



How model-based V&V improves safety assurance in the development of highly-automated vehicles

ESI - IDEW 2021 – Track Verification, Validation, Configuration

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Introduction AVL Group

Solutions

ENGINEERING



TESTING



SIMULATION TECHNOLOGIES



Elements

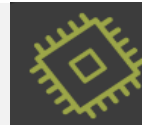
Combustion Engine



Transmission



Control Unit



E- Motor



Energy Storage Battery, FC



Vehicle



Industries

Pass Car



Racing



2- Wheelers



On / Off Road



Rail



Marine



Aviation



Defense



Power Generation



Cooperation TNO and AVL

Test Case planning with
*realistic and relevant
parameter ranges*

Scenario Database

Road

Traffic

Environment

streetwise

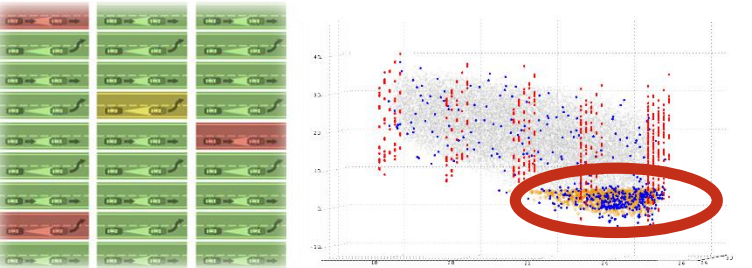
Real Road Statistics

AVL Test Case Generator

Testcases

Execute Simulation

Identify the critical situations



Identify appropriate criticality parameters:
Time-to-Collision, Time-Headway, etc.

Motivation for Model-Based V&V

Vision of the city of the future - autonomous systems act independently and communicate with people. They share common space, create new freedom and increase the quality of life.



www.daimler.com/innovation/pioneering

Research Project „SmartLoad“

- Research into new concepts for functionally safe design
- Exploring robust software and system architectures
- Research on new modular and standardisable development methods
- www.smartload-project.de

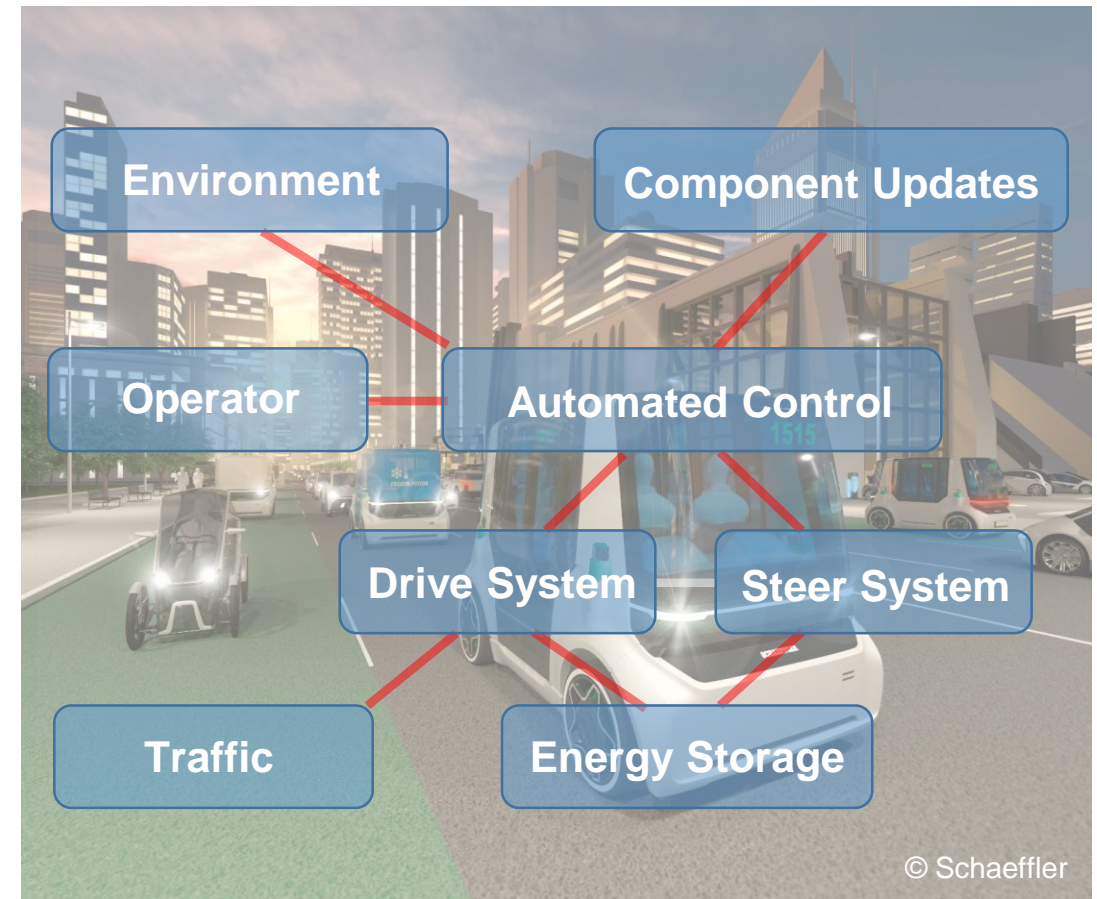
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and Research

SMARTLOAD

Neue Methoden zur Zuverlässigkeitssteigerung
von hochautomatisierten elektrischen Fahrzeugen



Use-Case eTractor

- Multiple operation areas
 - Private ground, Public roads,
 - On-Road, Off-Road
- Multiple operation modes
 - Manned, Teleoperator, Unmanned
- Multiple traction systems
 - Tire, Chain
- Multiple implements
 - Front, Rear, Side, Top
- Multiple working configurations
 - Trailer, Swarm, Drone Carrier, etc.



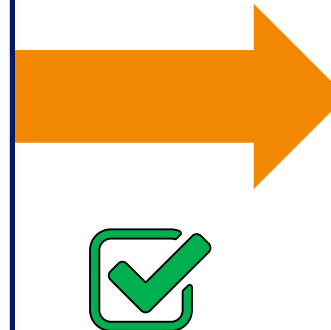
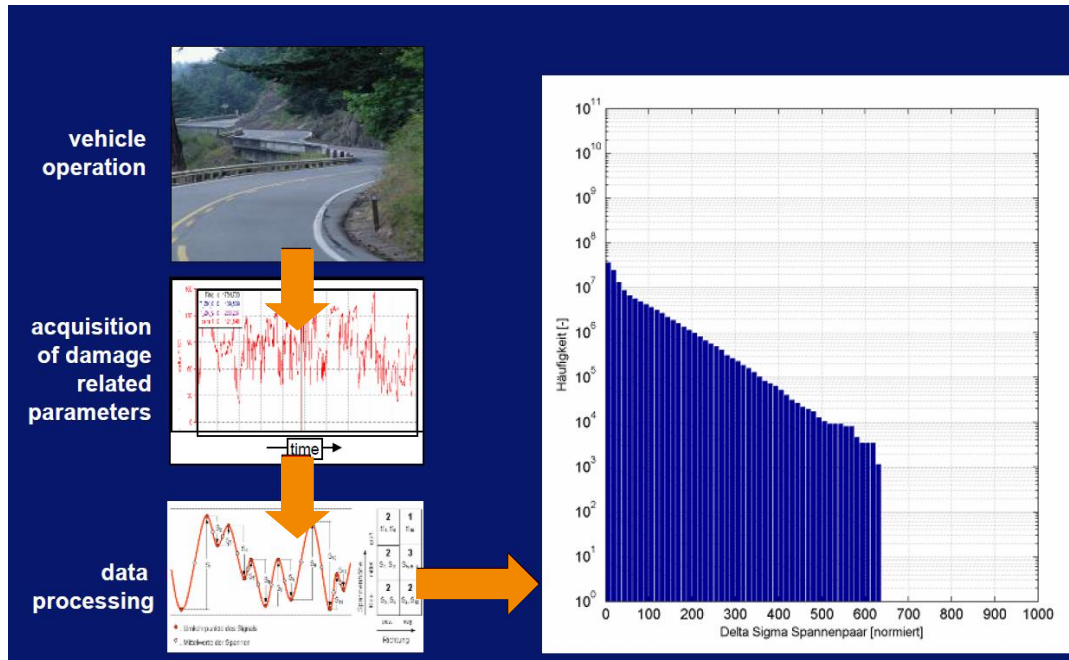
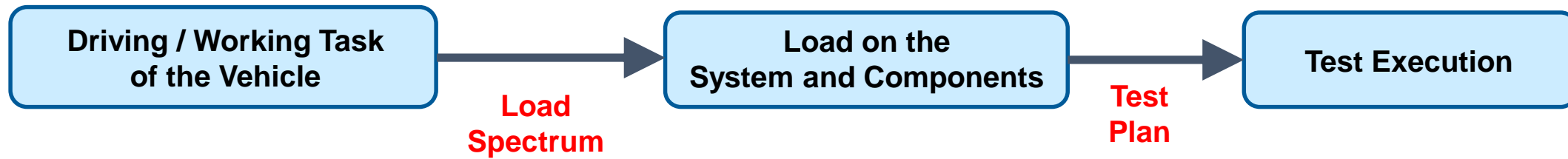
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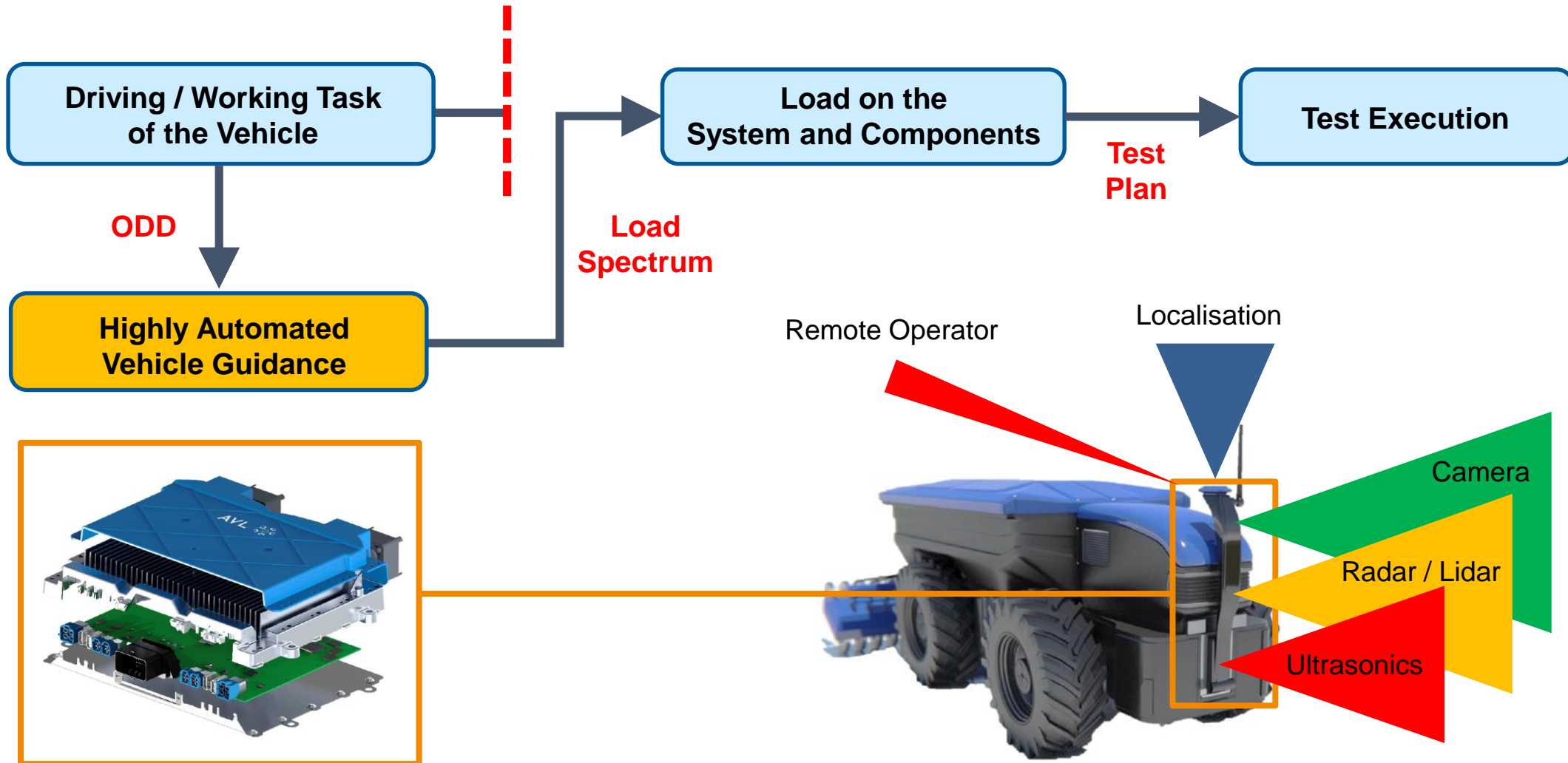


<https://www.youtube.com/watch?v=FwRj4uQSag4>

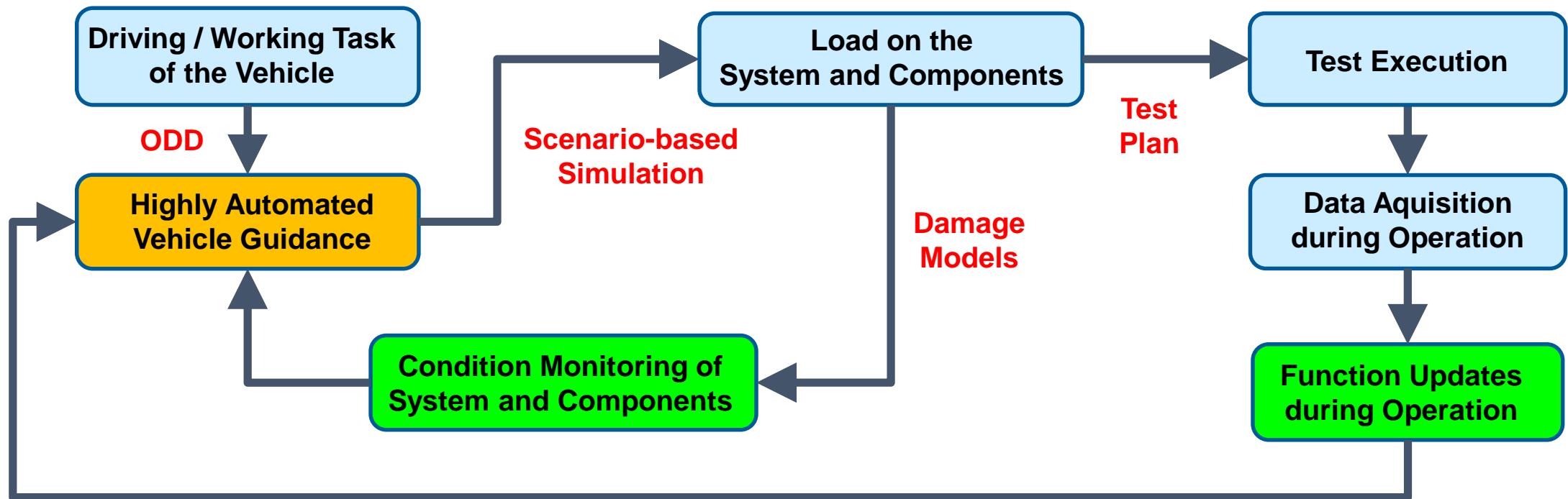
Traditional Approach for Conventional Electric Vehicles



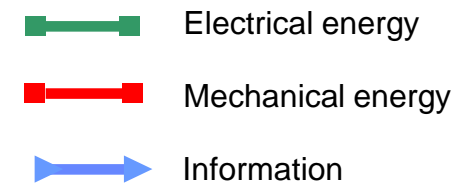
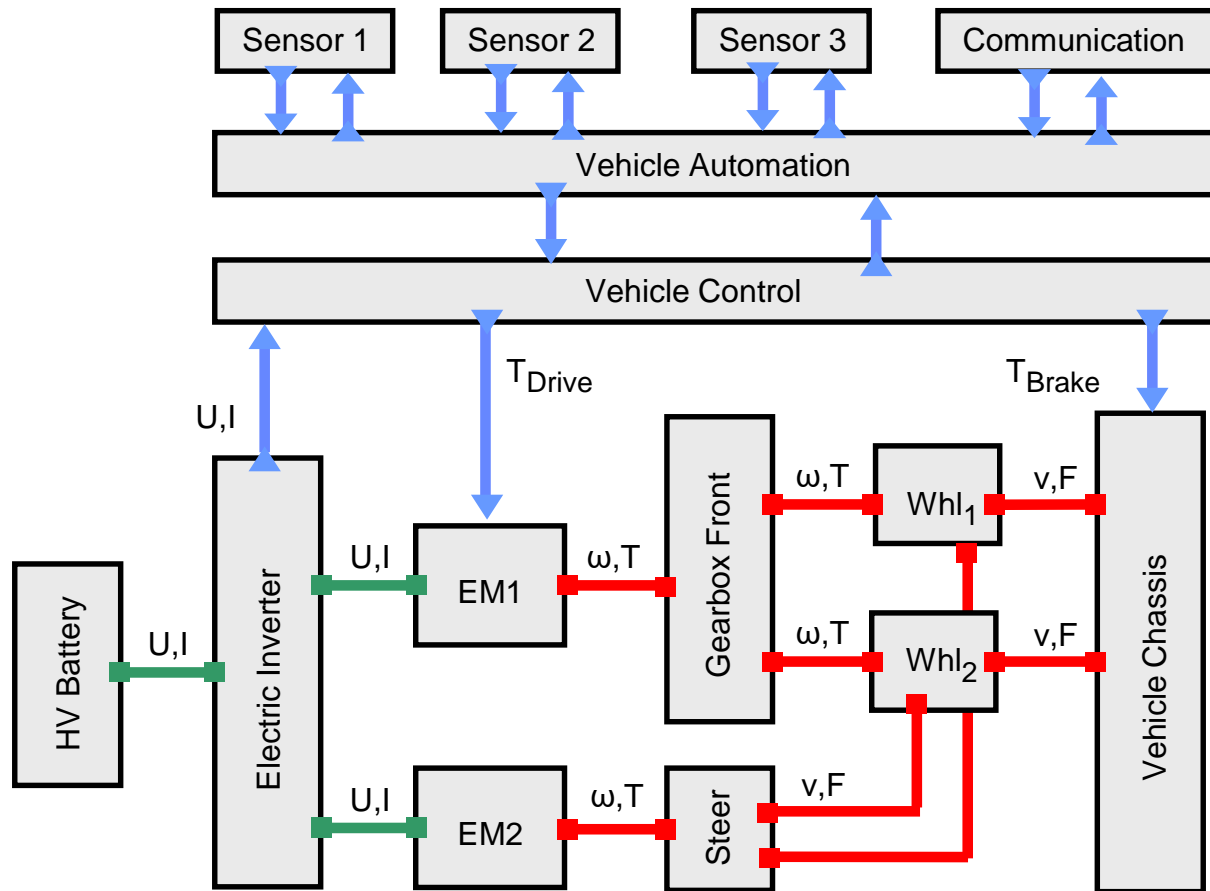
Traditional Approach for Highly-Automated Vehicle ?



New Approach

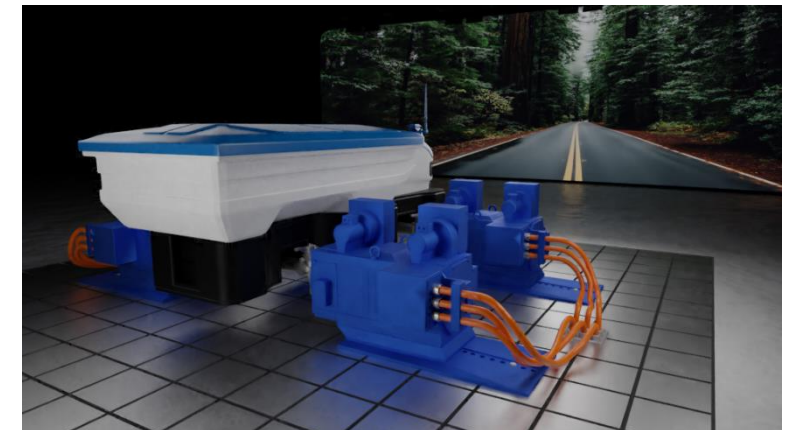
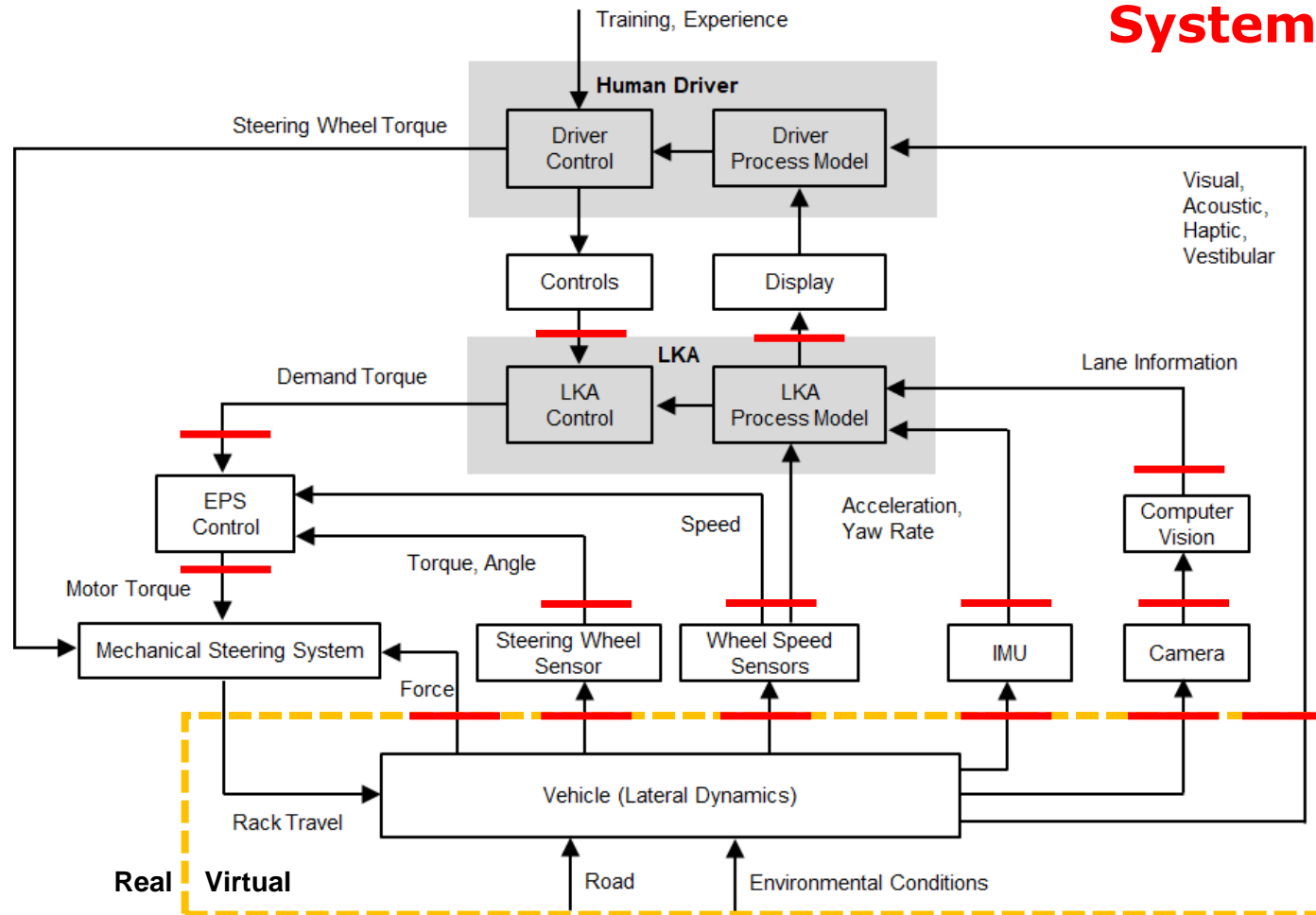


Elements for V&V – Systems Engineering



Elements for V&V – Safety Analysis and Vehicle Test Bed

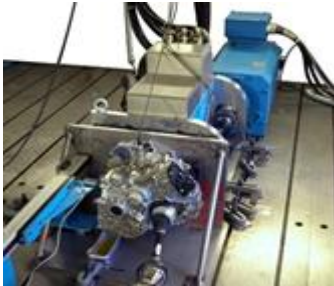
Systems-Theoretic Process Analysis (STPA)



- System Borders at Vehicle-in-the-Loop
- Required Fail-Safe-Tests

Elements for V&V – Distributed Co-Simulation

**Gearbox Test Bed
IPEK Karlsruhe**



**Steering Test Bed
STAG Karlsruhe**



**Virtual Vehicle
AVL Karlsruhe**



**E-Motor Test Bed
IEW Stuttgart**



**Inverter Test Bed
AVL Wangen**



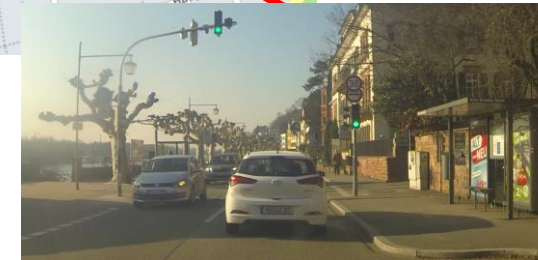
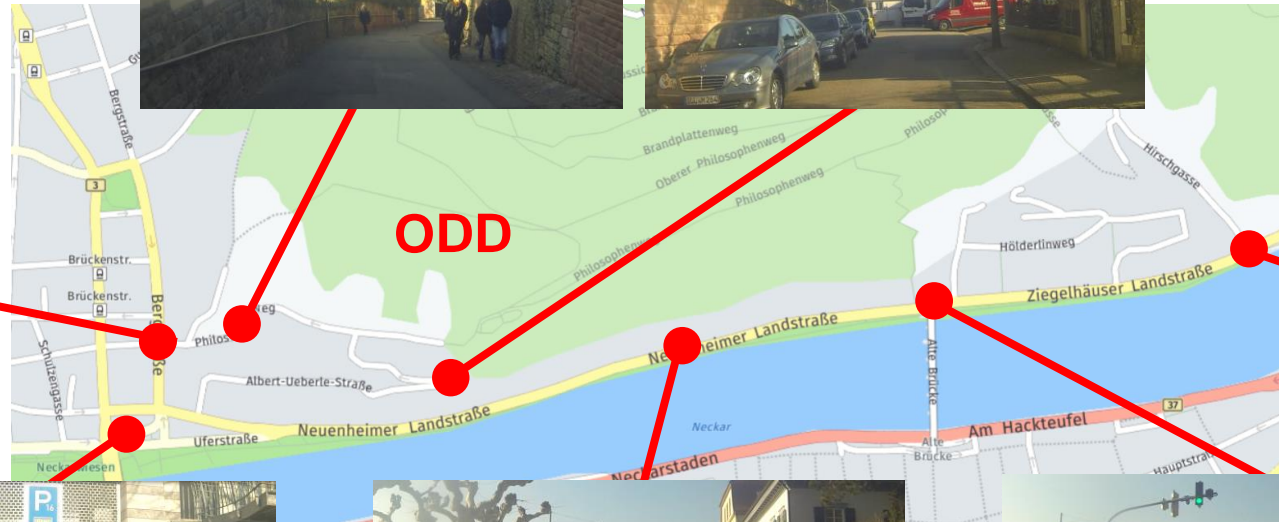
Elements for V&V – DGT and Scenario Catalog



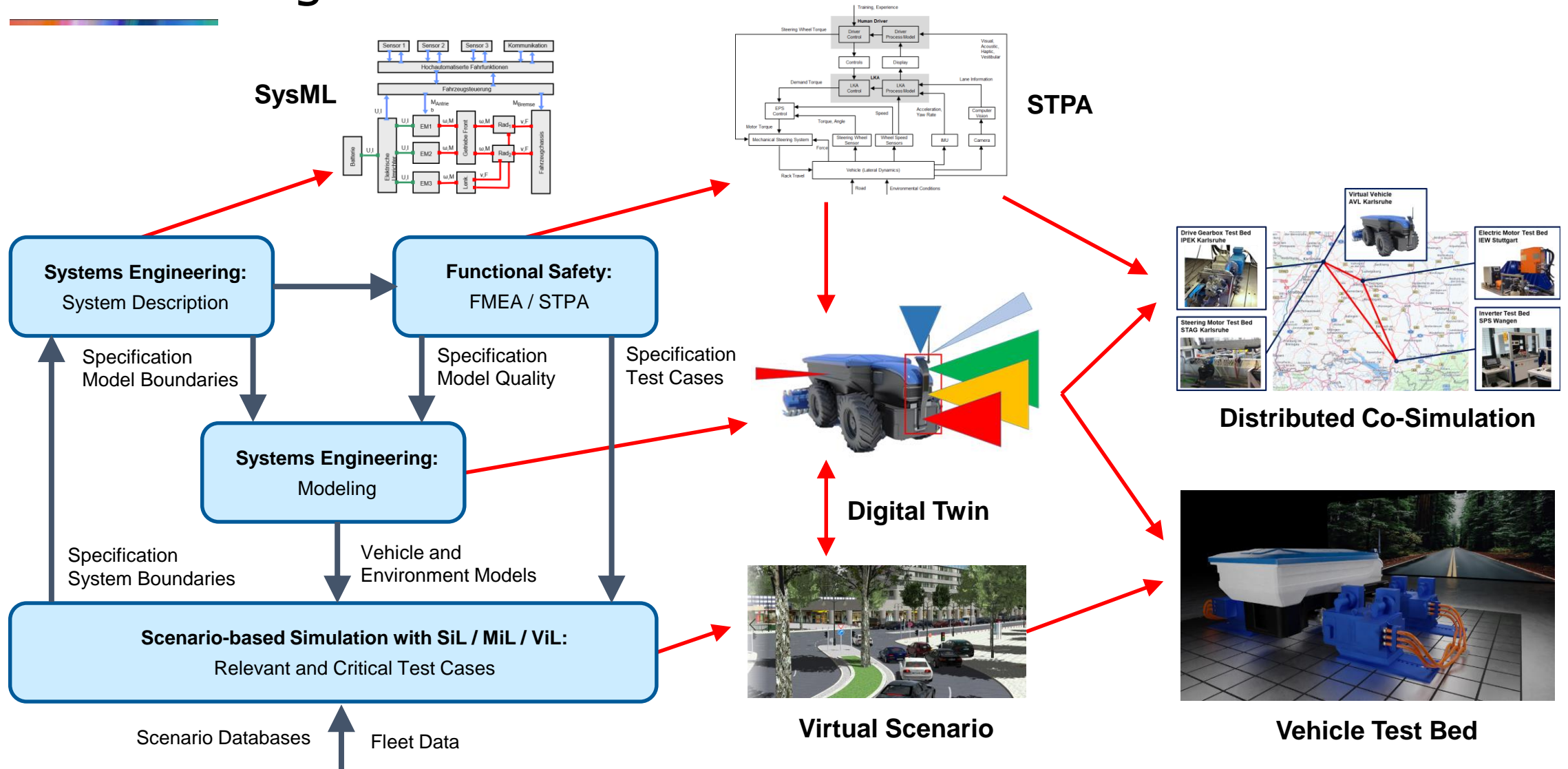
AVL DGT



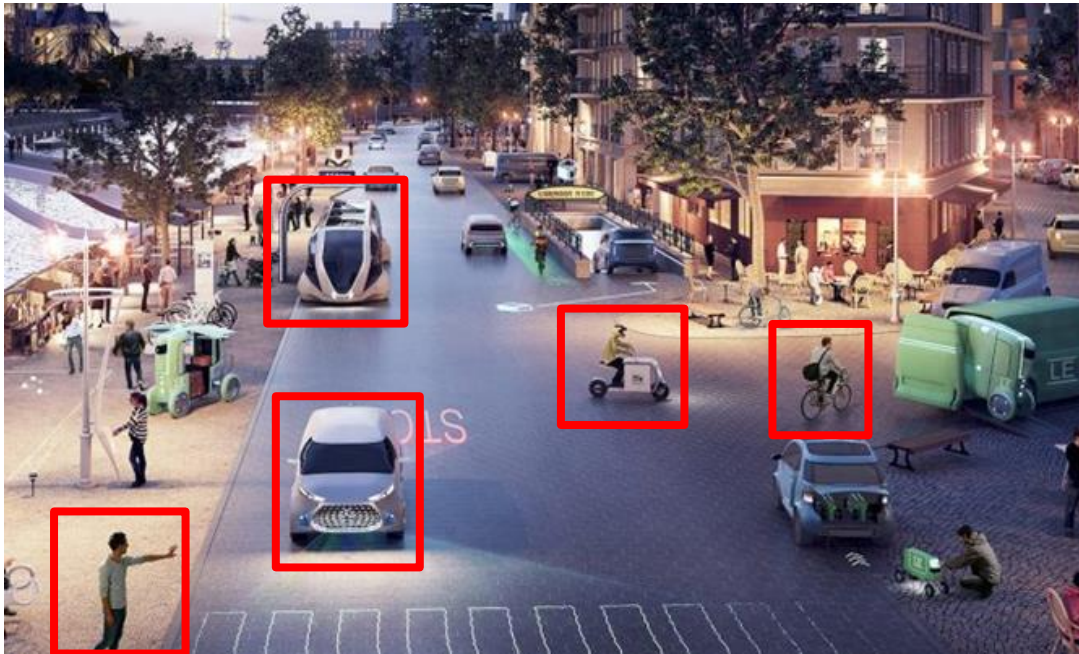
Elements for V&V – DGT and Scenario Catalog



Put it all together ...



Summary and Outlook



New V&V Methods and Tools to Ensure Reliability, Safety and Security