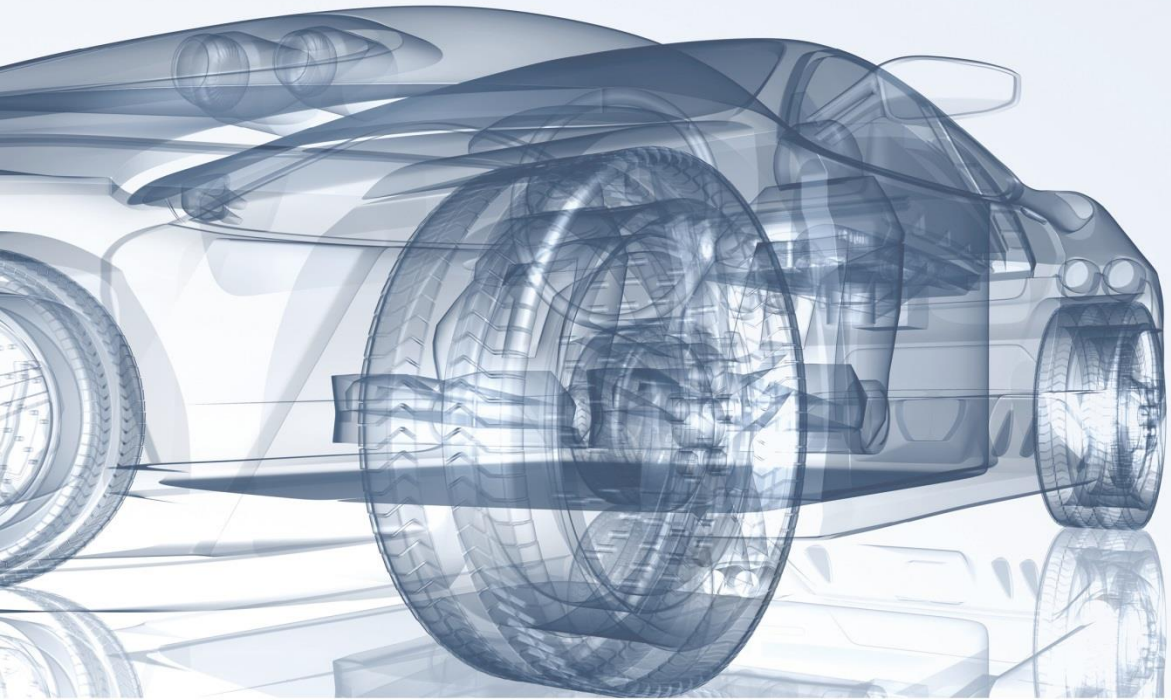
evs 30



The 30th International
Electric Vehicle
Symposium & Exhibition

October 9–11, 2017

Messe Stuttgart, Germany

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Laboratory Network Baden-Württemberg for Electric Mobility

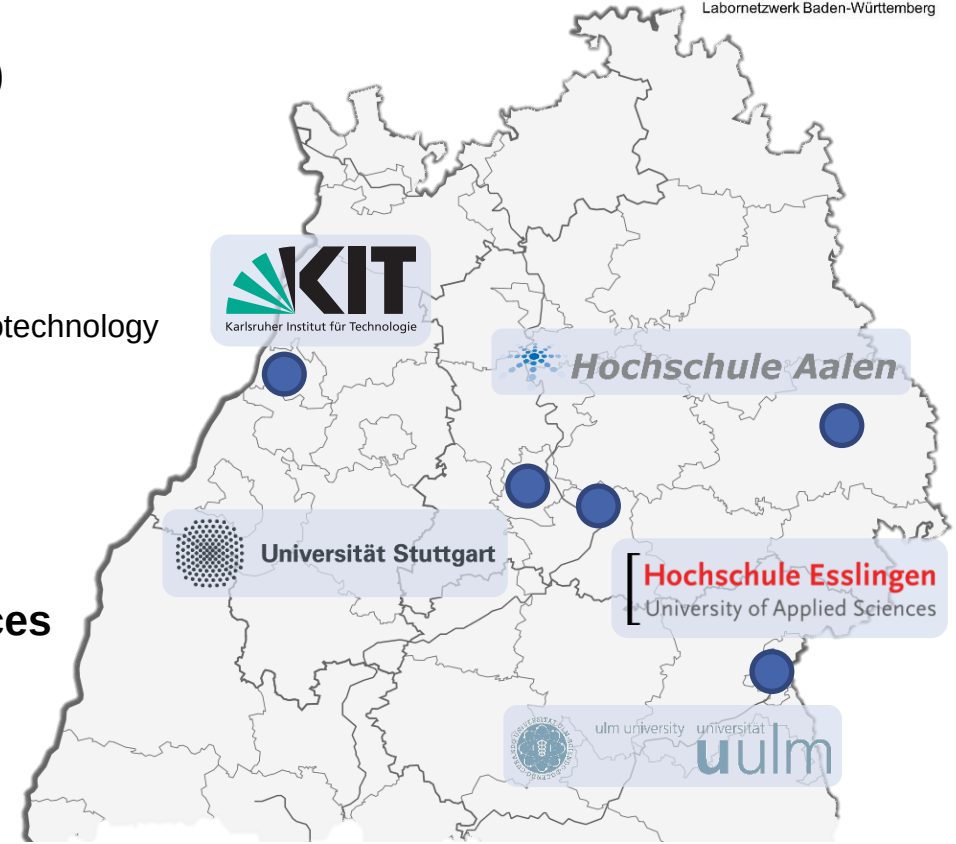
A. Albers, K. Dietmayer, M. Bargende, M. Behrendt, S. Yan, M. Buchholz, S. Zaiser, A. Rößler, T. Bernthaler

Frameworkbasiertes XiL-Labornetzwerk BW für Elektromobilität

XiL BW e
Labornetzwerk Baden-Württemberg

XiL-BW-e Project Partners

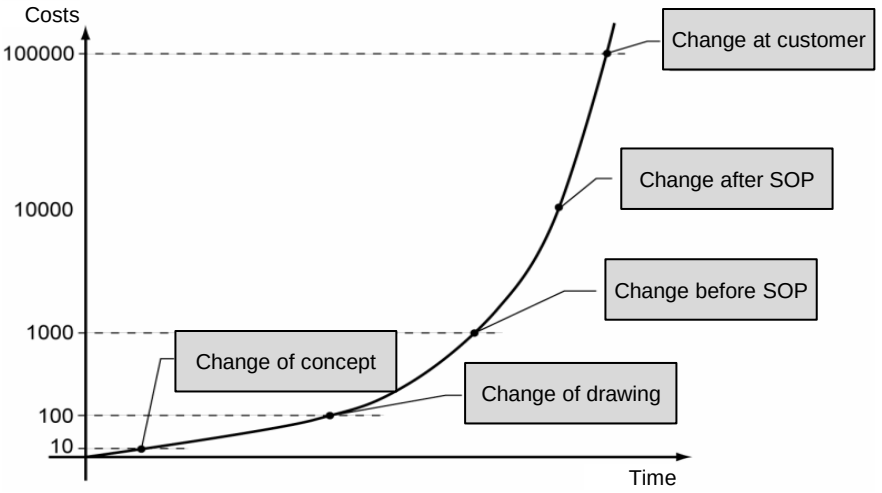
- **Karlsruhe Institute of Technology (KIT)**
  - IPEK - Institute of Product Engineering
  - FAST - Institute of Automotive System Technology
  - IFKM - Institute for Piston Machines
- **Ulm University**
  - MRM - Institute of Measurement, Control and Microtechnology
  - IE - Institute of Electrochemistry
  - IVK - Institute for Internal Combustion Engines and Automotive Engineering
- **University of Stuttgart**
  - IEW - Institute of Electrical Energy Conversion
- **Esslingen University of Applied Sciences**
  - Faculty of Information Technology
- **Aalen University of Applied Sciences**
  - IMFAA – Materials Research Institute



Introduction

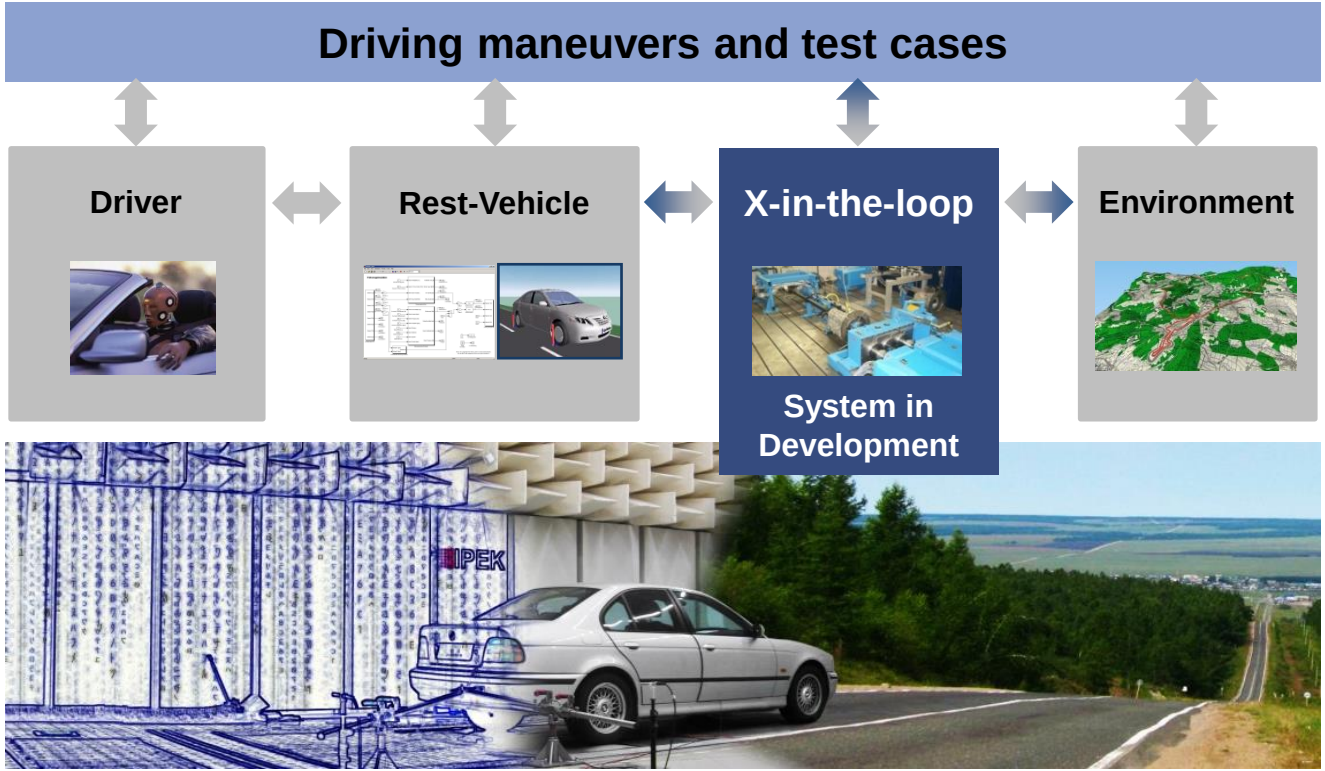
- Rule of Ten: The later an error is detected and corrected, the more expensive it is!

- Therefore error detection has to be:
  - Early as possible
  - Conducted with reasonable effort and quality
  - With the right quality at the right time



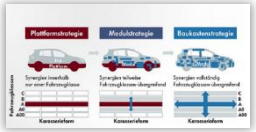
IPEK X-in-the-Loop-Approach to support early, continuous and holistic validation

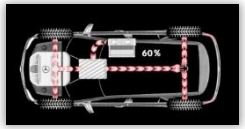
IPEK-XiL-Approach



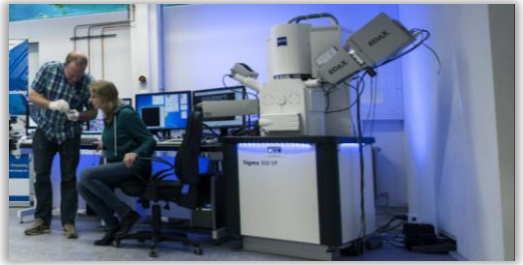
Motivation

- Changes and challenges in automotive development
  - Consolidation of modularization and modular strategies
  - Increased usage of **electric components in drive trains**
  - E-mobility, Connected Car and ADAS
  - **New key competences** in the automotive industry (e.g. **battery technology**)
- Increased and closer **interdisciplinary cooperation**
- Better **utilization of testing infrastructure**





Automotive product development will become more **distributed** and has to be more **connected** in the future!

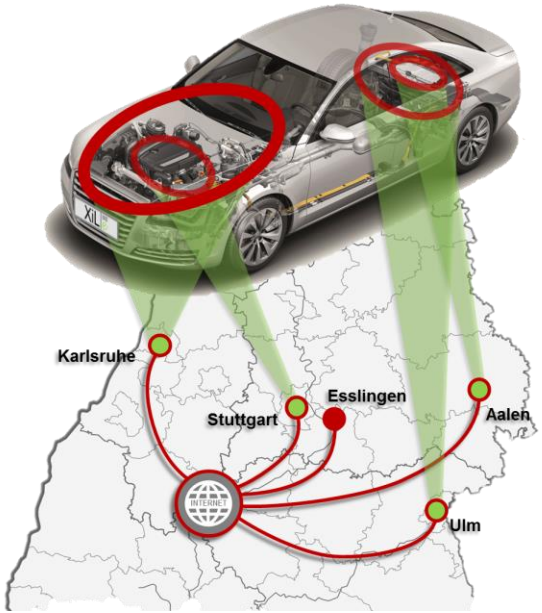


Laboratory Network BW for Electric Mobility

XiL BW e
Labornetzwerk Baden-Württemberg

Increase the competitiveness of the **research facilities in BW** by cooperative and cross-site **interdisciplinary research** in the field of **electric mobility**.

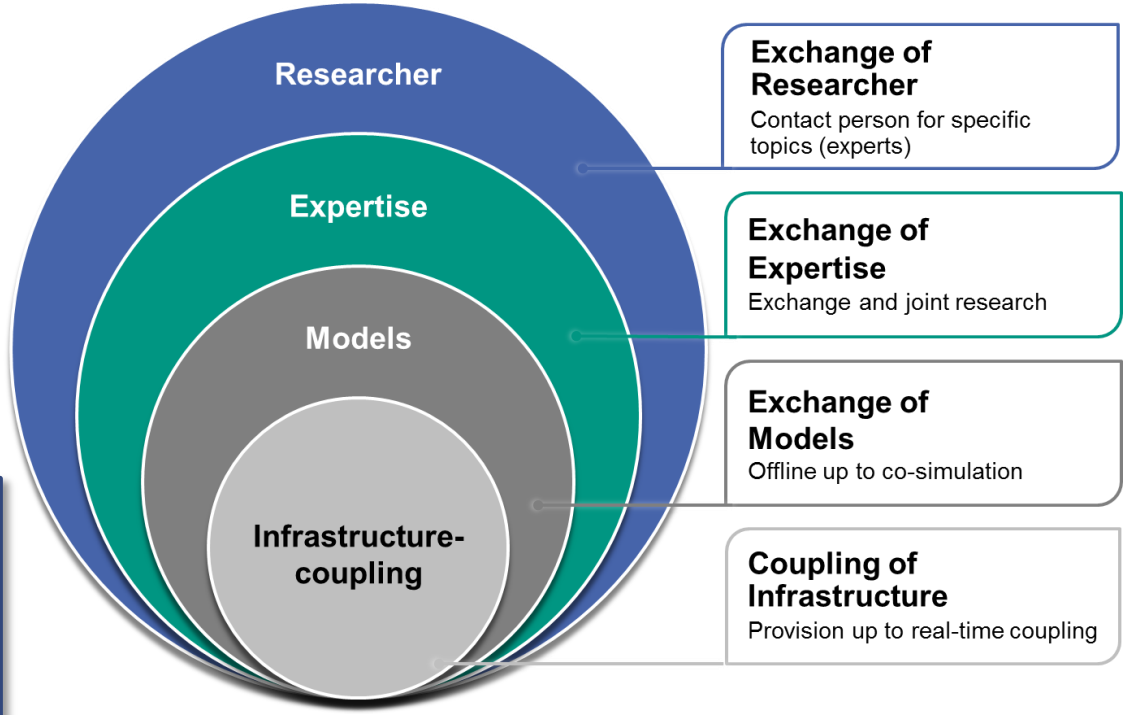
- **Organizational** integration
  - Structures for conducting collaborative research work
  - Central contact persons
  - Legal framework
- **Technical** integration
  - Online network of test beds
  - Offline sharing of simulation models
- Transfer to **industry**



Holistic Networking in XiL-BW-e

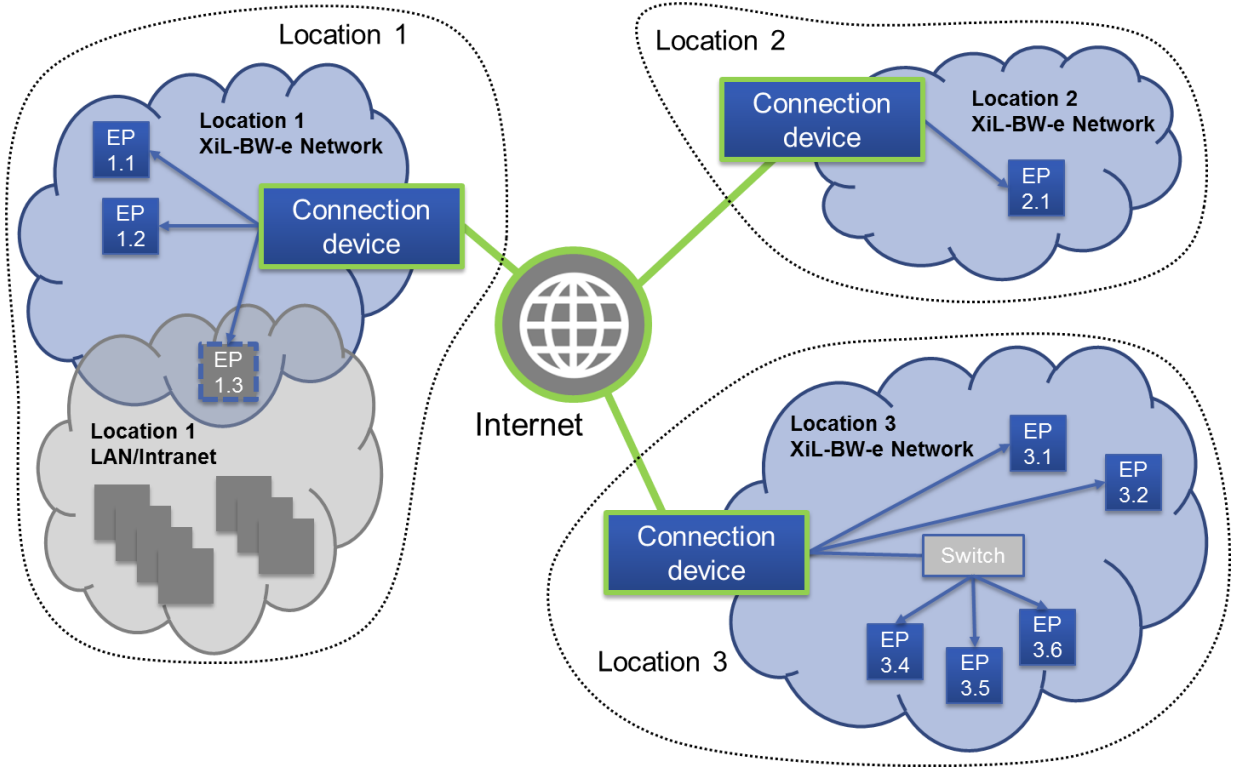
- **System testing network**
  → Overall **interactions** of single components of a vehicle
- **Battery analysis network**
  → **Battery cell** as a key component for electric mobility

Solutions have to be **accessible for researches** and **platform-independent** (esp. infrastructure coupling)



Technical Concept: Virtual Laboratory

- **Objective**: Connect specialized test beds for different components
- **Virtual Private Network** using the existing internet infrastructure
- State-of-the-art level of privacy by **encrypting all traffic**



EP: End Point

Technical Concept: Virtual Laboratory

- Network between Ulm and Esslingen
  - Every day within a week
  - Every hour within a day

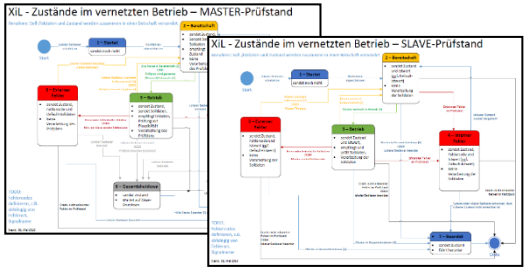
	UDP
Average RTT	3,25 ms
Minimal RTT	2,14 ms
Maximum RTT	21,65 ms
RTT < 10 ms	99,6718 %
RTT < 5 ms	96,3693 %

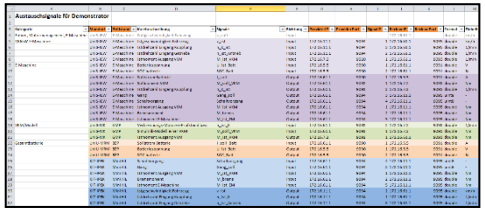
Average round-trip-time (RTT)

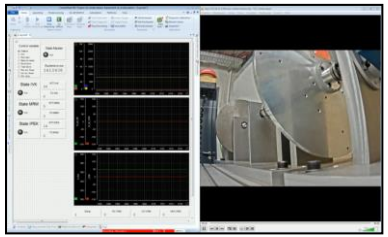
Uhrzeit	Montag	Dienstag	Mittwoch	Donnerstag	Freitag
00:00	3.07 ms	3.07 ms	3.08 ms	3.07 ms	3.08 ms
01:00	3.07 ms	3.07 ms	3.07 ms	3.06 ms	3.06 ms
02:00	3.05 ms	3.07 ms	3.07 ms	3.07 ms	3.09 ms
03:00	3.06 ms	3.06 ms	3.06 ms	3.07 ms	3.08 ms
04:00	3.08 ms	3.07 ms	3.06 ms	3.06 ms	3.07 ms
05:00	3.06 ms	3.07 ms	3.07 ms	3.08 ms	3.08 ms
06:00	3.07 ms	3.07 ms	3.07 ms	3.08 ms	3.07 ms
07:00	3.06 ms	3.13 ms	3.08 ms	3.08 ms	3.07 ms
08:00	3.07 ms	3.08 ms	3.09 ms	3.09 ms	3.13 ms
09:00	3.06 ms	3.08 ms	3.09 ms	3.08 ms	3.08 ms
10:00	3.09 ms	3.13 ms	3.07 ms	3.08 ms	3.08 ms
11:00	3.07 ms	3.07 ms	3.12 ms	3.10 ms	3.17 ms
12:00	3.06 ms	3.10 ms	3.09 ms	3.07 ms	3.09 ms
13:00	3.09 ms	3.09 ms	3.10 ms	3.07 ms	3.07 ms
14:00	3.06 ms	3.07 ms	3.12 ms	3.08 ms	3.08 ms
15:00	3.0	3.00		3.09	3.07 ms

Technical Concept: Application Layer

- Requirement: **Applicable on every test bed**
- **Master-slave architecture** for joint test runs
  - Standardized state machine available
- **IP/UDP**-based **communication** and **safety protocols**
  - First frames reserved for control and protocol data
  - Payload frames are defined specific for every test bed
  - **Payload signal table** defines the possible payload
- Log and save measurement data for post processing
  - Exchange signals are logged at the master testbed
  - Other measurement data are shared on a data server for post-processing
- **Video transmission** of test beds **within the VPN**.

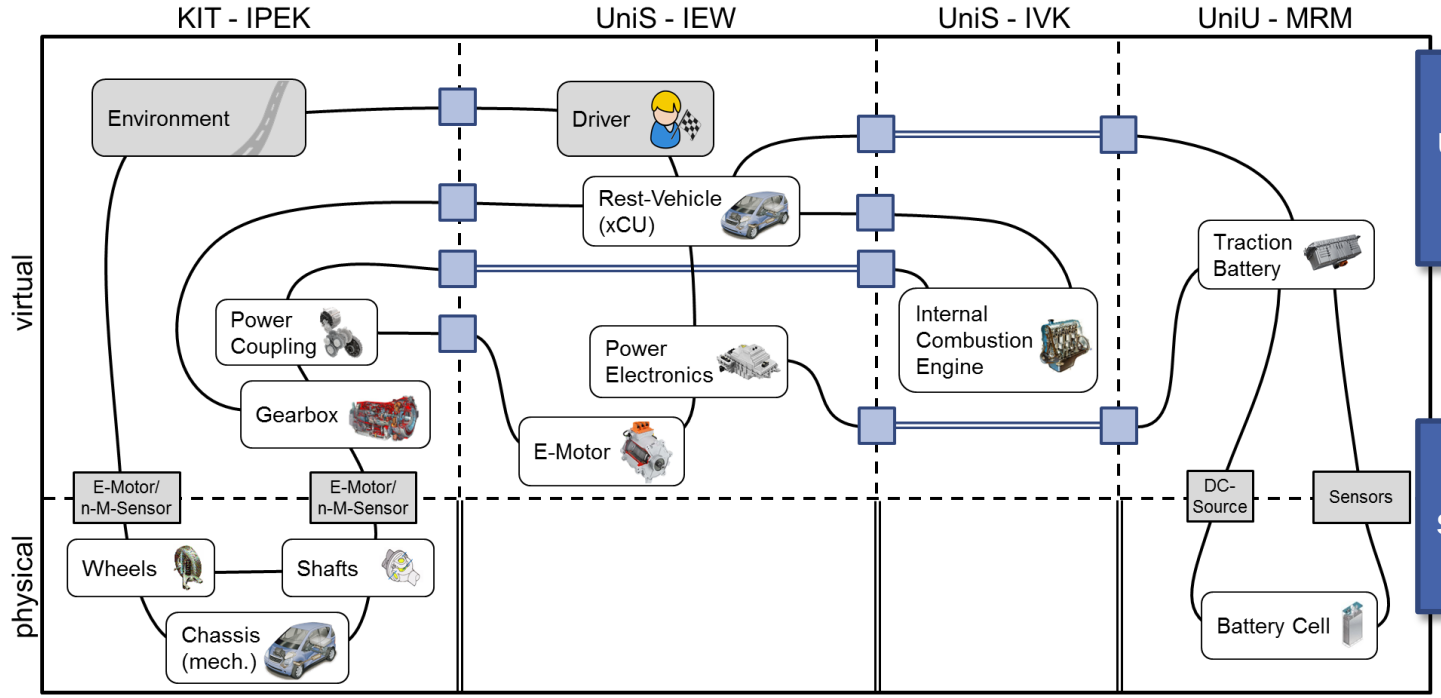






Hybrid Vehicle as Demonstration System

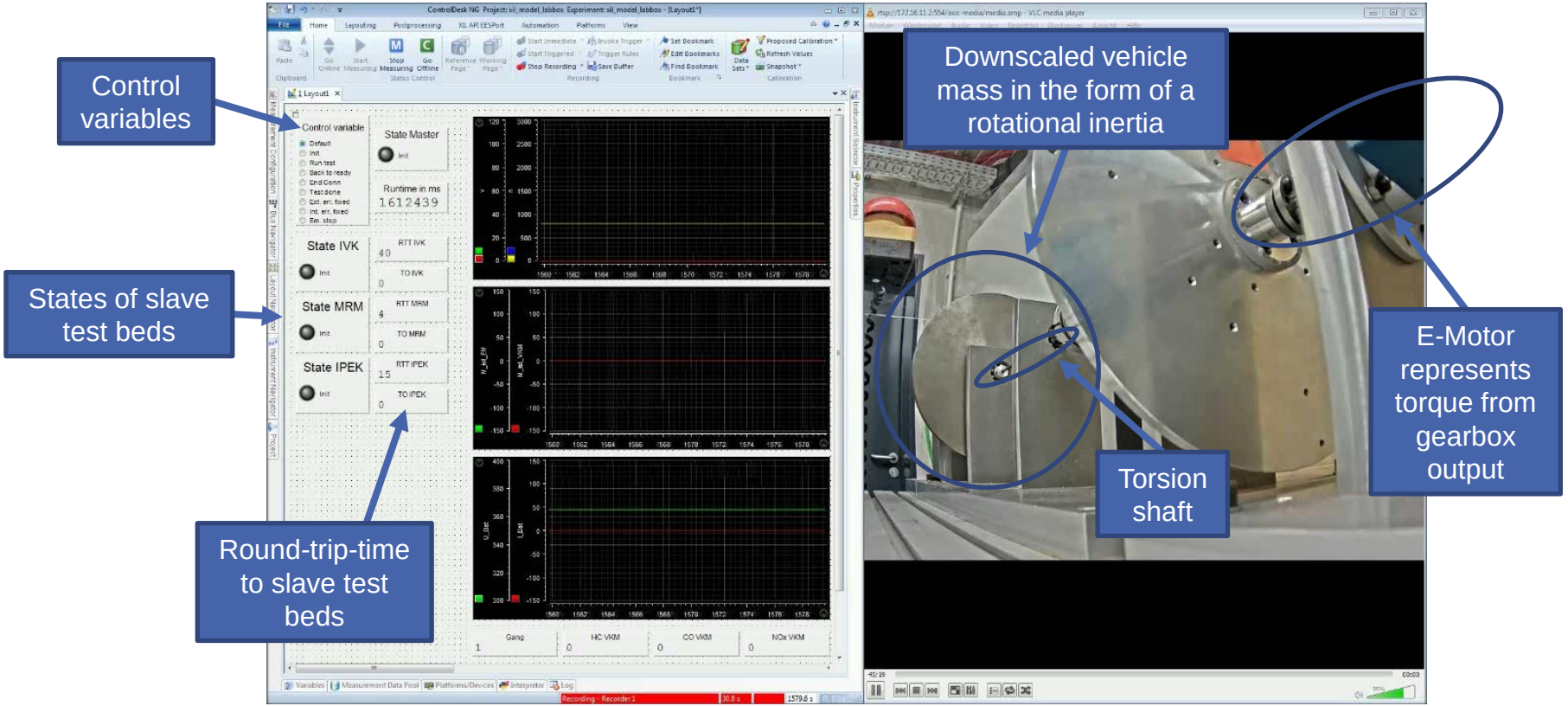
- Method for Planning: **Spatial location** and **model domain** of subsystems



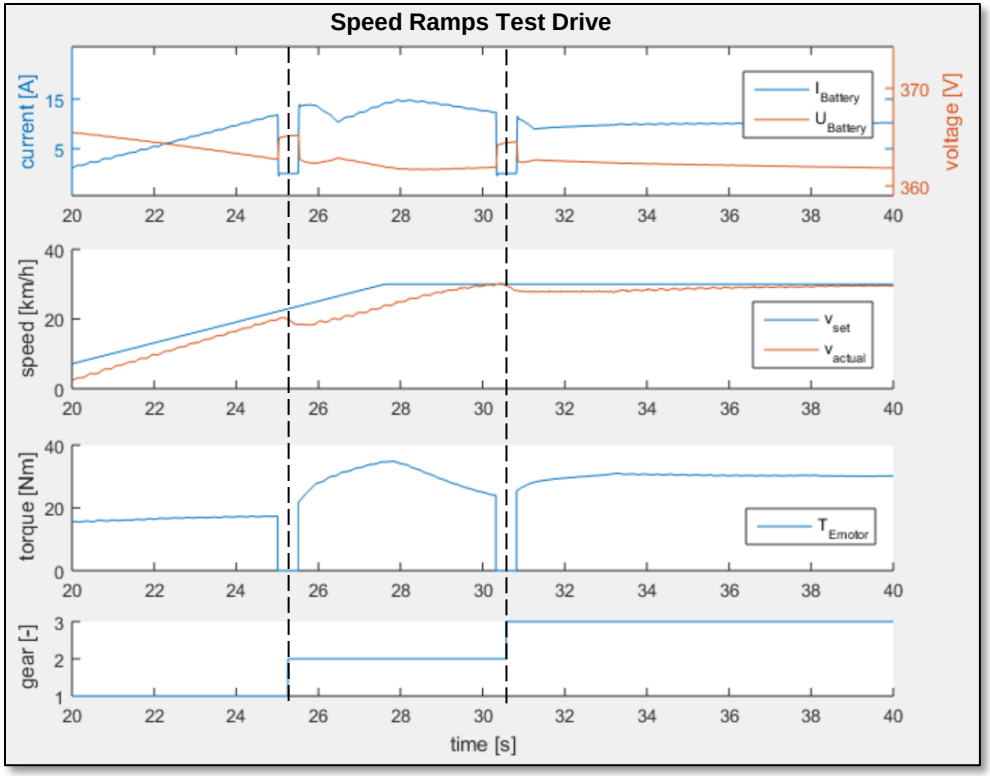
Create a common understanding of the **systemic state of distribution**!

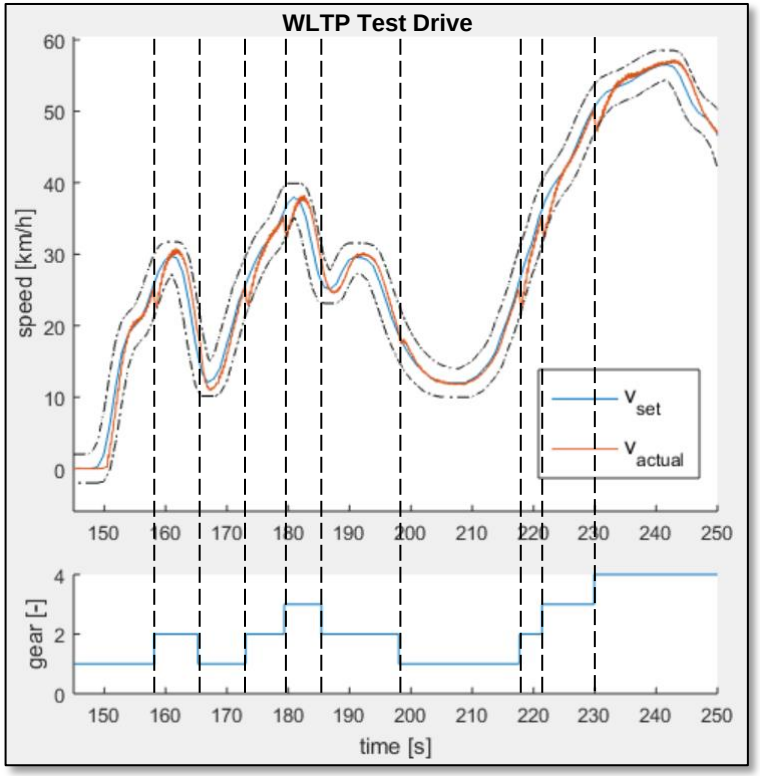
Define **exchange signals** according to payload table

Screenvideo at Master Test Bed (UniS-IEW)



Demonstration System: Exemplary Results





Summary and Outlook

- **XiL-Approach** for distributed validation environment implemented
- Strong network for testing and research in the area of electric vehicles
- **Organizational, legal and technical framework** for testing and research of components based on real loads in the specific use cases
- Better **utilization of existing testing infrastructure**

- New research possibilities:
  - Battery aging
  - Operation strategies
  - Real-driving emissions
  - Powertrain topology optimization

…even **before complete vehicle prototypes are built!**

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for more infomation

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BACKUP: Payload Signal Table for Demo

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	Kategorie	Standort	Prüfstand	Kurzbeschreibung	Signale	Richtung	ProviderIP	ProviderPort	SignalID	RecieveIP	RecievePort	Format	Einheit
4	Fahrer, Motormanagement, E-Maschine	UniS-IEW	E-Maschine	Sollgeschwindigkeit Fahrzeug	v_soll	Input	-		-	172.16.61.1	-	double	km/h
5	186kW E-Maschine	UniS-IEW	E-Maschine	Istgeschwindigkeit Fahrzeug	v_ist	Input	172.16.11.1	9094	1	172.16.61.1	9095	double	km/h
6		UniS-IEW	E-Maschine	Istdrehzahl Eingang Kupplung	n_K_ist	Input	172.16.11.1	9094	3	172.16.61.1	9095	double	1/min
7		UniS-IEW	E-Maschine	Istdrehzahl Eingang Getriebe	n_ist_Antrieb	Input	172.16.11.1	9094	2	172.16.61.1	9095	double	1/min
8		UniS-IEW	E-Maschine	Istmoment Ausgang VKM	M_ist_VKM	Input	172.16.7.2	9020	1	172.16.61.1	9093	double	1/min
9	E-Maschine	UniS-IEW	E-Maschine	Batteriespannung	U_ist_Batt	Input	172.16.5.5	9090	1	172.16.61.1	9091	double	V
10		UniS-IEW	E-Maschine	SOC batterie	SOC_Batt	Input	172.16.5.5	9090	2	172.16.61.1	9091	double	%
11		UniS-IEW	E-Maschine	Sollstrom Batterie	I_soll	Output	172.16.61.1	9090	1	172.16.5.5	9091	double	A
12		UniS-IEW	E-Maschine	Sollmoment VKM	M_soll_VKM	Output	172.16.61.1	9092	1	172.16.7.2	9093	double	Nm
13		UniS-IEW	E-Maschine	Istdrehzahl Eingang Kupplung	n_K_ist	Output	172.16.61.1	9092	2	172.16.7.2	9093	double	1/min
14		UniS-IEW	E-Maschine	Gang	Gang_soll	Output	172.16.61.1	9094	3	172.16.11.1	9095	uint8	-
15		UniS-IEW	E-Maschine	Schaltvorgang	Schaltvorgang	Output	172.16.61.1	9094	4	172.16.11.1	9095	uint8	-
16		UniS-IEW	E-Maschine	Istmoment Ausgang VKM	M_ist_VKM	Output	172.16.61.1	9094	1	172.16.11.1	9095	double	Nm
17		UniS-IEW	E-Maschine	Bremsmoment	M_brems	Output	172.16.61.1	9094	2	172.16.11.1	9095	double	Nm
18		UniS-IEW	E-Maschine	Istmoment E-Maschine	M_ist_EM	Output	172.16.61.1	9094	5	172.16.11.1	9095	double	Nm
19	VKM/Modell	UniS-IVK	GMP	Verbrennungs-Motoren-Prüfstand bzw.	n_ist_K	Input	172.16.61.1	9092	2	172.16.7.2	9093	double	1/min
20		UniS-IVK	GMP	Simulink-Modell einer VKM	M_soll_VKM	Input	172.16.61.1	9092	1	172.16.7.2	9093	double	Nm
21		UniS-IVK	GMP	Istmoment Ausgang VKM	M_ist_VKM	Output	172.16.7.2	9092	1	172.16.61.1	9093	double	Nm
22	Gesamtbatterie	UniU-MRM	BZP	Sollstrom Batterie	I_soll_Batt	Input	172.16.61.1	9090	1	172.16.5.5	9091	double	A
23		UniU-MRM	BZP	Batteriespannung	U_ist_Batt	Output	172.16.5.5	9090	1	172.16.5.5	9091	double	V
24		UniU-MRM	BZP	SOC batterie	SOC_Batt	Output	172.16.5.5	9090	2	172.16.5.5	9091	double	%
25		KIT-IPEK	MiniHiL	Schaltvorgang	Schaltvorgang	Input	172.16.61.1	9094	4	172.16.11.1	9095	uint8	-
26		KIT-IPEK	MiniHiL	Gang	Gang_soll	Input	172.16.61.1	9094	3	172.16.11.1	9095	uint8	-
27		KIT-IPEK	MiniHiL	Istmoment Ausgang VKM	M_ist_VKM	Input	172.16.61.1	9094	1	172.16.11.1	9095	double	Nm
28		KIT-IPEK	MiniHiL	Bremsmoment	M_brems	Input	172.16.61.1	9094	2	172.16.11.1	9095	double	Nm
29		KIT-IPEK	MiniHiL	Istmoment E-Maschine	M_ist_EM	Input	172.16.61.1	9094	5	172.16.11.1	9095	double	Nm
30		KIT-IPEK	MiniHiL	Istgeschwindigkeit Fahrzeug	v_ist	Output	172.16.11.1	9094	2	172.16.61.1	9095	double	km/h
31		KIT-IPEK	MiniHiL	Istdrehzahl Eingang Kupplung	n_ist_K	Output	172.16.11.1	9094	1	172.16.61.1	9095	double	1/min
32		KIT-IPEK	MiniHiL	Istdrehzahl Eingang Getriebe	n_ist_Antrieb	Output	172.16.11.1	9094	3	172.16.61.1	9095	double	1/min