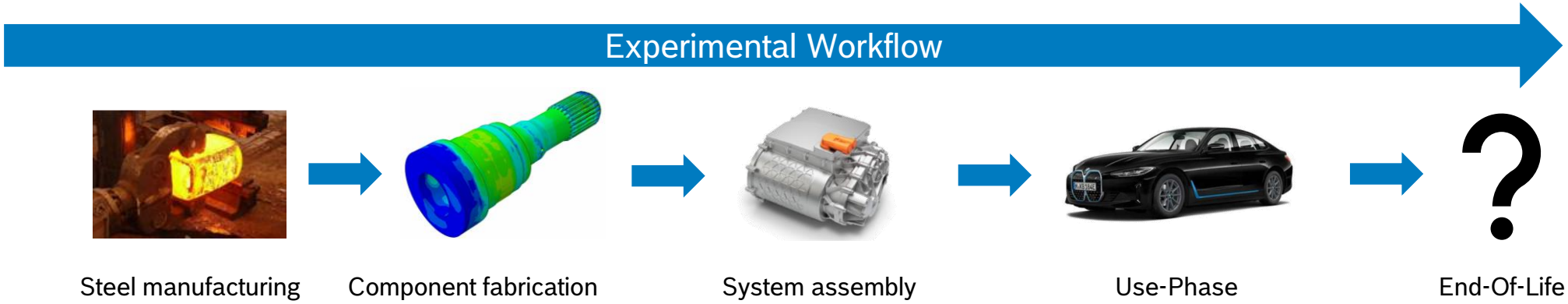
Digital material analysis along the entire value chain for **St**eel components; **E**fficiency, service **L**ife and carbon footprint (**DiStEL**)

Federal Ministry
of Research, Technology
and Space

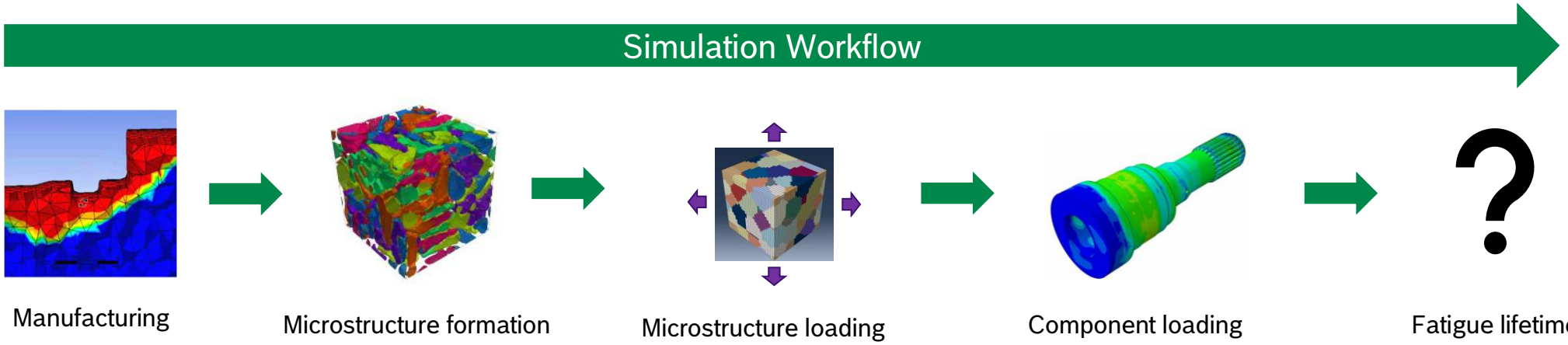
DiStEL – Motivation



Challenges:

- Individual steps in process chain designed separately from each Tier
- EOL decision / R-strategies can not be based on composition, process chain and use-phase
- Product carbon footprint calculation not accurate
- Holistic optimization of process chain not possible due to lack of interoperability

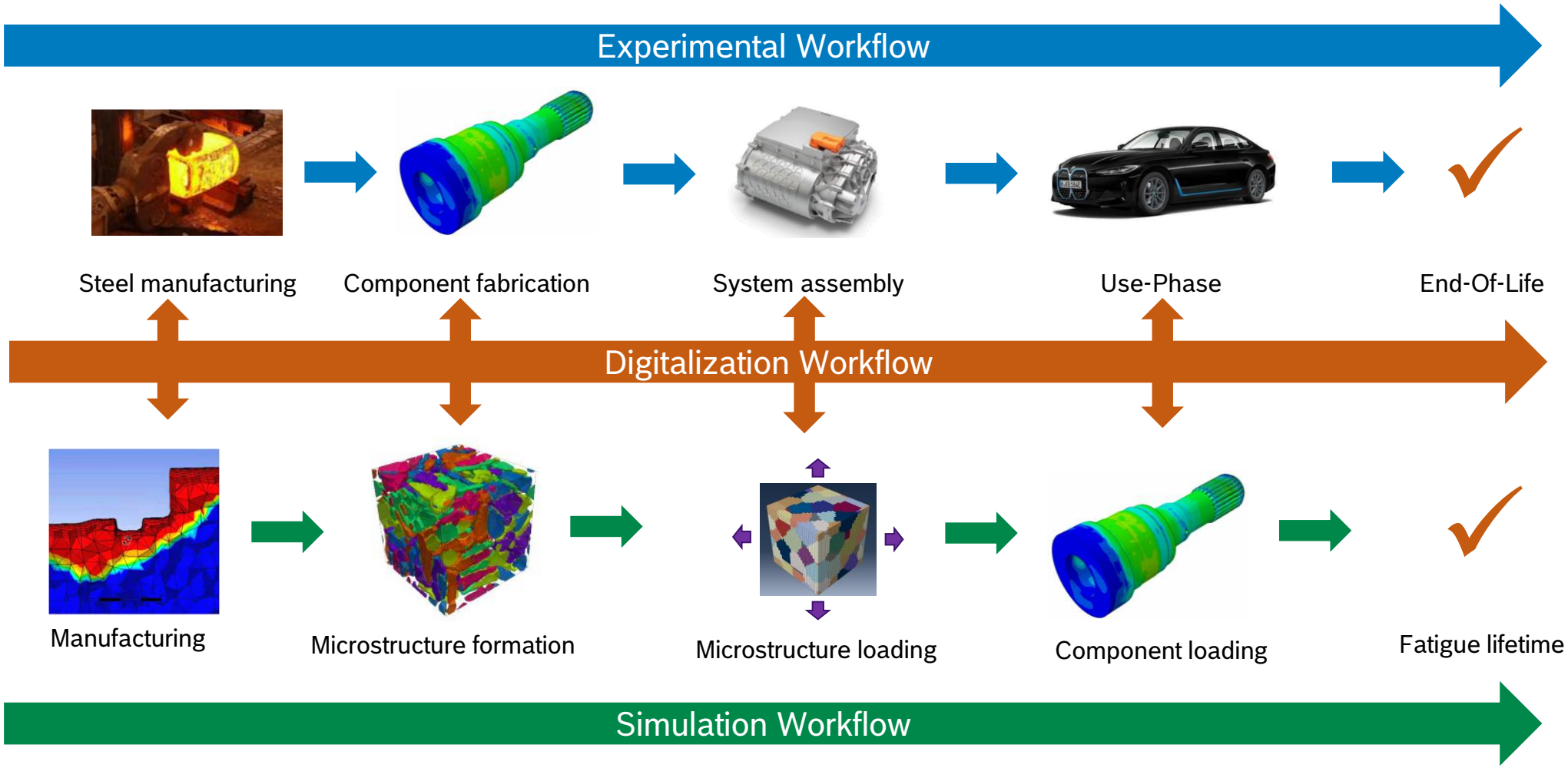
DiStEL – Motivation



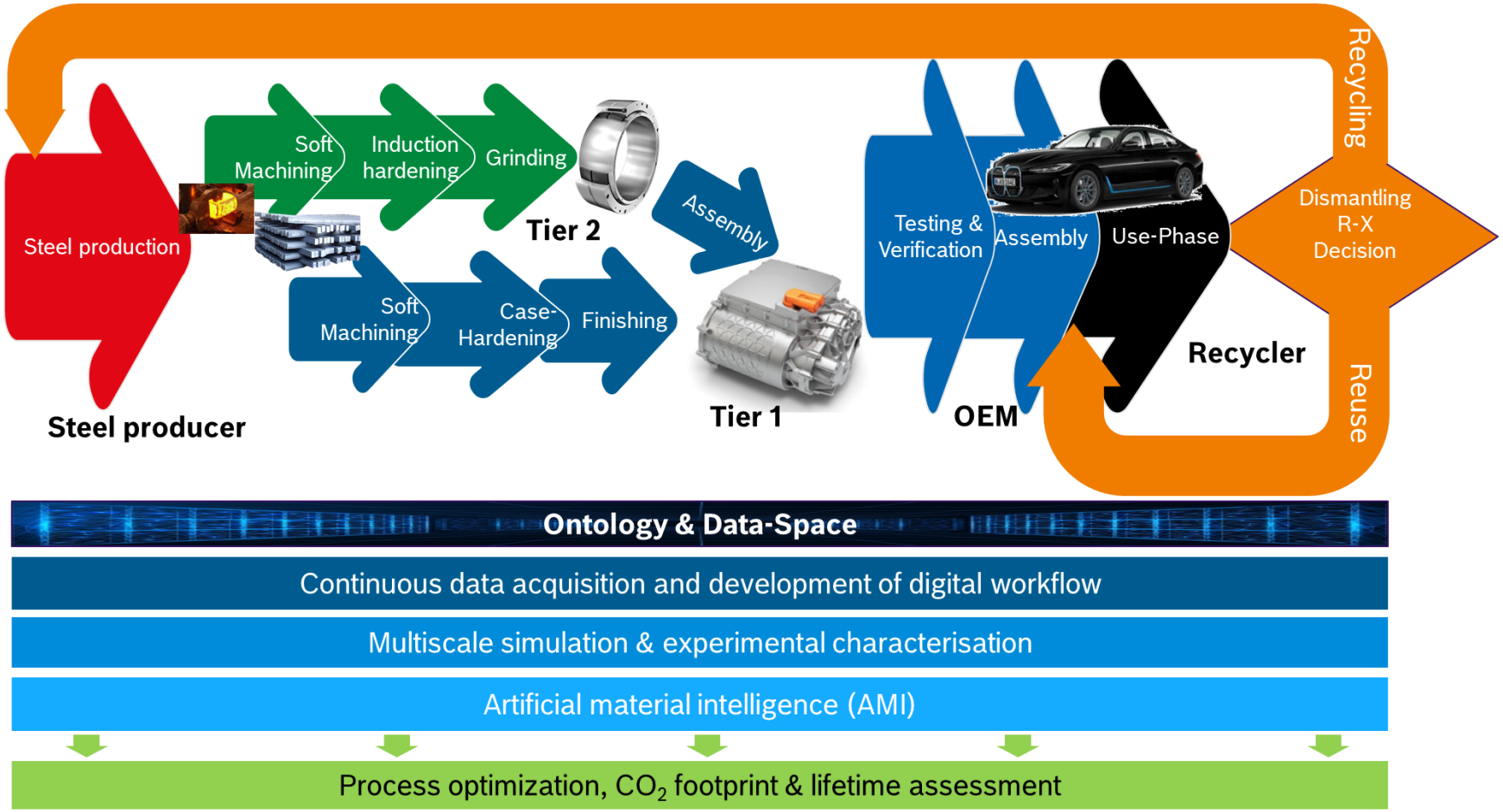
Challenges:

- Material data for individual simulation steps not readily available
- Process chain not considered
- Real-world loading cases unknown
- Holistic optimization of process chain not possible not possible due to lack of interoperability

DiStEL – Motivation



DiStEL – Overview Value Chain



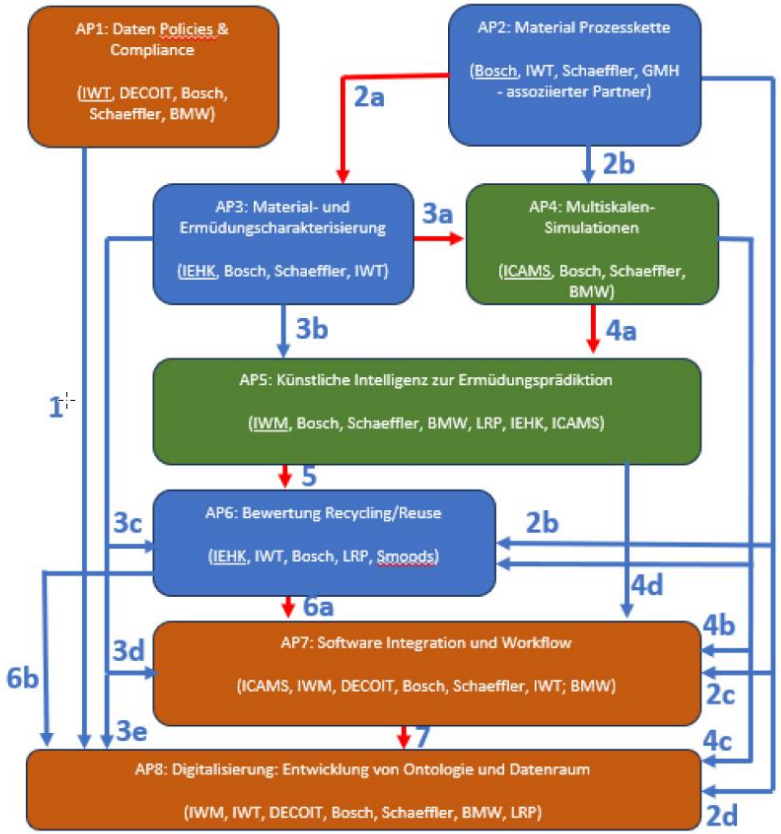
DiStEL – Overview
Goals, Benefits, Technologies

Goals:
- Holistic **digital representation** of material states during manufacturing, use-phase and 2nd-life
- Establish **intercompany exchange** using a federated **Data-Space**
- Show potential for **data-driven business**

Benefits:
- **Optimization** of process chains, Product Carbon Footprint (PCF) and component lifetime
- Improved decision making for **R-strategies**

Technologies:
- **Multi-scale Modeling and Simulation** (heat treatment, crystal plasticity, fracture mechanics, component level)
- **Experimental Characterization** (chemical, metallographic, microstructural, quasi-static, fatigue)
- **Ontology** for semantic description of process, µ-structure and material properties
- **Catena-X Data-Space** for intercompany exchange

DiStEL – Overview
Consortium and Work Packages



Industrial partners:

- Bosch (Digitalization, Experimental, Simulation - **lead**)
- BMW (Digitalization, Experimental)
- Schaeffler (Digitalization, Experimental, Simulation)
- LRP (Digitalization, Experimental)
- Decoit (Digitalization)
- Smoods (Digitalization)

Academic partners:

- IWT (Digitalization, Experimental)
- IWM (Digitalization, Simulation)
- ICAMS (Simulation)
- IEHK (Experimental)

Associated partners:

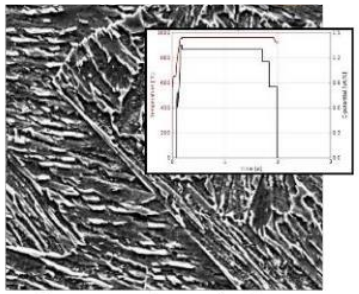
- GMH (Experimental)
- Open-Phase Solutions (Simulation)
- Greenable (Digitalization)

DiStEL – Current status
Working Group Experiments

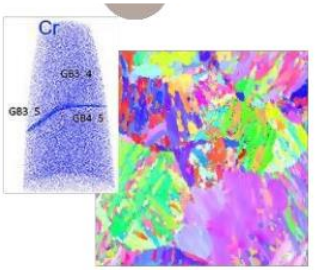
- Recycling melts with increased Cu and Cu + Sn content

- Extensive microstructural and mechanical testing

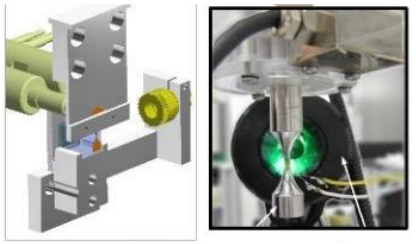
Continuous collection of processing data



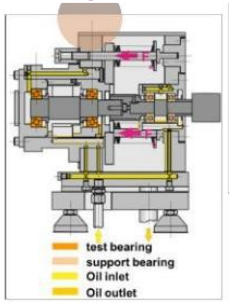
Analytical methods



Fatigue properties micromechanical



Fatigue properties component



IWT Leibniz-Institut für Werkstofforientierte Technologien

IEHK RWTH AACHEN UNIVERSITY

IWT Leibniz-Institut für Werkstofforientierte Technologien

BOSCH SCHAEFFLER

Fraunhofer IWM

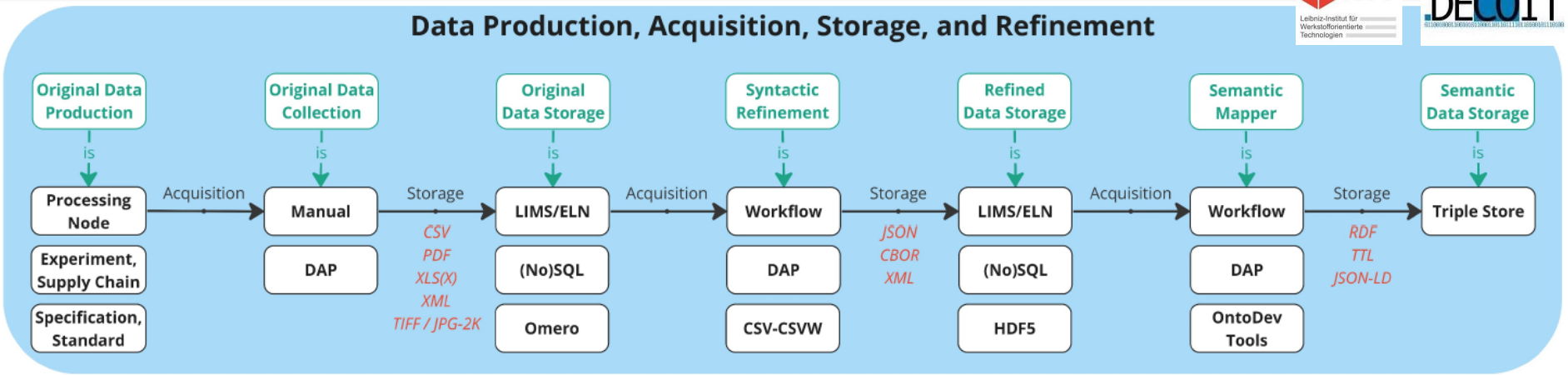
- Dismantling and R-strategies

BOSCH SCHAEFFLER smoods SMART CAR RECYCLING LRP BMW

BOSCH

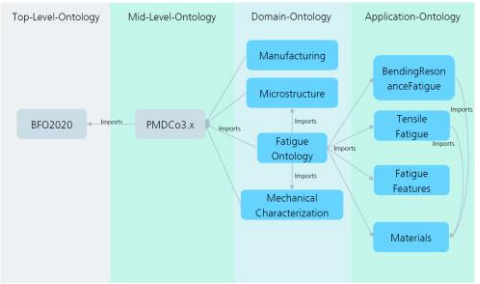
DiStEL – Current status
Working Group Digitalization

- Data Acquisition Pipeline



- Application ontology development

Institute	Concepts	Category	Remarks
Schaeffler	Material delivery	Objects	Conformance of material to material-compliance policies, mater
	Heat treatment	Manufacturing	SHD, heat treatment parameters (austenitization temperature, h
	Induction hardening	Manufacturing	Inductor geometry, current, voltage, frequency, actual temperatu
	Rolling contact fatigue test	Characterization	Residual stress profiles, lifetime, medium, temperature
	Cyclic elastic-plastic stress strain	Characterization	Material parameters from stress-strain raw data
	EBSD	Characterization	Predominant crystallographic planes
	Usage		Use-phase CO2 emission for load spectrum, running condition
	Lifetime model	Data Transformation	Remaining lifetime for load spectrum
Bosch	Material to Products	Objects	Materials to Product level description including properties incl. te
	Heat treatment	Manufacturing	Austenitization temperature, holding period, number of pulses, a
	Case hardening	Manufacturing	
	Machining	Manufacturing	
	Fatigue test	Manufacturing	Remaining lifetime for load spectrum
ICAMS	Heat treatment simulation	Manufacturing	Nominal composition, cooling rate, cooling medium, software ve
LRP	Disassembly of e-axle	Disassembly	Disassembly procedure, duration, lubricant information
	Condition assessment	Characterization	Surface damage (cracks, pitting, abrasion, rust) using imaging
	Remaining lifetime assessment	Data Transformation	

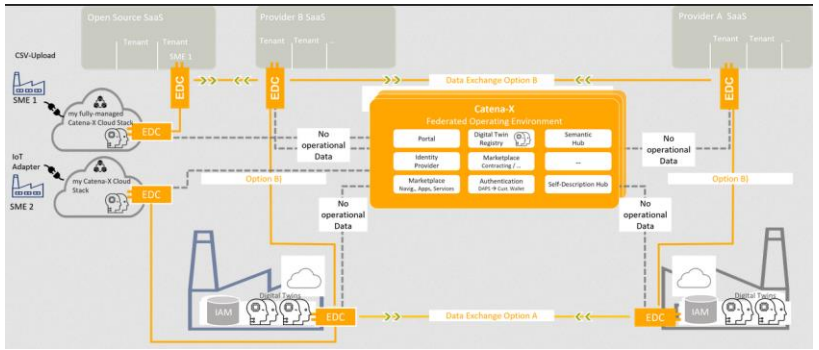


DiStEL – Current status
Working Group Digitalization

- PMD Tools:
  - Data Portal / CKAN
  - OntoDocker

MATERIALDIGITAL
DataPortal

- Catena-X DataSpace



Catena-X
Your Automotive Network

- Connecting both worlds, **see also PMD-X project talk EDCar**

DiStEL – Current status
Working Group Modeling

Macroscale

Microscale

Load profile

Heat treatment simulation

BOSCH
SCHAEFFLER

Loading simulation

Georgsmarienhütte GMH GRUPPE

Chemical composition

Chemical composition

Cooling curve

Load profile

Effective properties

Fraunhofer IWM

BOSCH
SCHAEFFLER

ICAMS

Microstructure

Microstructure Formation

Property prediction

DiStEL – Summary