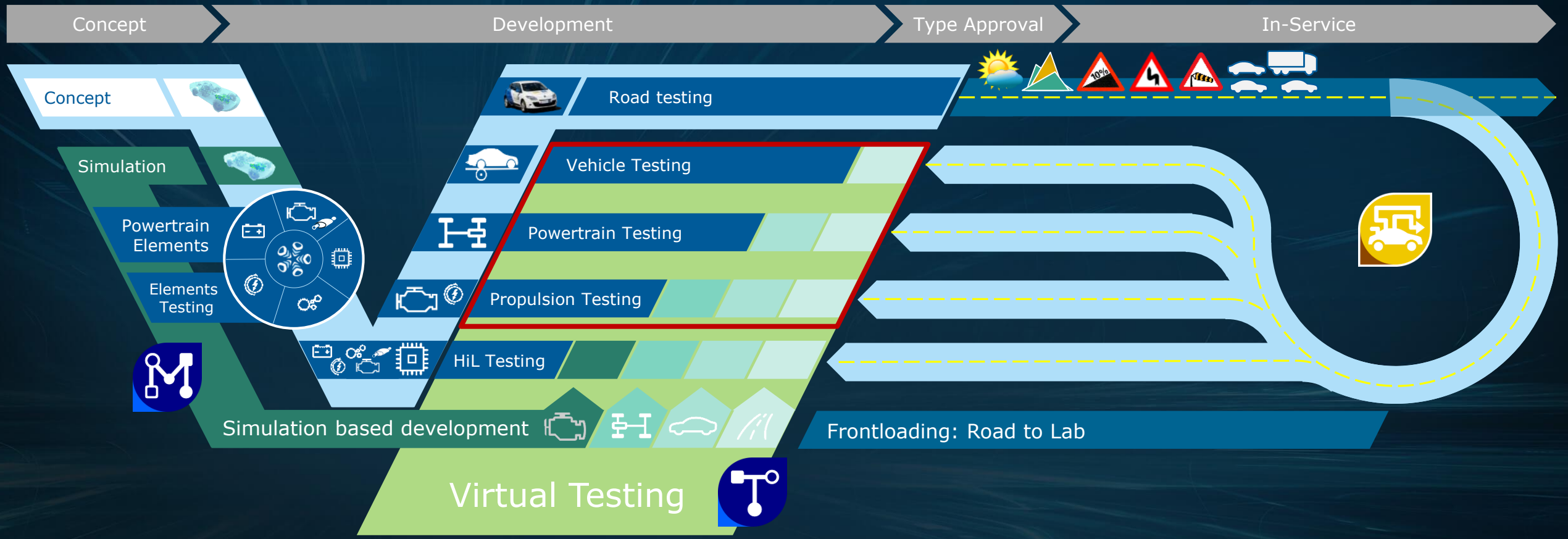
AVL Simulation Meets Testing Conference 2019

Simulation on Testbeds. The AVL Approach, Challenges and Customer Examples

Dr. Christian Mayr

The AVL approach of Simulation on Testbeds

Simulation on Testbeds in the V-Cycle



3 Pillars

Knowledge

Co-Simulation

Testbeds

Integration

Methodology

Road to Lab

Thermal Integration

Open Simulation Platform

Testbed.CONNECT™

Model.CONNECT™

What is Testbed.CONNECT™?

Any kind of Testbed

Any kind of Automation system

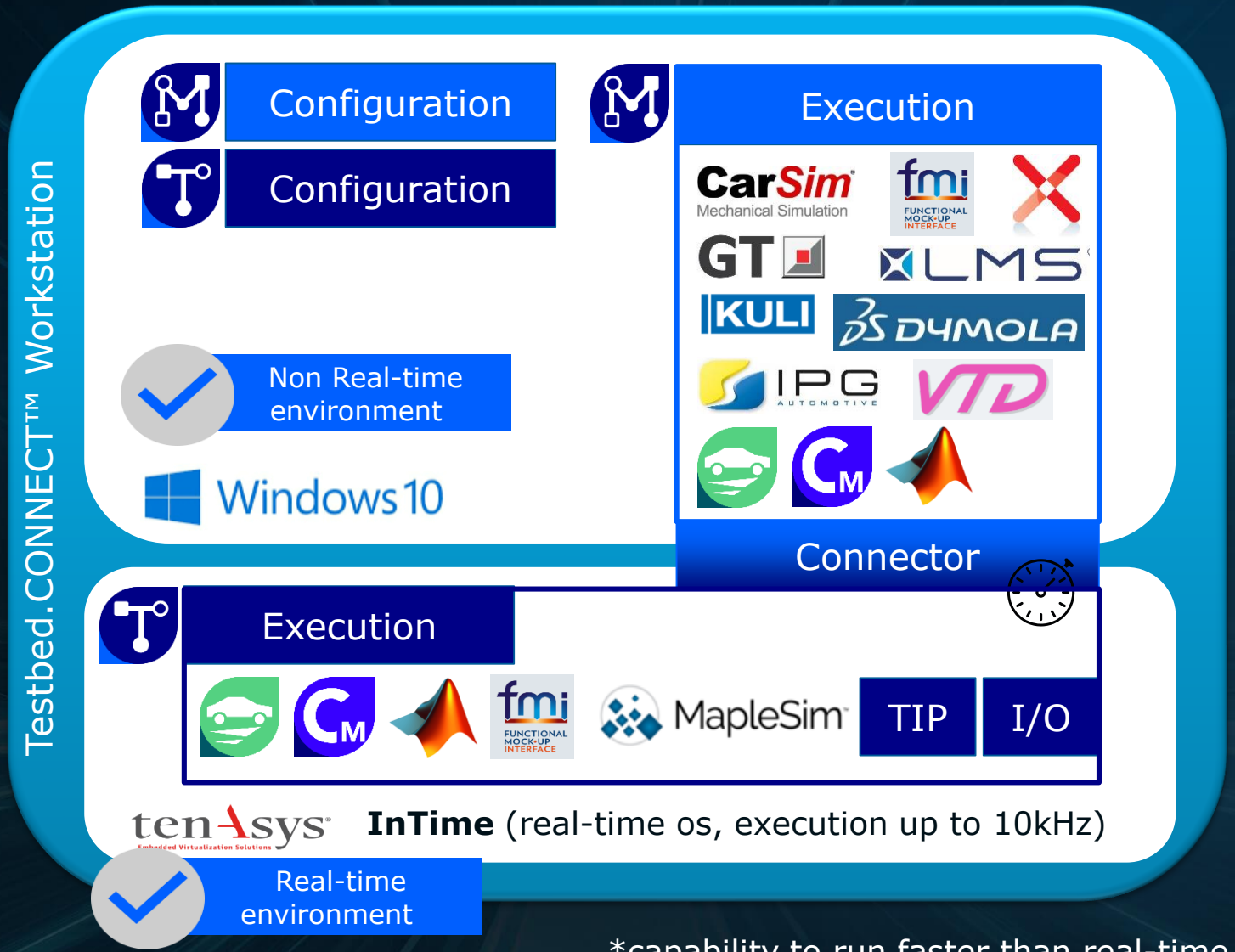
Testebed.CONNECT

Simulation Models

Testbed.CONNECT™ is an open integration platform for methodology and test engineers to bring simulation models to the test field

* Required in some cases

Testbed.CONNECT™



*capability to run faster than real-time

Workstation

- Dual Operating Systems (Windows & InTime)
- Dual Intel Xeon CPUs
- 4 cores for Windows (Model.CONNECT™)
- 4 cores for InTime (Testbed.CONNECT™)

Connector

- Clock from Real-Time System for Windows simulation
- Patented technology
- Enables integration of *Windows simulation models** to real-time environments (e.g. testbeds)

TIP (Testbed Integration Package)

- Standard interfaces for Engine/E-Motor Testbed, Driveline Testbed, Powertrain Testbed and Chassis Dyno
- Incl. basic safety features

I/O

- CAN (1kHz)
- EtherCAT (10kHz)
- UDP (2kHz, customer specific extension)
- Analog, digital and frequency I/Os

What makes the AVL approach unique

We are doing simulation on testbeds

- projects with/for customers
- worldwide
- every day
- nothing else

Thermal management
CRUISE, GT, AMESim, FLOWMASTER, SIMULINK, Exothermia, SIMPACK

Control development
Dymola, Simulink

Turbo-lag behavior
CRUISE M, VSM, DRIVE, GTP

Advanced Calibration of Drivability
CAMEO, PUMA, DriCon, VSM, DRIVE, INCA,…

Virtual Shift Strategy Calibration
Model.CONNECT, VSM, SPA, Simulink,…

Data driven solutions
Integrative different data sources

Belt Starter Generator Control on ETB
PUMA, CRUISE M

Advanced Driver Assistance Systems
VTD, ADAMS, Simulink

Electrification, Thermal Management, ADAS
CRUISE, CRUISE M, VSM, VTD Vires, Simulink

Thermal management in the loop
Cruise, Simulink, Kuli, FMUs, CarMaker

Vehicle controls
Adams, Simulink

Engine and powertrain control function development
CarMaker, GT, Simulink, Saber
Optimization tasks via DVI server

RDx applications expanding to Testbed.CONNECT
CarMaker, VSM, GT, Simulink, Silver-QTronic

Challenges of Simulation on Testbeds

Challenges of the Organization

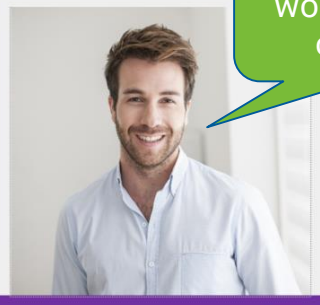
Addressing different stakeholders:

Sophie

Use existing tool landscape

Simulation Engineer

Oliver



Make the workflow less complex

Virtual Testing Expert

Franck

Test within the complete vehicle at every development step

Calibration Engineer
Kalibrationsingenieur

Mario

Do things in an effective and simple way

Testbed Operator Chassis
Prüfstandstechniker Rolle

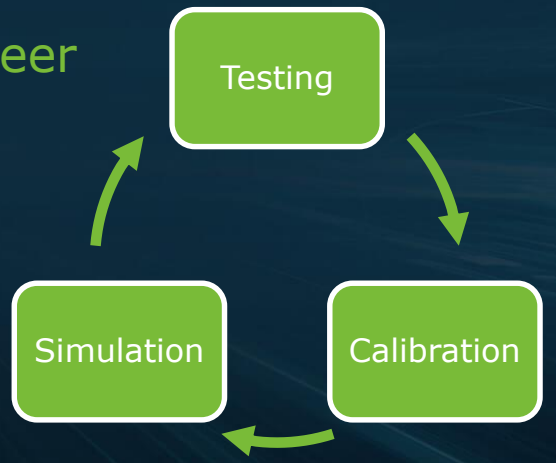
What are the challenges and benefits

- Closer collaboration

- New role in the organization required:

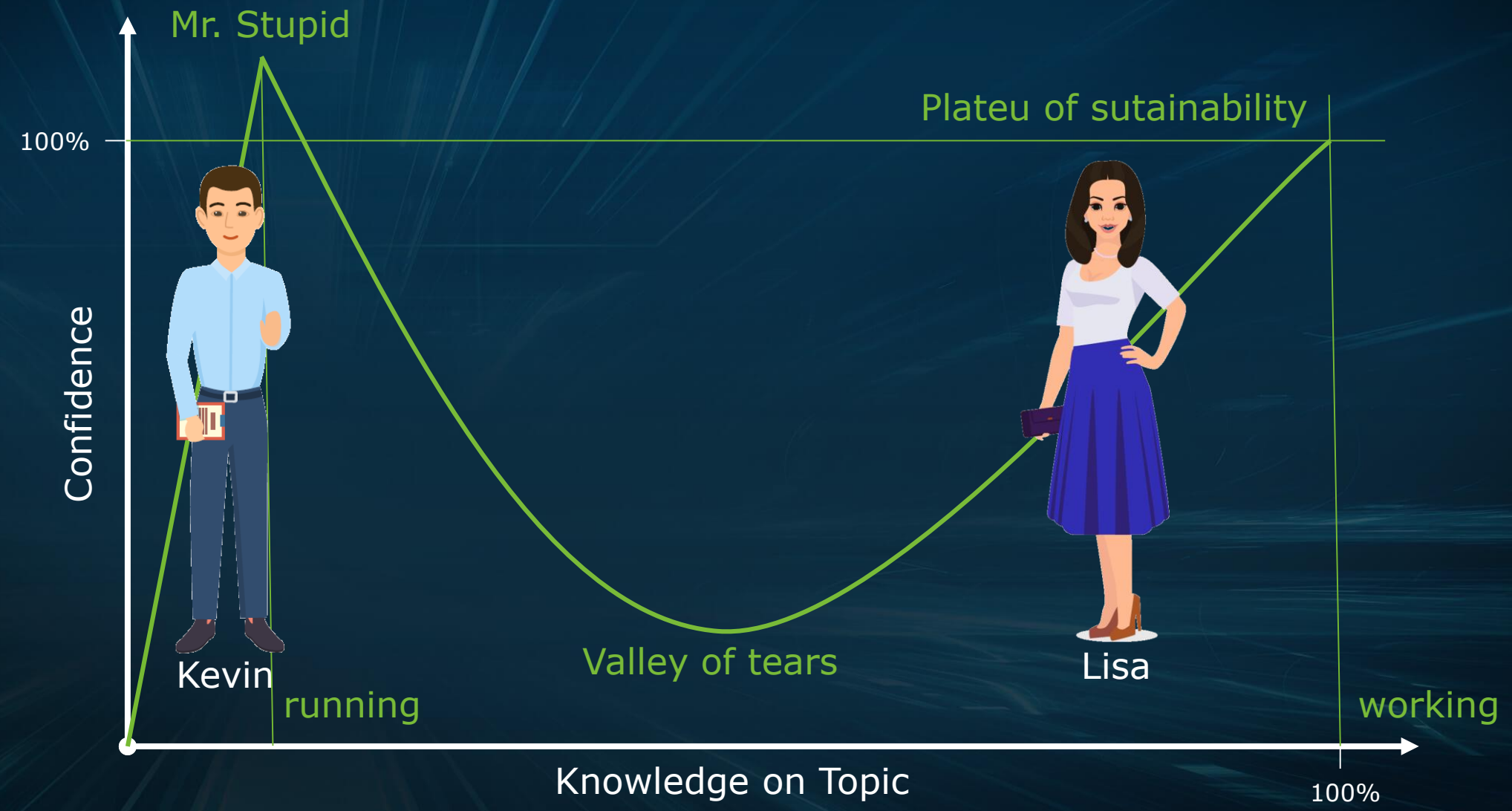
  Virtual Testing Expert/Engineer

- Shorter iterations
  - Improvement cycle:



Challenges in terms of Knowledge

The Dunning Kruger Effect

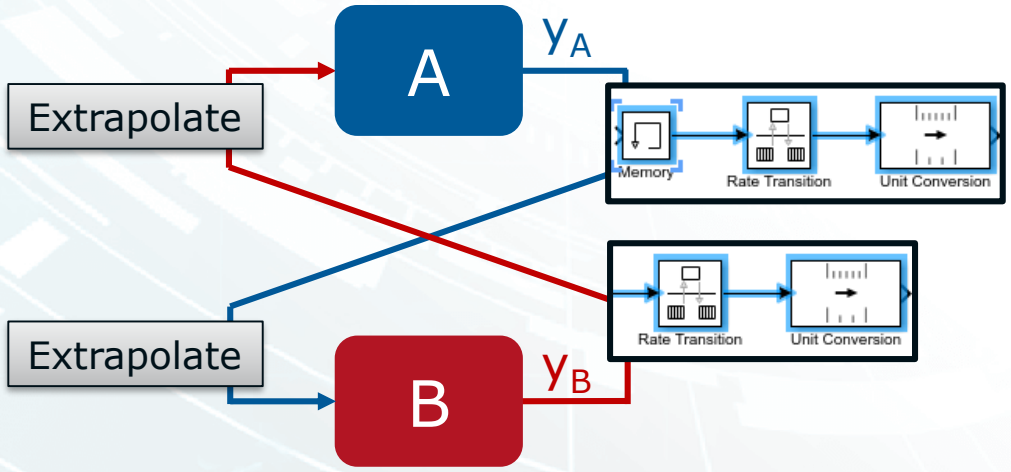


Co-Simulation
Coupling Mechanisms

Technical approach – Co-Simulation

- Subsystems are solved independently over predefined time-intervals
  - Independent solvers (FSS/VSS)
  - Independent frequencies

Ho to couple multiple subsystems

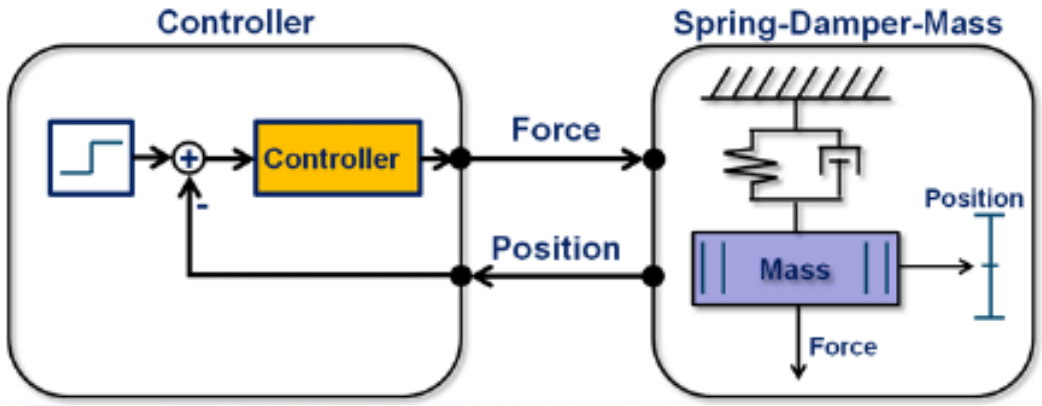


	Parallel
Calculation	Each time
Extrapolation	-
Duration	+
Trigger sequence	

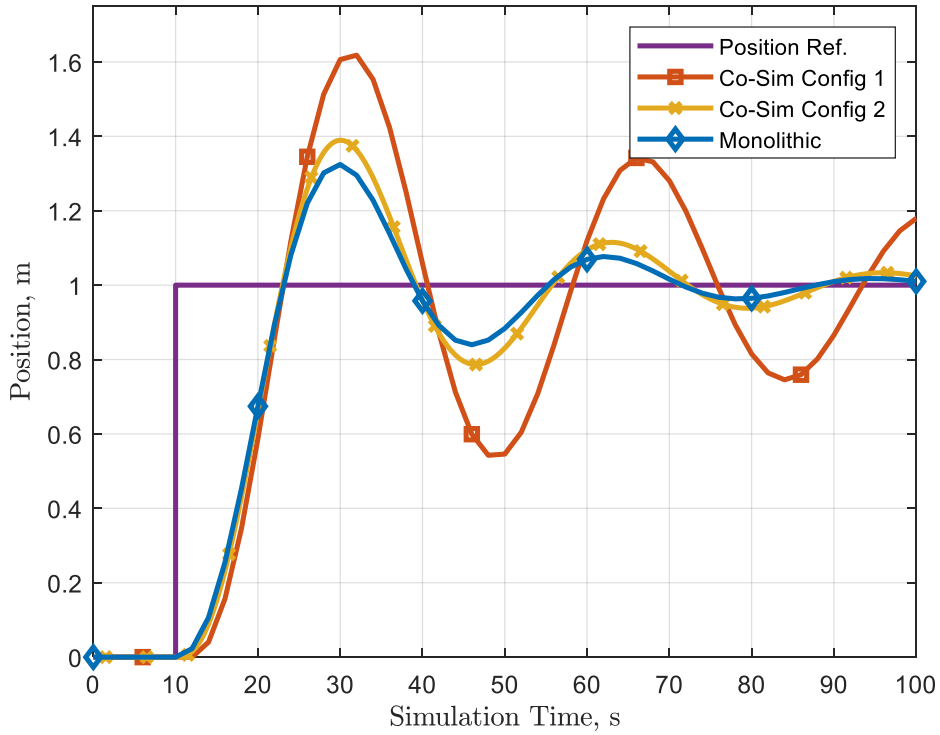
Co-Simulation Example SDM

Example: „Spring-Damper-Mass“

- 2 Subsystems (Simulink)
- Solver Settings: $\mathrm{FSS}, \delta T = 0.001s$



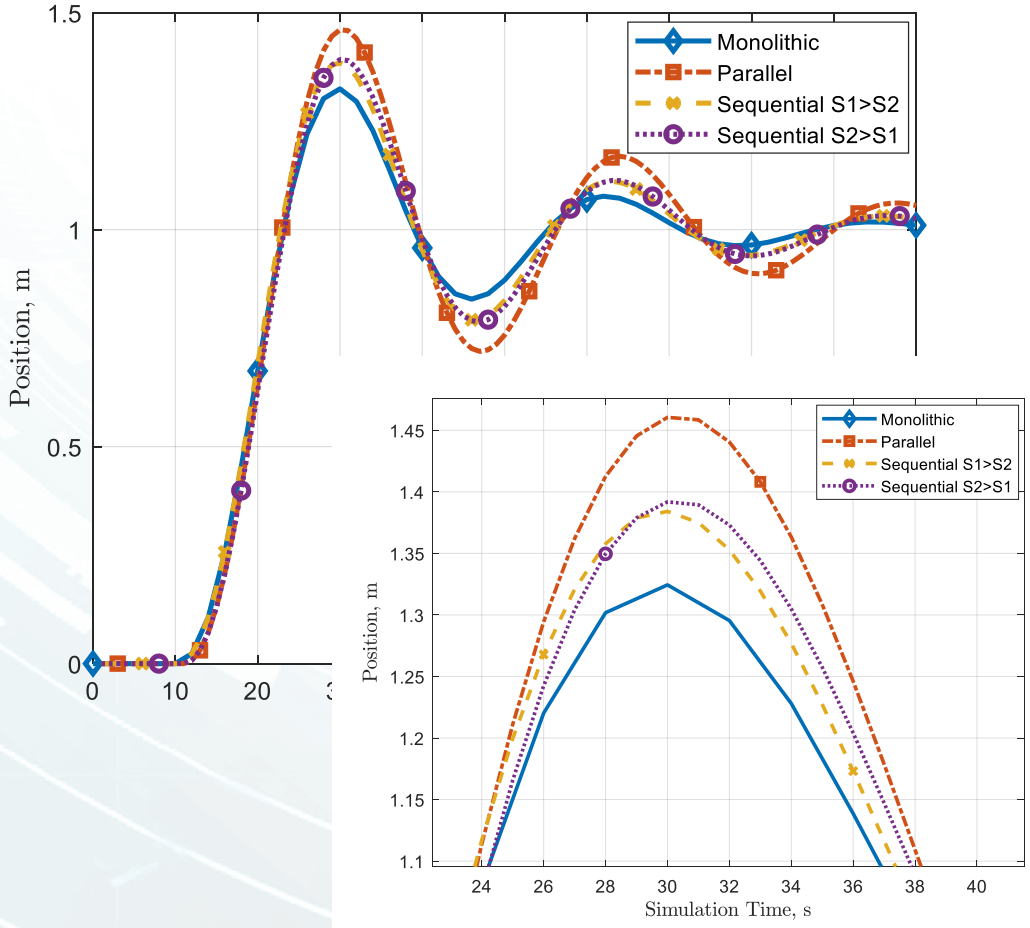
Simulation Result:



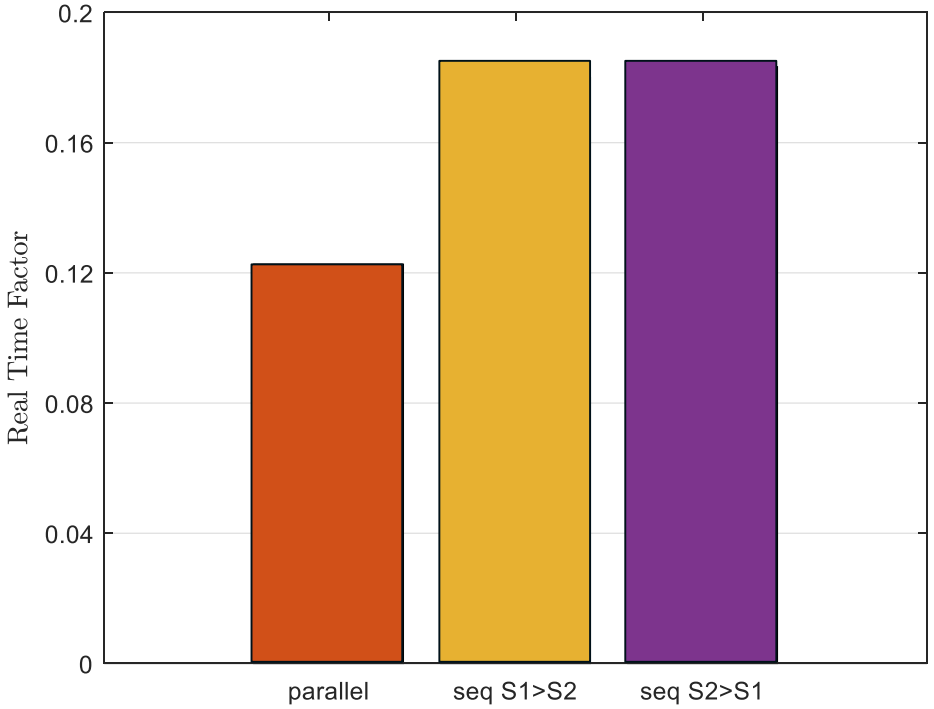
Coupling Mechanism

Coupling Mechansim: Parallel vs. Sequential @ $\Delta T = 1s + ZOH$

Simulation Results:



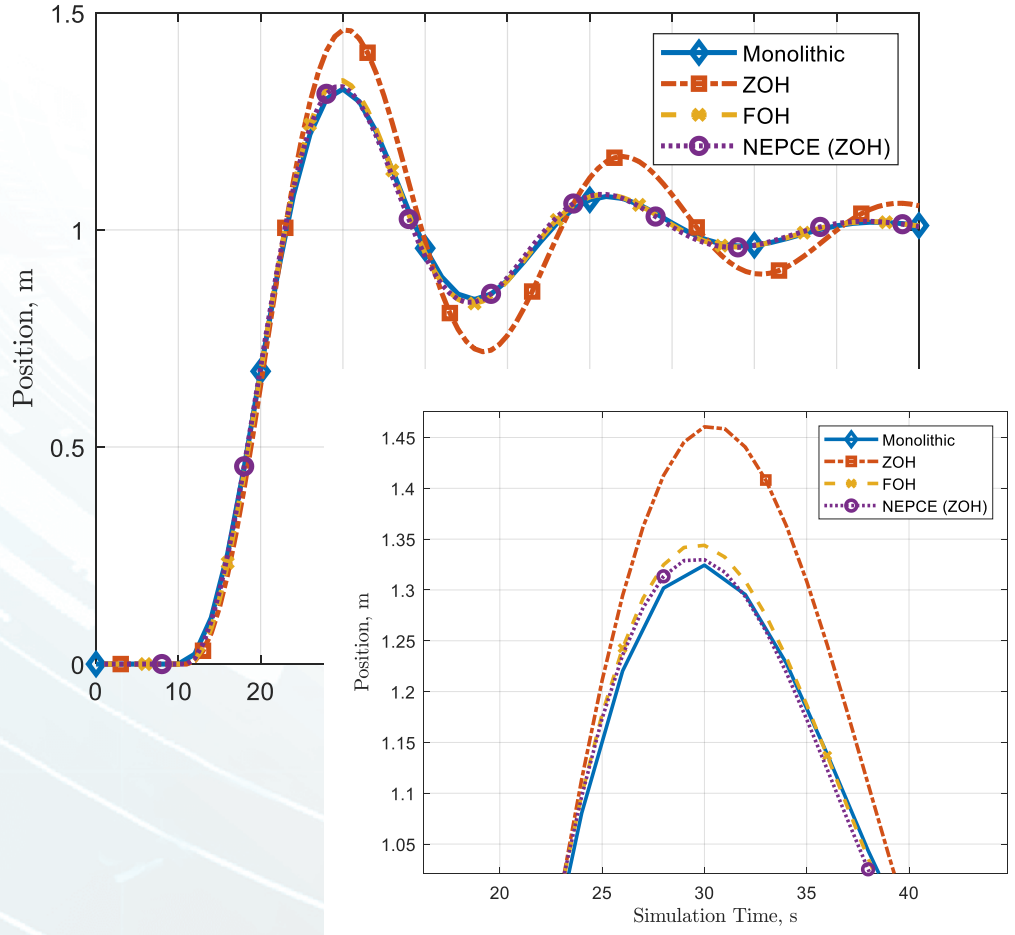
Simulation Effort:



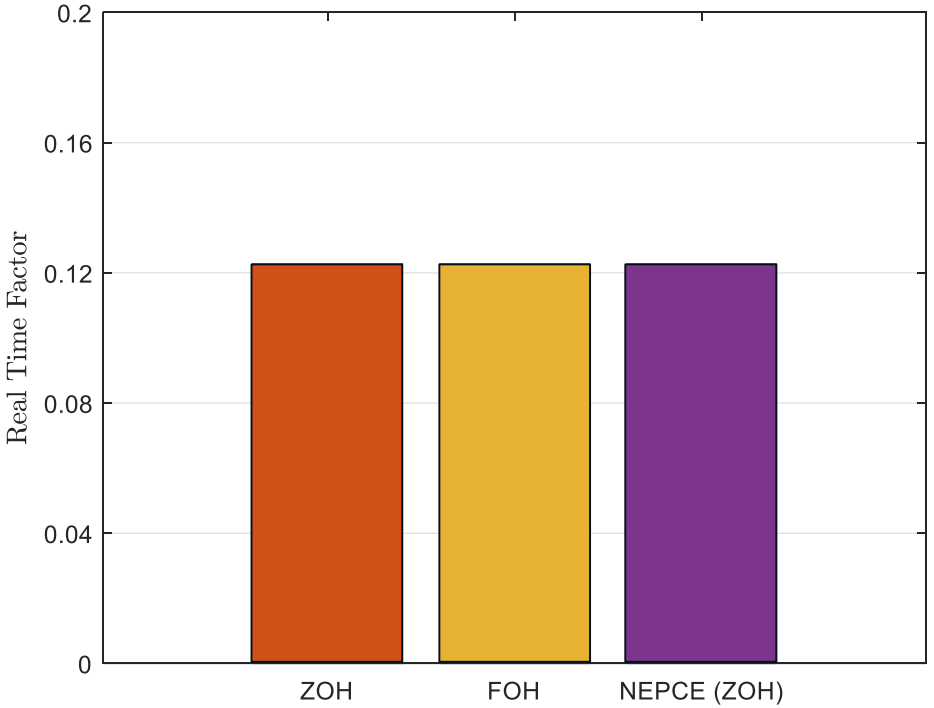
Extrapolation Filter

Extrapolation Filter: ZOH vs. FOH vs. NEPCE @ $\Delta T = 1s$ + parallel

Simulation Results:



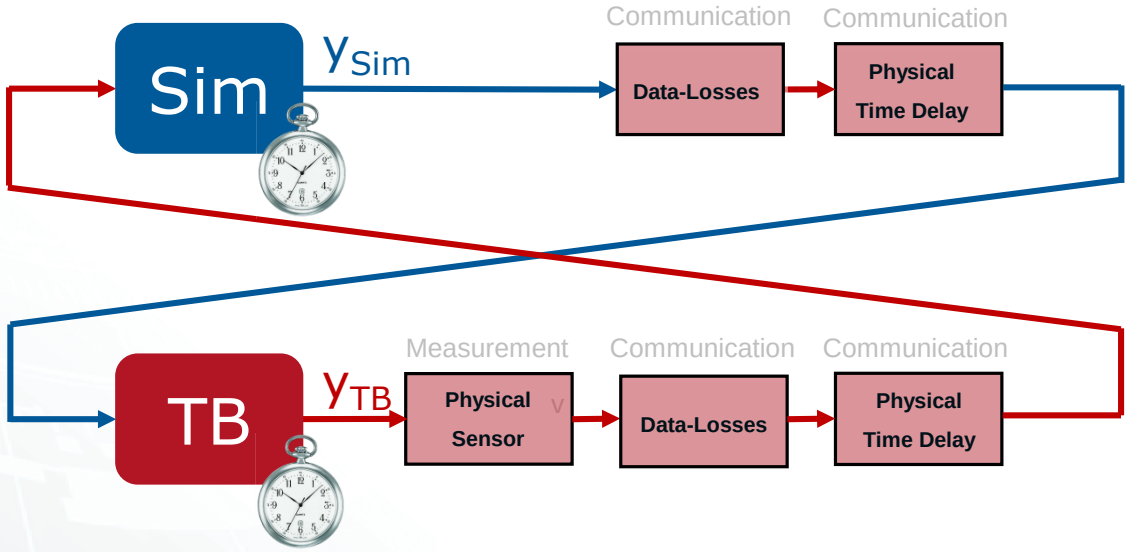
Simulation Effort:



Real-Time Co-Simulation
The Problem of Causality

Technical approach – RT-Co-Simulation

- Synchronization with respect to wall clock time
- Subsystems are solved independently over predefined time-intervals
- Noisy coupling signals / data losses / communication delays



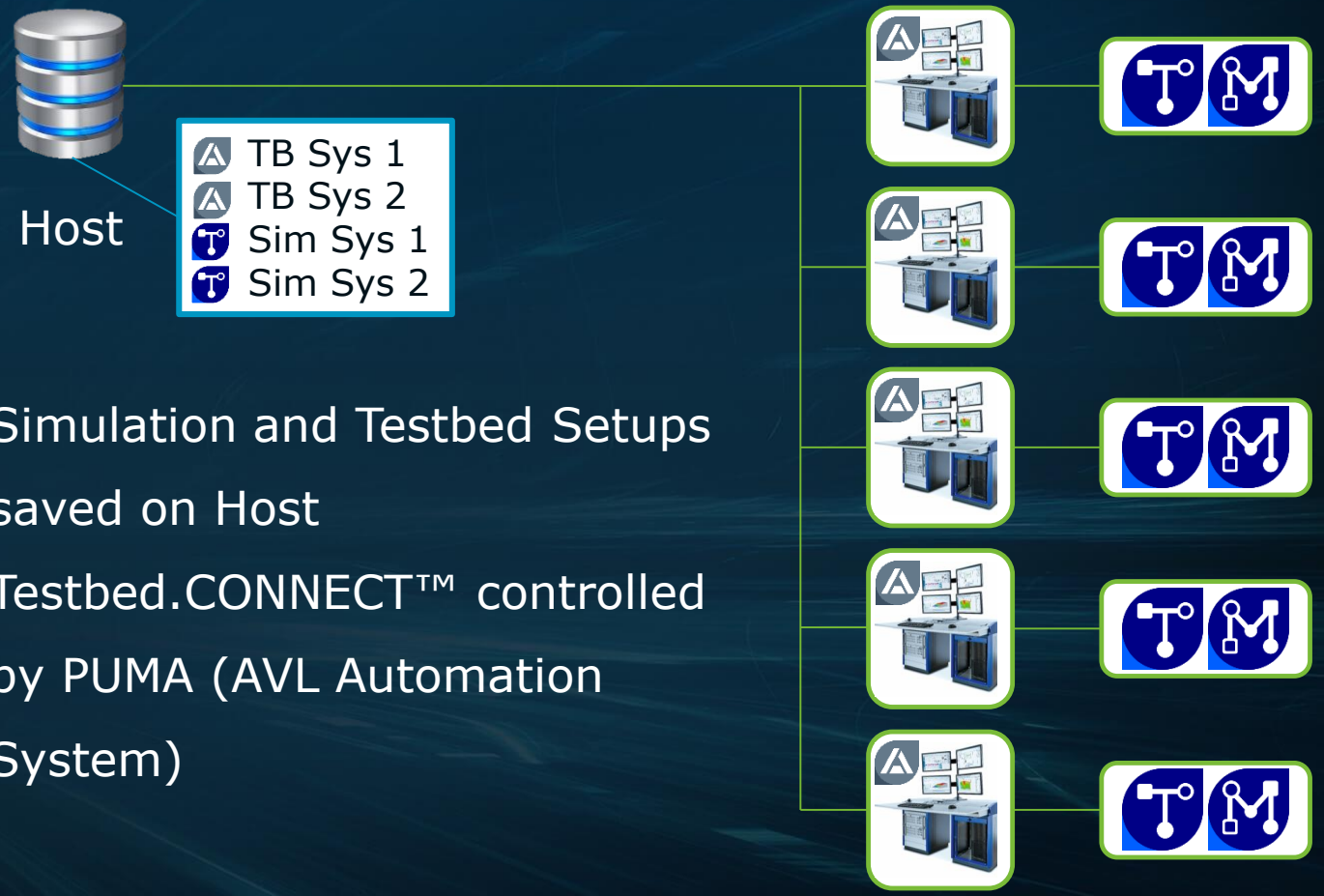
Challenges in terms of scaleability
Simulation in a testfield

- Today most of the available products are „island solutions“

⇨ Not scaleable in testfields

The AVL Solution

Availalbe from Testbed.CONNECT™ 1R4.2 (end of 2019)



- Simulation and Testbed Setups saved on Host
- Testbed.CONNECT™ controlled by PUMA (AVL Automation System)

Customer Examples

Boundary Conditions

SAFETY
Safe operation for humans and components

COST
Testbed hours are valuable
⇨ Methodology for efficient integration of simulation models on testbeds

USABILITY
Testbed operator must be able to handle the system

Thermal Management Development of BEV

Customer Project

Will be presented at the Methodology Symposium 2019

PARALLELSEKTION 3A

New Challenges in Electrification; Sektionsleiter: Prof. G. Hohenberg, IVD Prof. Hohenberg GmbH

15.45 Testen von Antriebsumrichtern mit Power-Hardware-in-the-Loop-Emulatoren als virtuelle e-Maschine
Dr. A. Schmitt, Dr. P. Winzer, Dr. M. Schnarrenberger, H. Hammerer – AVL SET GmbH

16.15 To charge, or not to charge
M. Bersac – Valeo Siemens eAutomotive France SAS

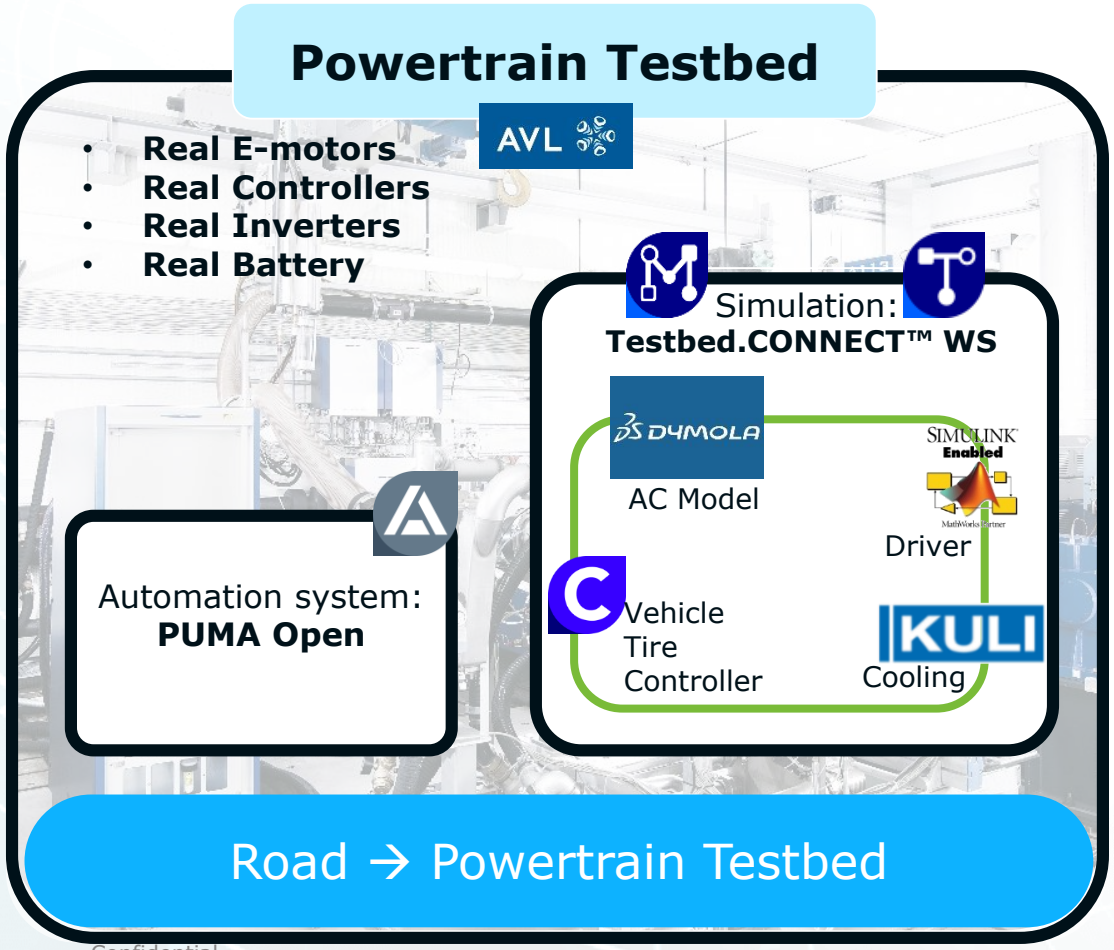
16.45 Ansatz zur Optimierung des szenariobasierten, thermischen Managements eines batterie-elektrischen Fahrzeugs durch automatisierte Simulation von Fahrbetriebskollektiven
A. Kowallik – BMW AG; Prof. C. Beidl – Technische Universität Darmstadt

17.15 ThermoLab für Elektrofahrzeuge – Entwicklung Thermomanagement am Prüfstand
A. Koller, Dr. H. Raiser – Dr. Ing. h.c. F. Porsche AG; C. Mayr, M. Walcher – AVL List GmbH; D. Ciglar – AVL-AST d.o.o.

Customer Reference
BEV thermal management on powertrain testbed

Main goal

Frontload of thermal management development from road to testbed



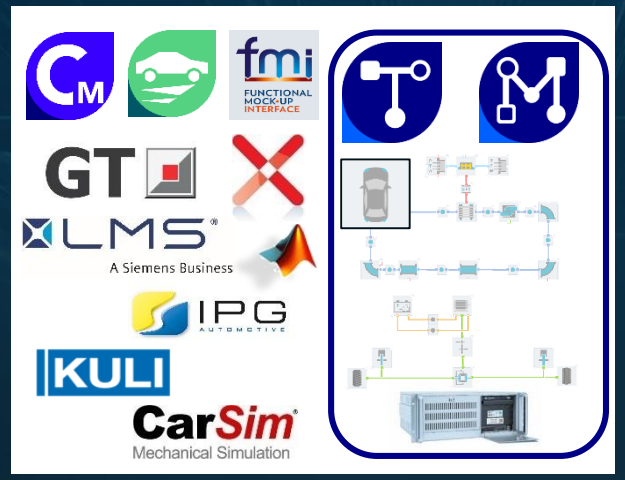
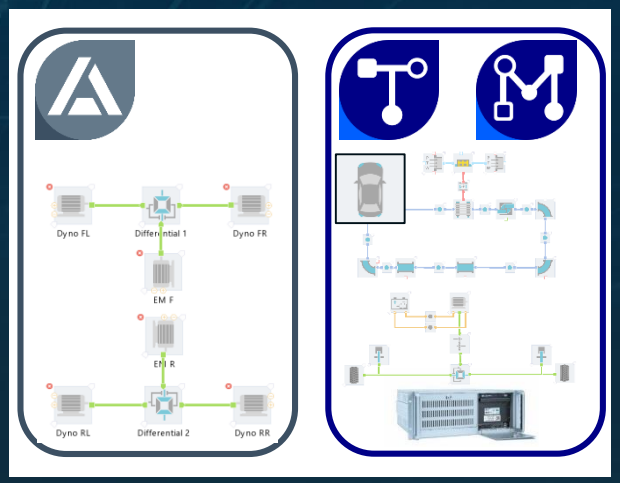
Key facts

- Market: Europe
- Thermal management simulation tool KULI
- KULI simulates the complete cooling circuit of the vehicle
- non-compiled KULI model on Testbed.CONNECT™
- Air conditioning model in Dymola

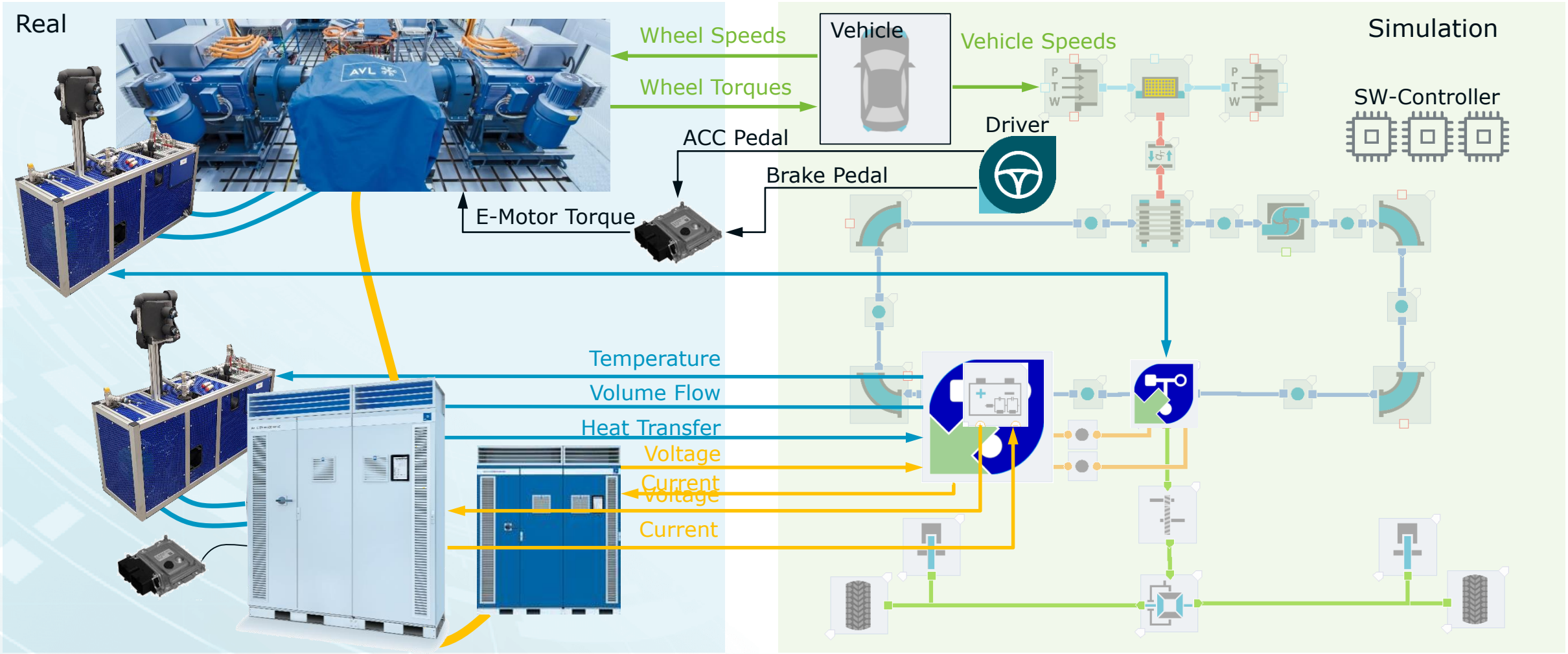
HIGHLIGHTS

- Quick charge tests with thermal management simulation on testbed
- High potential for development time savings
- Safety critical tests can be executed on testbed rather than road – Race track, full acceleration tests 0-200-0 km/h

Integration Methodology on Testbeds (for complex simulation models)

STEP 1	STEP 2	STEP 3
Prepare Simulation Models	**Testbed Simulator**	**Real Testbed**
		
1. Integrate required I/O 2. Ensure standalone real-time capability 3. Ensure co-simulation stability	1. Setup overall simulation 2. Integrate simulation on a testbed simulator 3. Test the testruns	1. Transfer Simulation on the real testbed 2. Conduct the testruns

Integration of Thermal Simulation on Testbeds



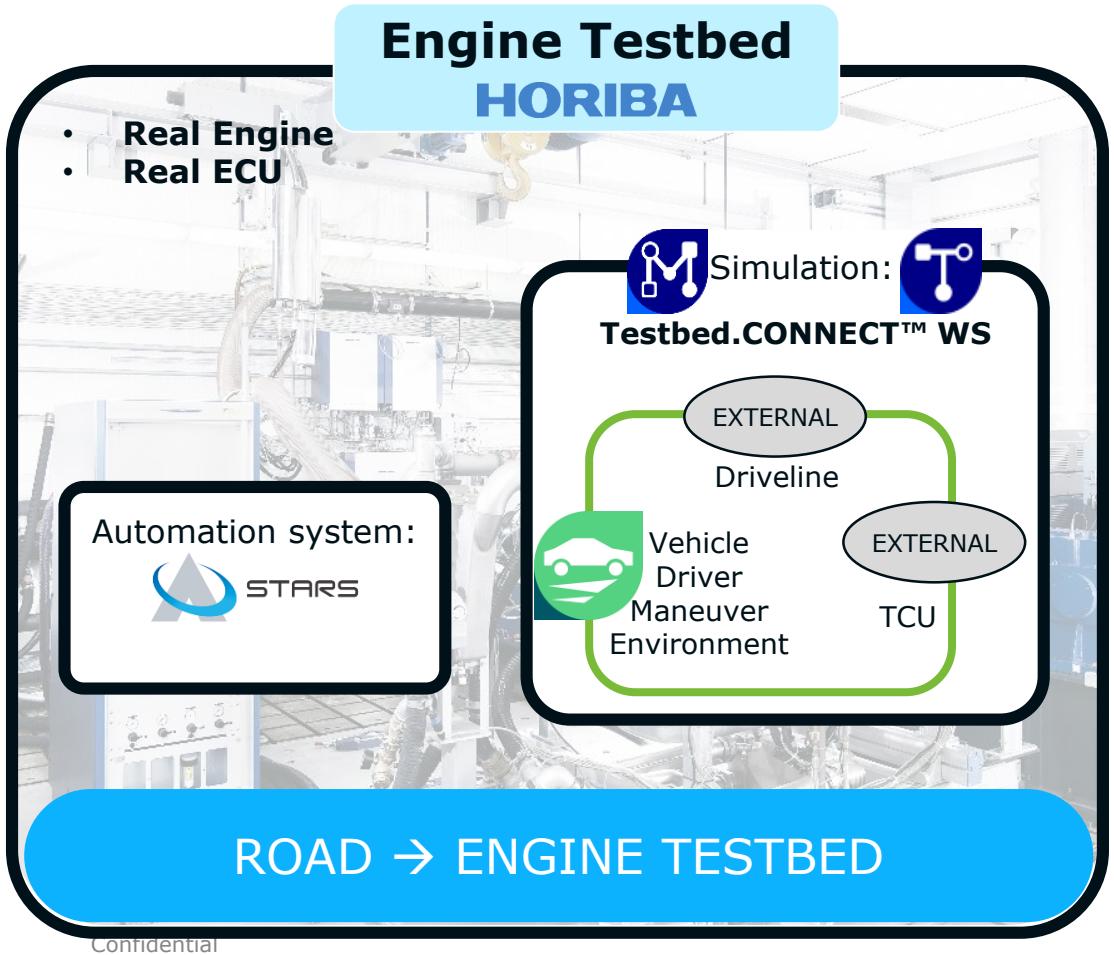
RDx

Customer Project with AMG

Published at the Conference Simulation & Test 2018

Customer Reference
Real World Driving Emissions on engine testbed

Main goal
Frontloading of RDE to ETB



Key facts

- Market: Europe
- Integration in 3rd party automation system (Horiba STARS) & external 3rd party simulation environment

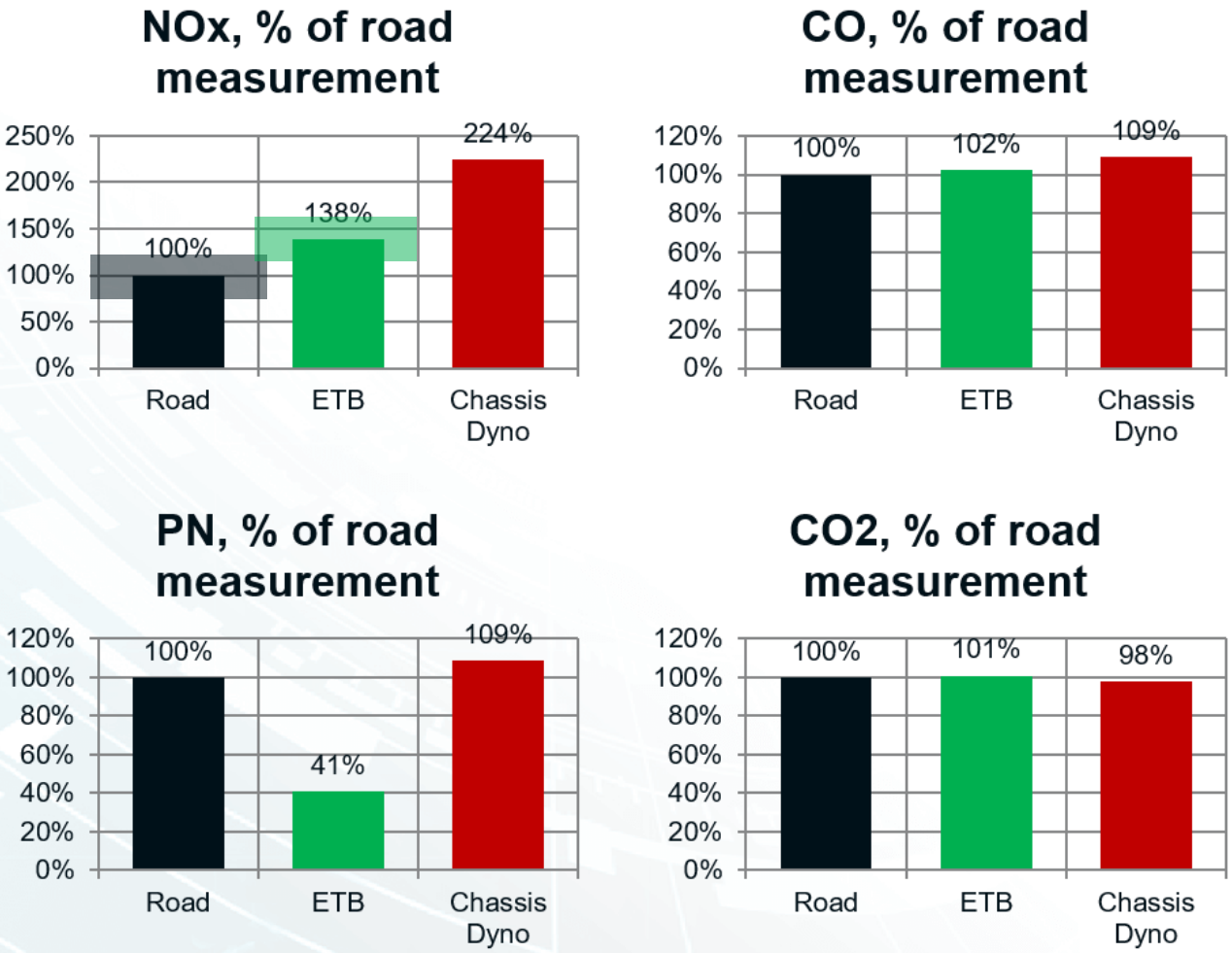
HIGHLIGHTS

- Time Reduction of 60% in in comparison to road
- Comparable results for different cycles with different driving styles, for both 2D and 3D
- Relevant events could be found much earlier
- RDE Calibration started much earlier before real hardware available

Details

Time course of gear, acceleration pedal, engine speed, engine torque and vehicle speed show good correlation.

Emission Results - Overall



- Norming the results to the road measurement leads to relatively big deviations – absolute deviations of the engine testbeds are in the range of the accepted measurement equipment error
- CO_2 and CO show a good match
- NOx and PN are strongly influenced by the boundary conditions (e.g.: fuel, air temperature and pressure)

Final Words

Where we need to improve

Simplify portfolio

Where we are good

Get the things done

Be like Lisa, not like Kevin.

www.avl.com