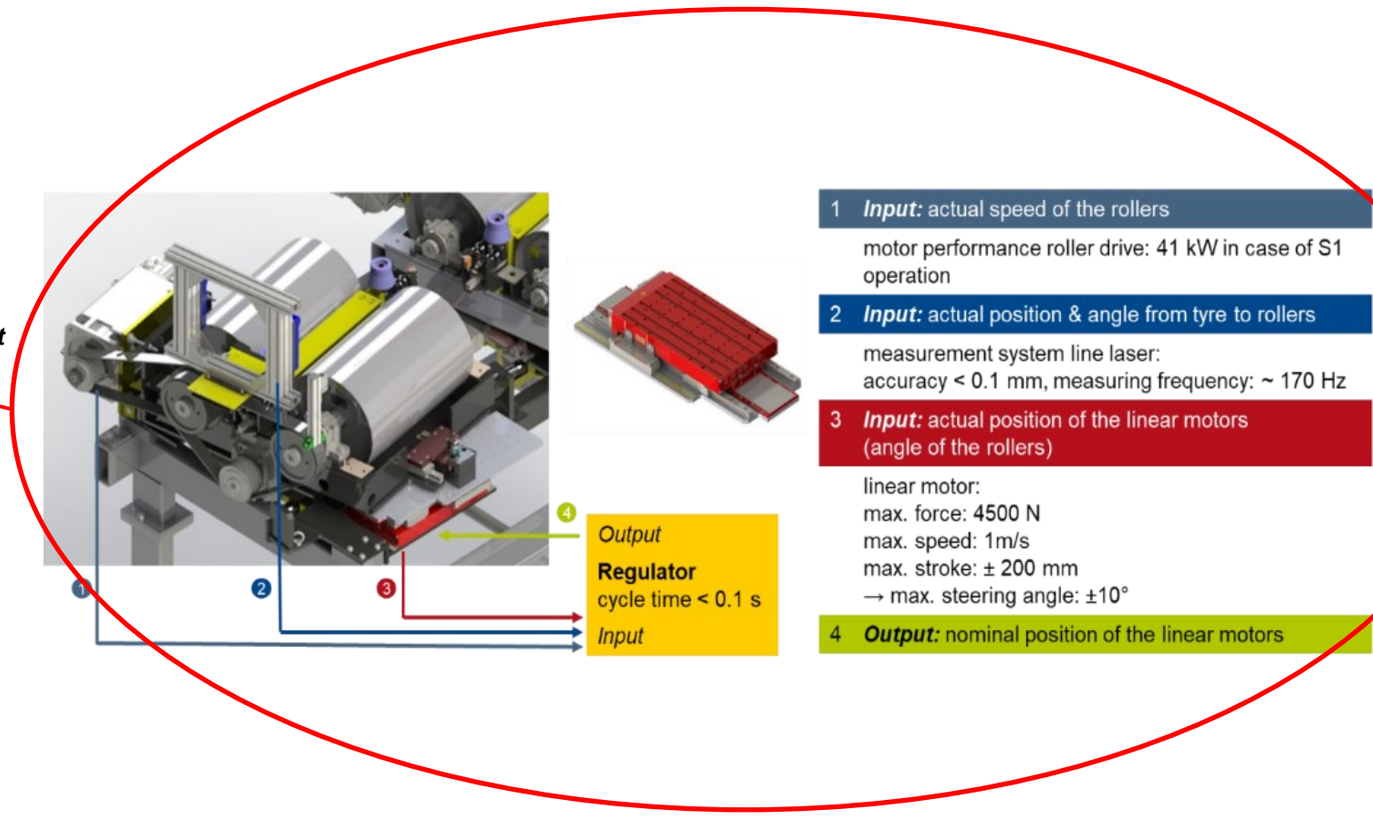


- Demonstration of two ADAS functions (ACC and LKA)
- Parametrization & Calibration

Mobileye 630 Camera

Demo Use Case: System Setup





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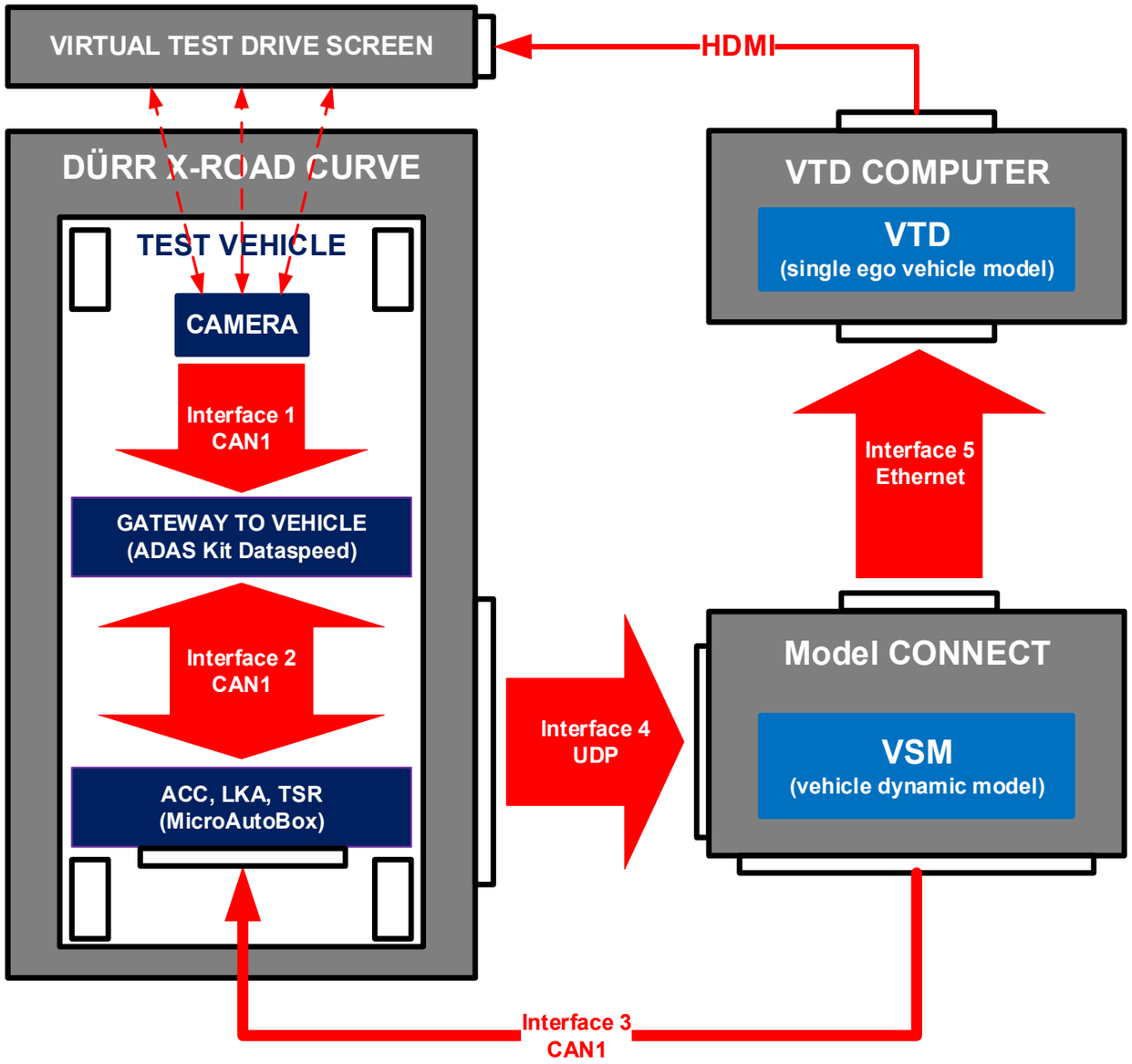
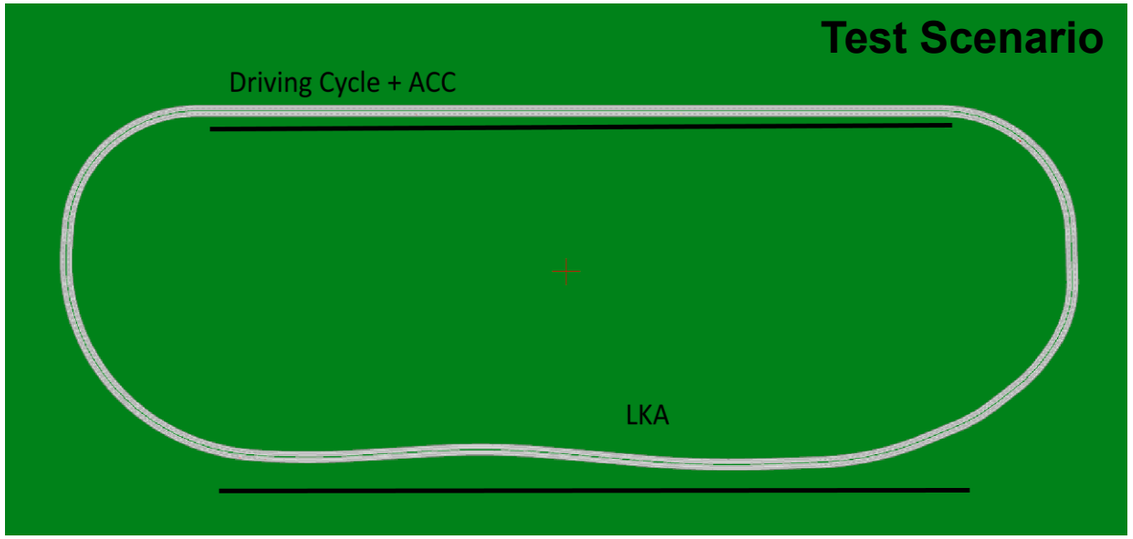
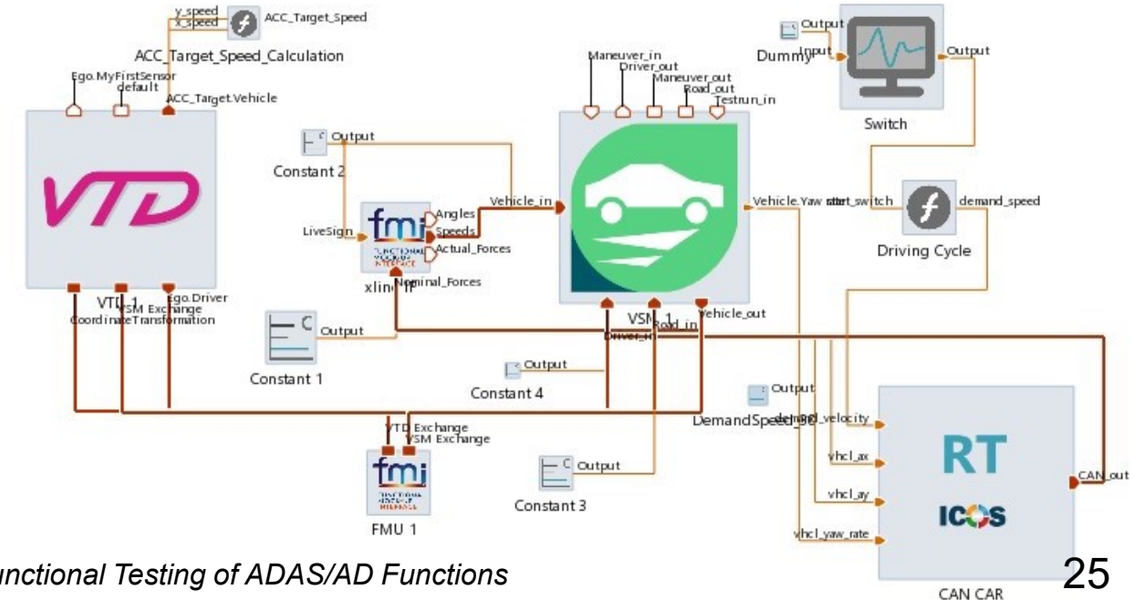


Preparation of circuit course in VTD



Model.CONNECT Topology



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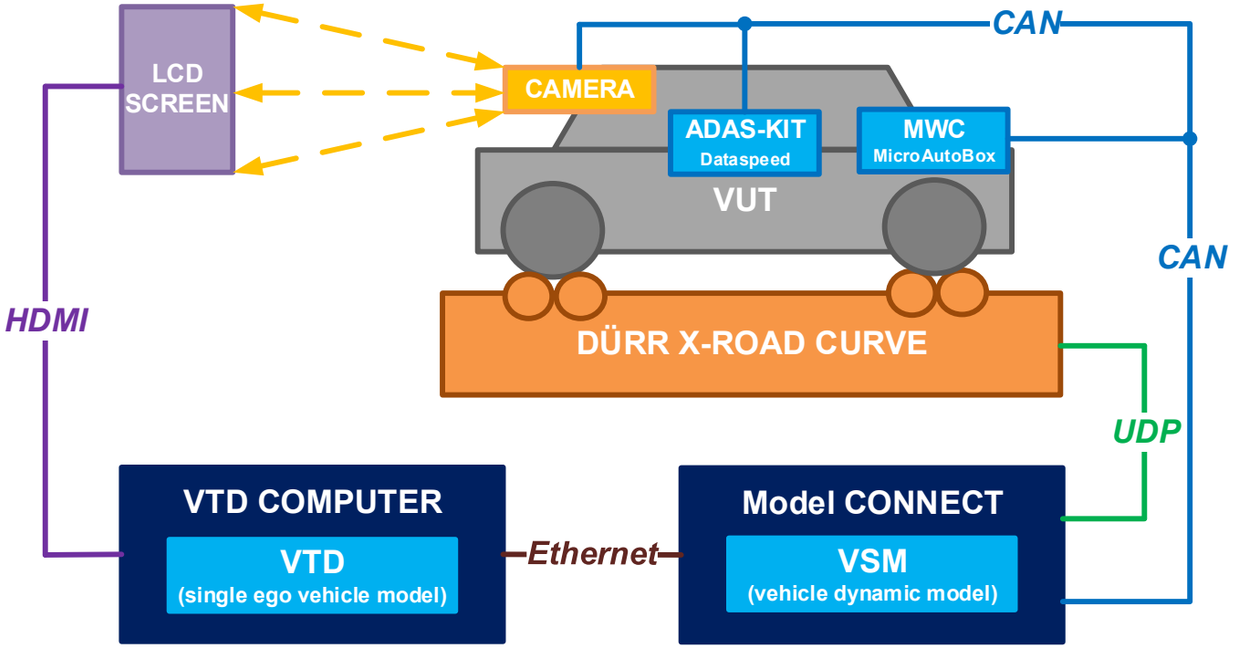
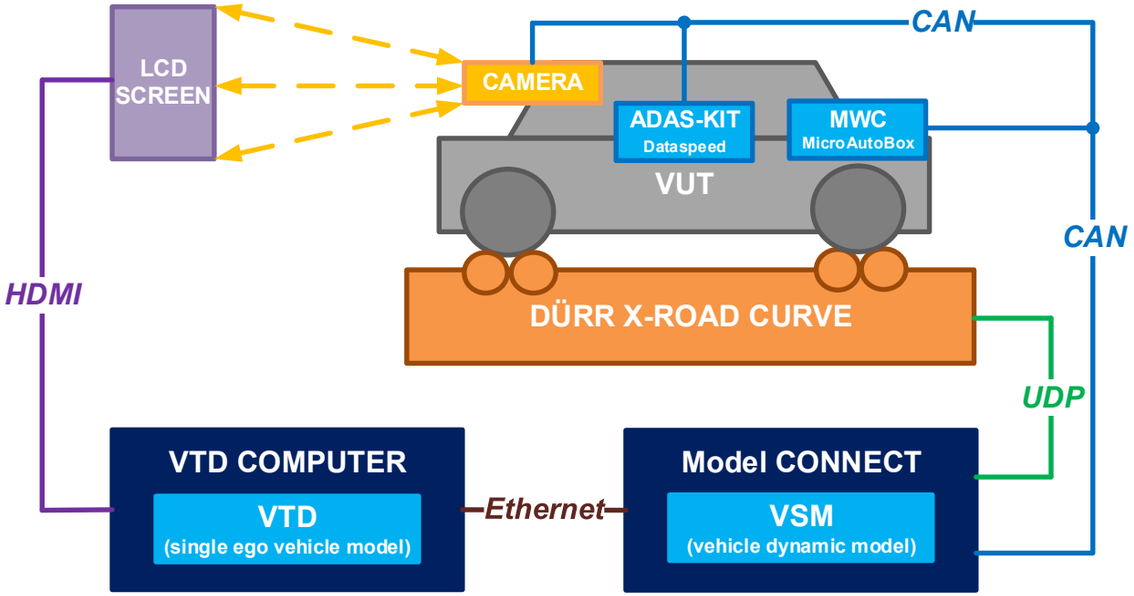
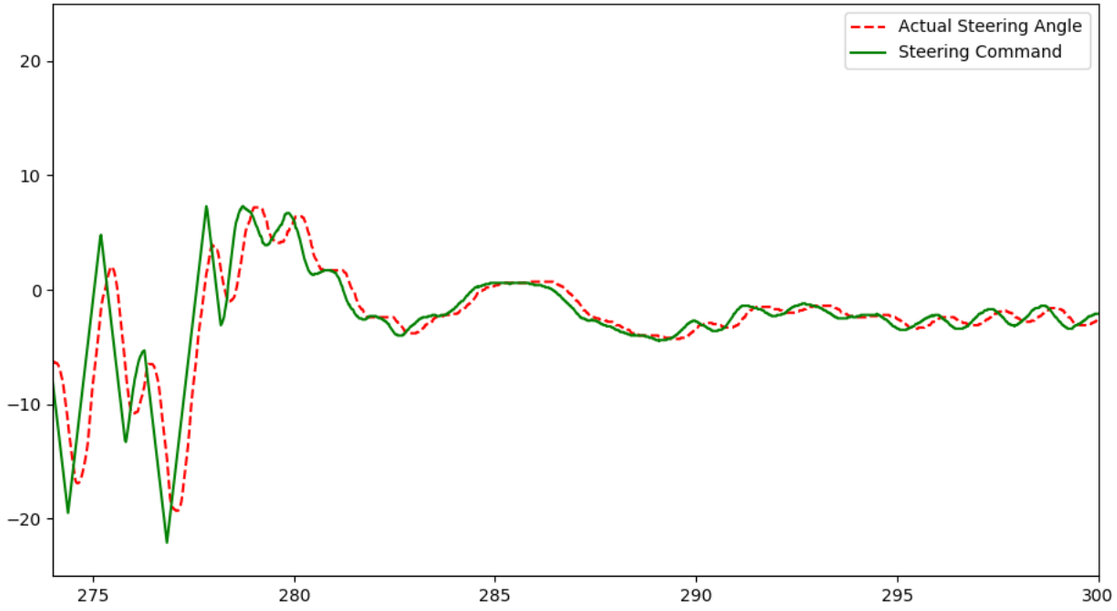


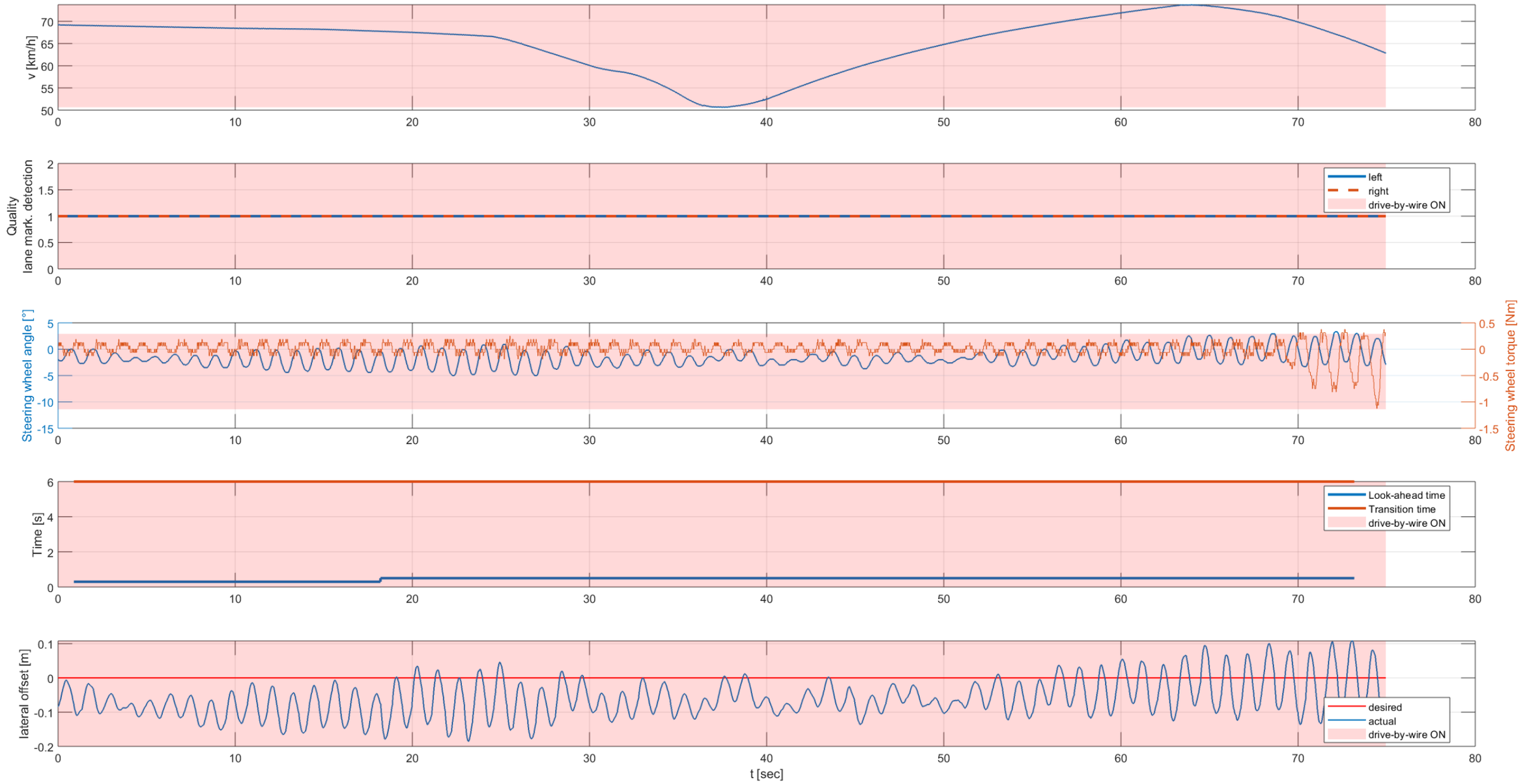
ADAS function Calibration & Observations

- Mobileye camera – TV Screen distance calibration based on the perceived and simulated distance is required
- Limitations of software and hardware
- Wheel angle maximum 10° due to testbed constraints
- Speed limitation for driving (~80 km/h) due to multiple feedback loops introduced by the testbed and the Model.CONNECT/VSM interfaces
- Partner interests initially on EOL use case





ADAS function Test Data



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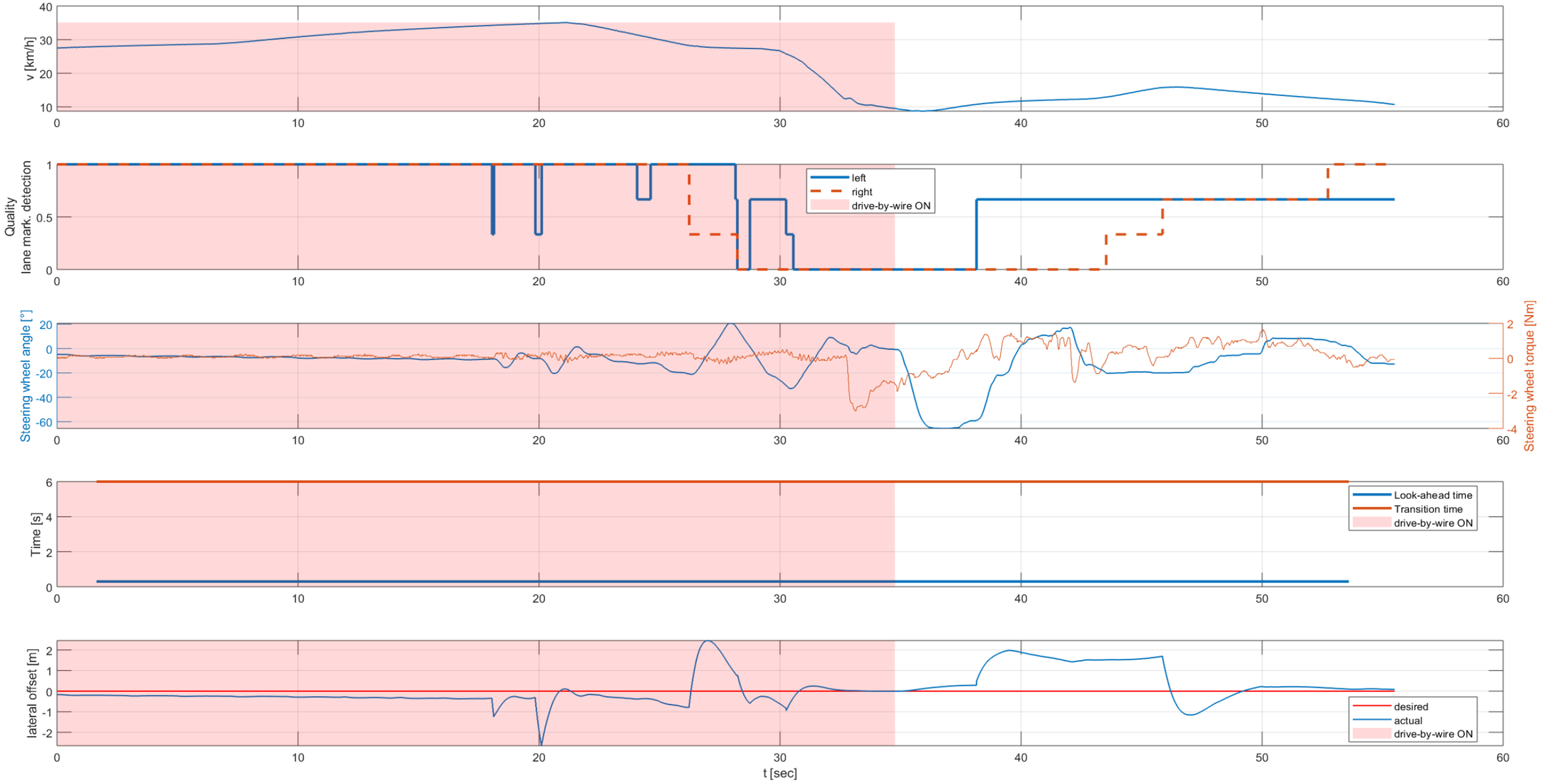
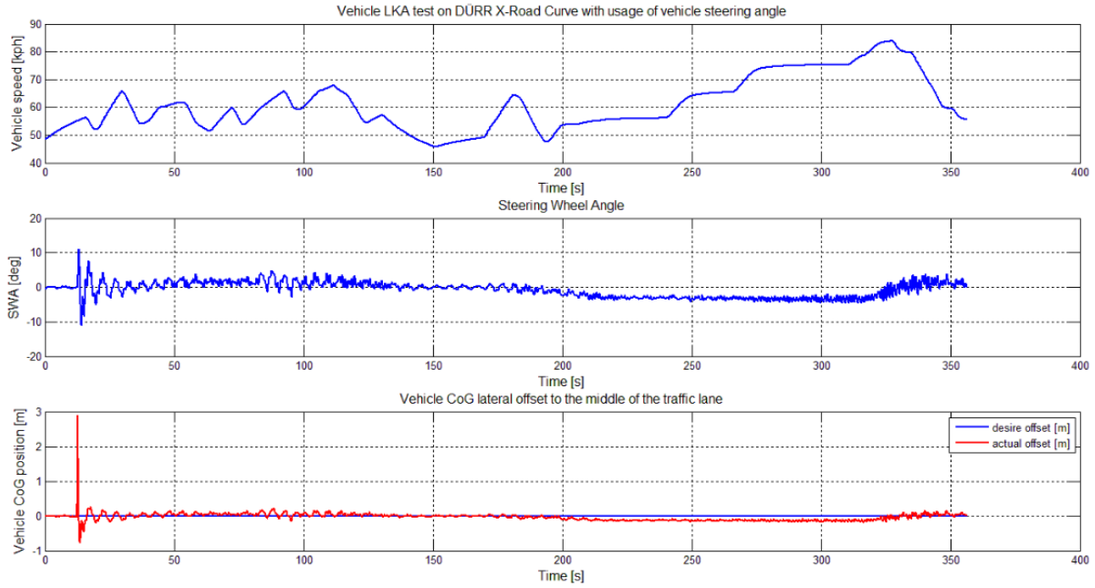
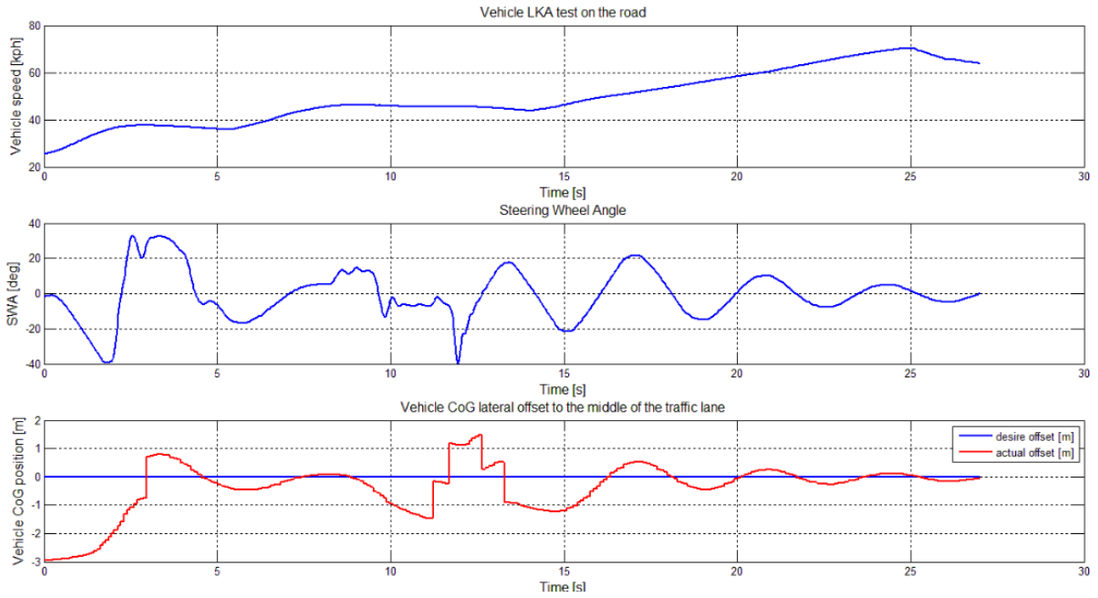


ADAS function Test Data



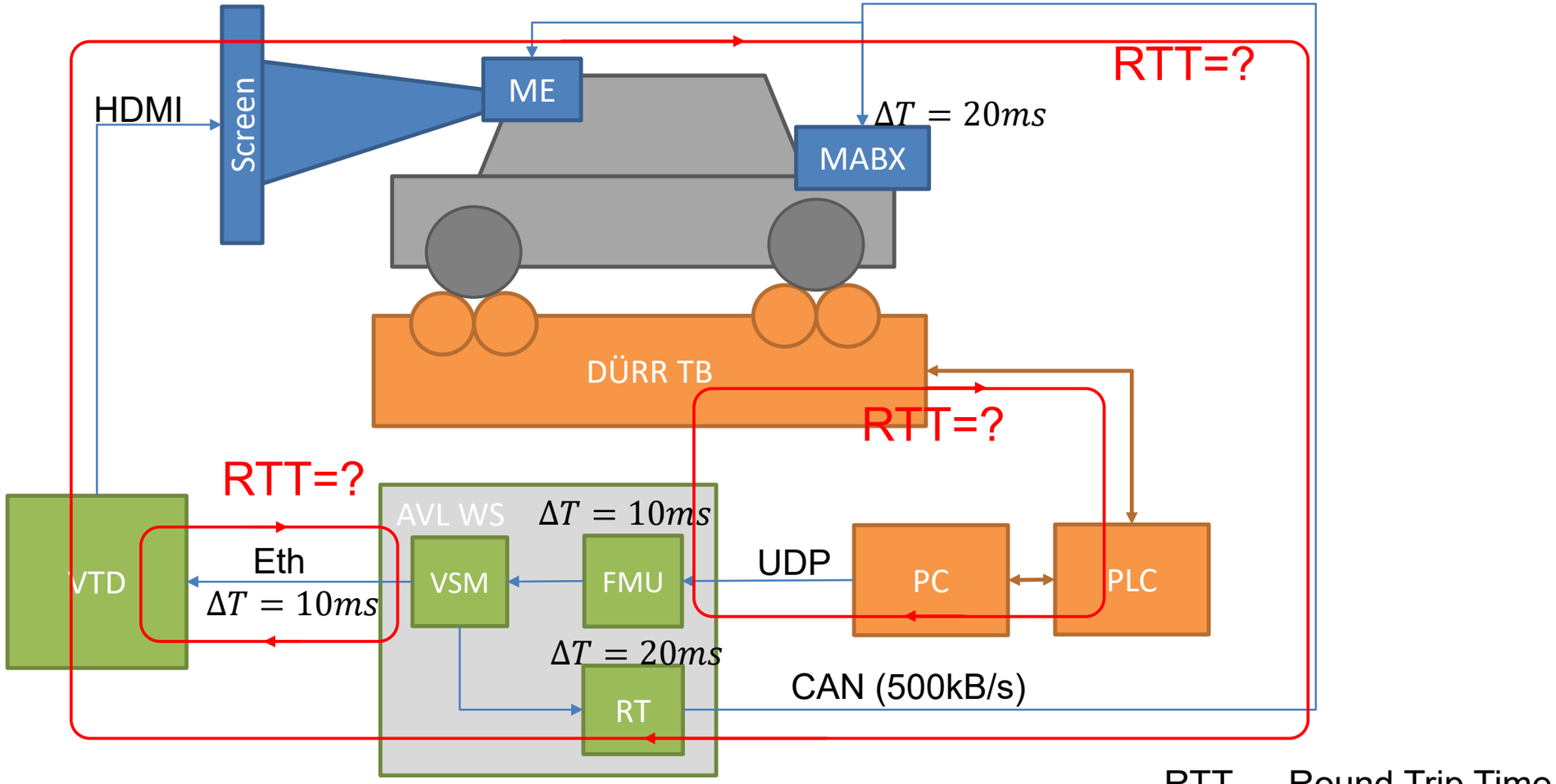


- Tuned parameters for ACC and LKA functions
- Controller gains with varying use case scenarios
- Time-gap desired
- Look ahead distance
- Controller update rates
- Communication and sensor delays

- Control performance evaluations
- Testing of data that is normally not possible or very costly in real-life testing

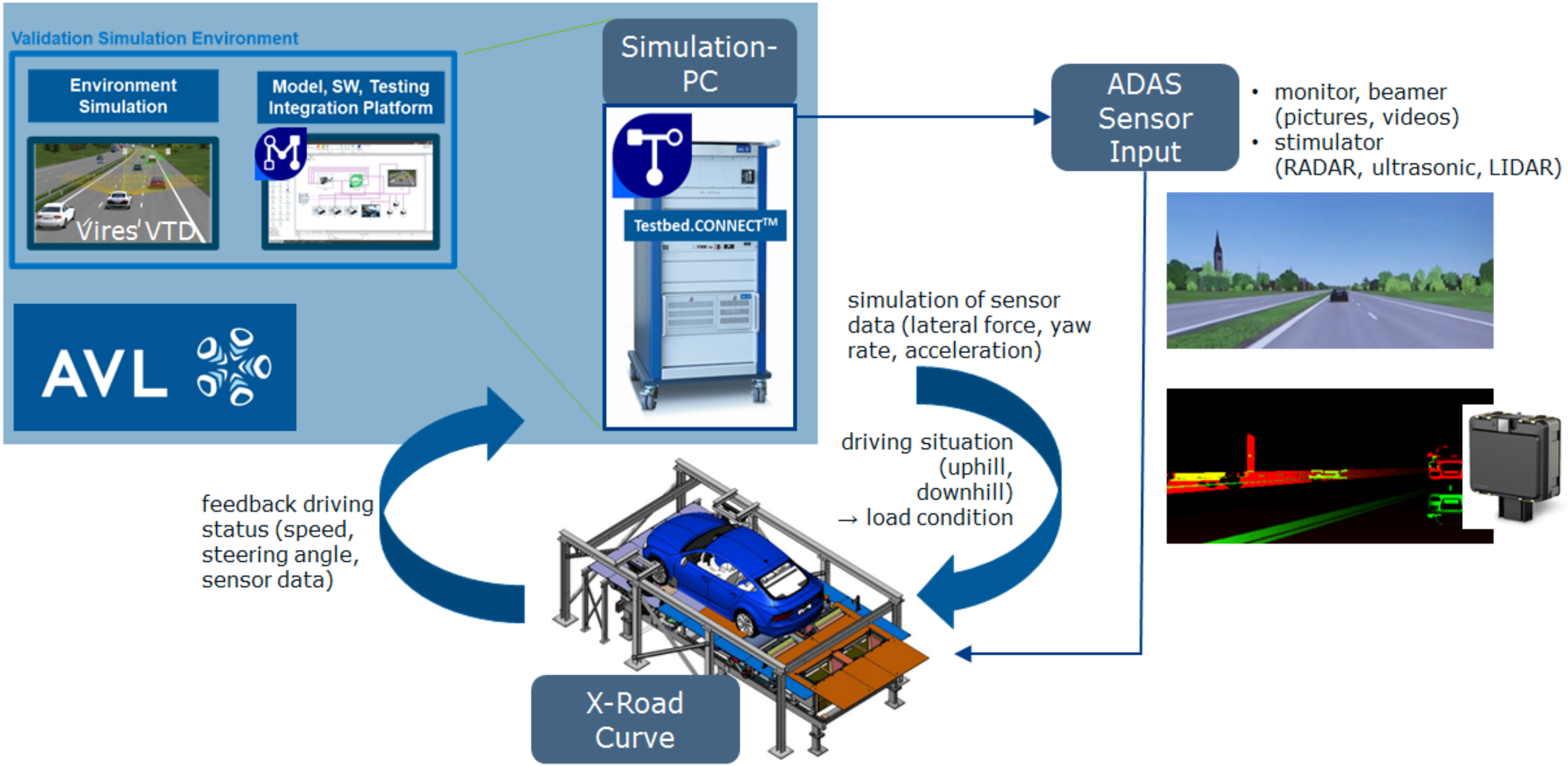
Identification of Signal Delays

- Further investigations required to identify the communication delays in the system



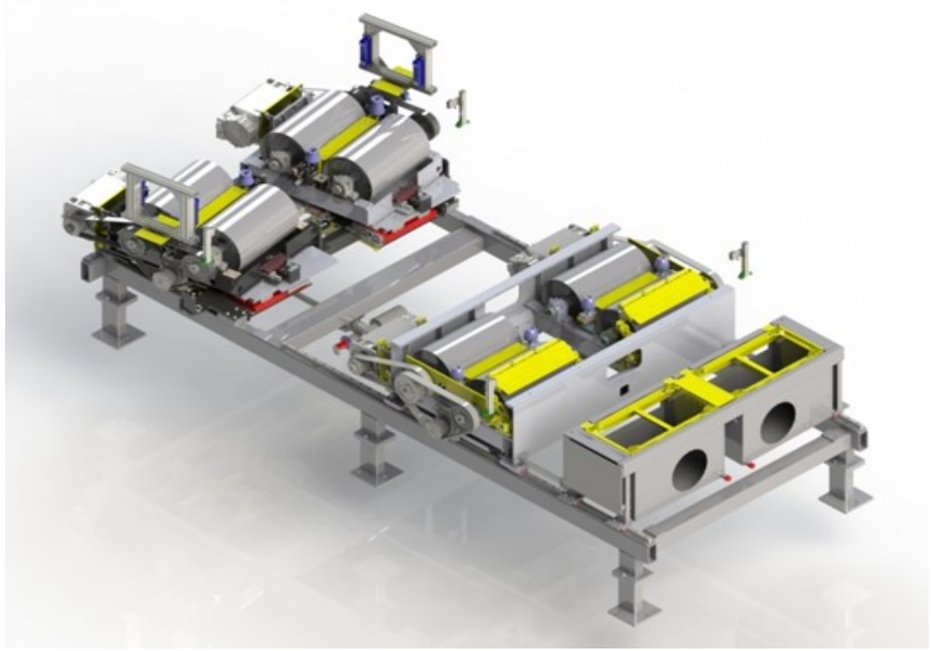
RTT … Round Trip Time

Future Research Outlook



Future Research Outlook

- Test track in a laboratory
- Development, functional testing of ADAS/AD systems
- Calibration of active safety systems and controllers
- End-of-Line final integrity test of ADAS/AD systems
- Euro NCAP tests emulation
- Integration with other sensor stimulation methods (radar, lidar, camera etc.)
- Integration with real recorded reference sensor measurements



THANK YOU

virtual vehicle

Enabling future vehicle technologies

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