

**The Fourth Sino-German Workshop on Digital Transformation of Manufacturing Industry
Artificial Intelligence and Digital Manufacturing, Shanghai, P.R. China**

Artificial Intelligence Solutions for Industrie 4.0

Professor Dr. Dr. h.c. mult. Wolfgang WAHLSTER



Saarbrücken, Kaiserslautern, Bremen, Berlin, Oldenburg, Osnabrück (Germany)

Phone: +49 30 238 95 1844/1800

Email: wahlster@dfki.de

WWW: <http://www.dfki.de/~wahlster>

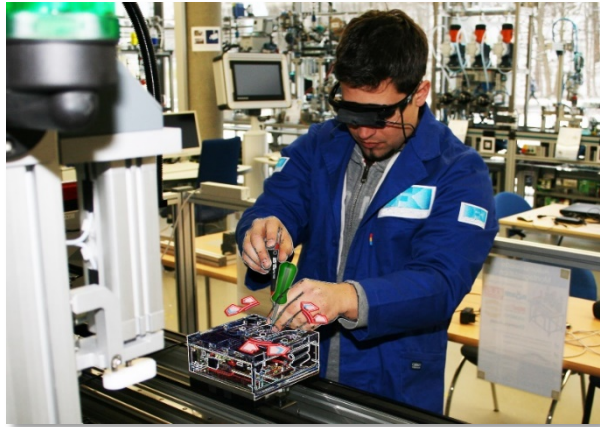
Worldwide Megatrend: Industrie 4.0 based on AI



The concept of Industrie 4.0 was created in 2010 and first published in 2011 by Wahlster, Kagermann and Lukas

Till 2019 more than 80.000 papers have been published on Industrie 4.0

PLATTFORM
INDUSTRIE4.0



Examples of Industrie 4.0
Smart Factories deployed
by DFKI's Shareholders



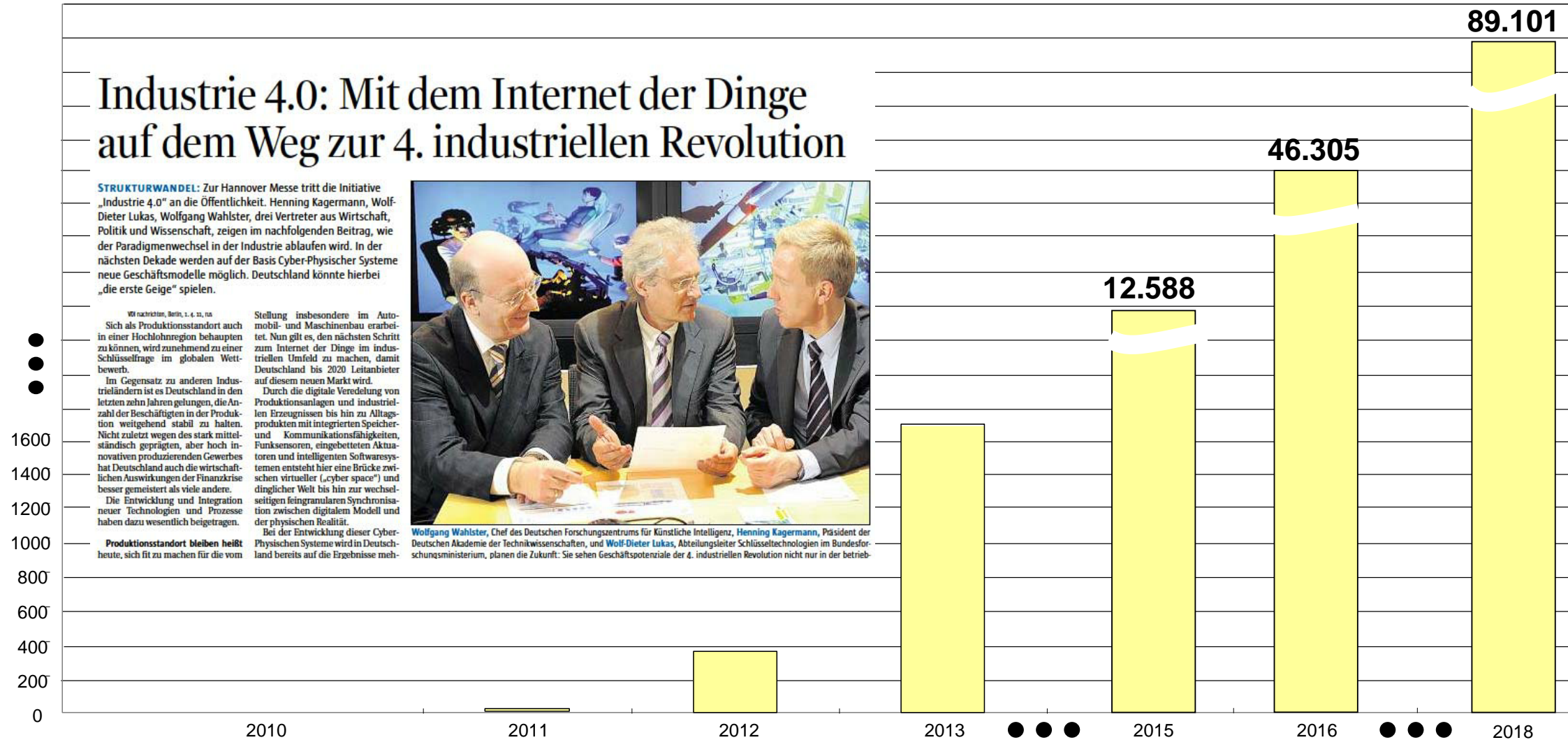
Total Investment in R&D
for Industrie 4.0: 140 Billion €
per year in Europe



VOLKSWAGEN
AKTIENGESELLSCHAFT

AIRBUS
GROUP

After Our Initial Publication in April 2011 the German Term „Industrie 4.0“ was Propagated Exponentially Worldwide



According to GENIOS Data Base of Publications in Germany

Artificial Intelligence for the Second Wave of Digitalization



First Wave:

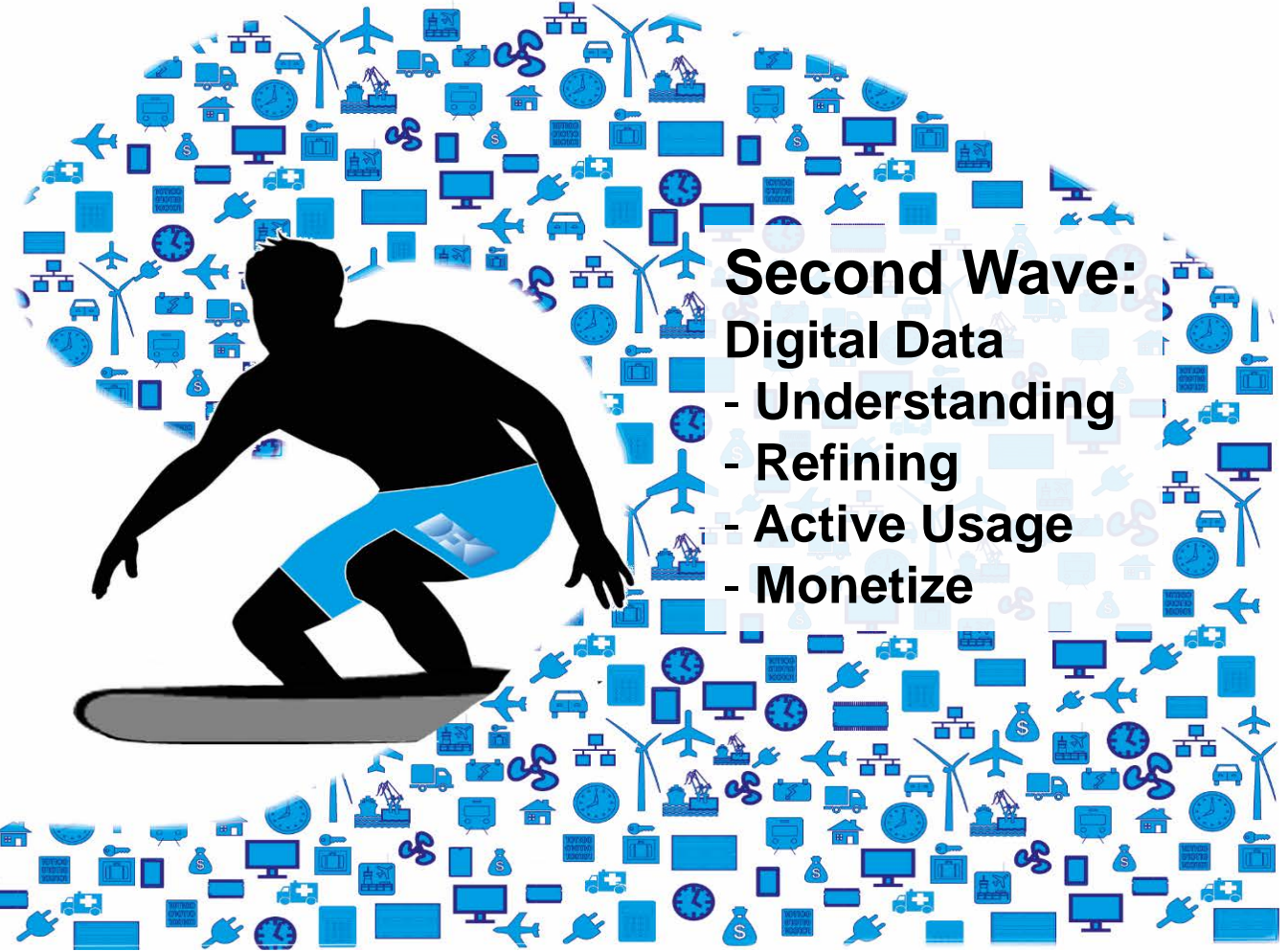
Digital Data

- Record
- Save
- Transmit
- Process

Second Wave:

Digital Data

- Understanding
- Refining
- Active Usage
- Monetize



Machine-readable Data:
Internet and Cloud
Technologies

Machine-understandable Data:
Artificial Intelligence and Machine Learning

Germany's AI Strategy Targeting Disruptive Service Innovations for National Export Champions



**Smart Farming Service:
Real-time Harvesting
Decision Support**

**Smart Certification Service
for Autonomous Cars**



**First National AI Summit: Expert Meeting
with the Chancellor and 6 Ministers
May 2018**



**Smart Construction Site Service
for Remote Activity Control**

**Smart Emergency Service
for Search and Rescue**

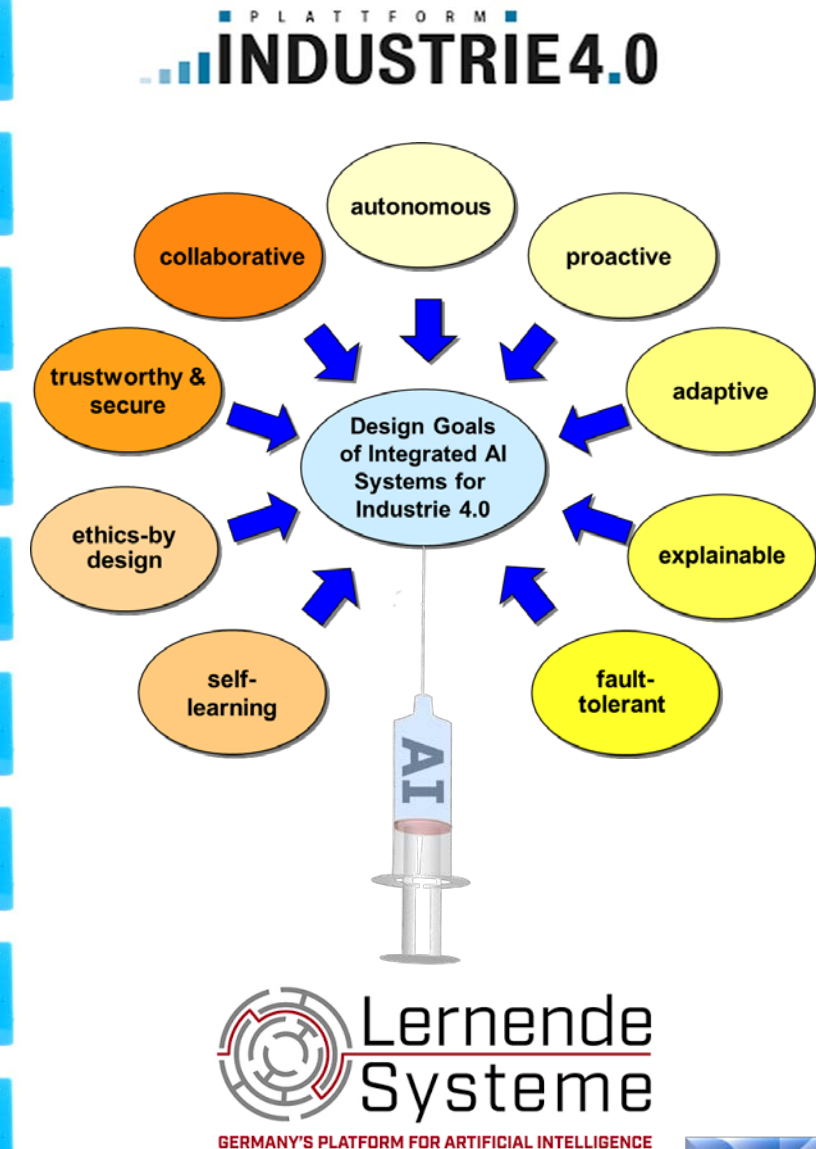
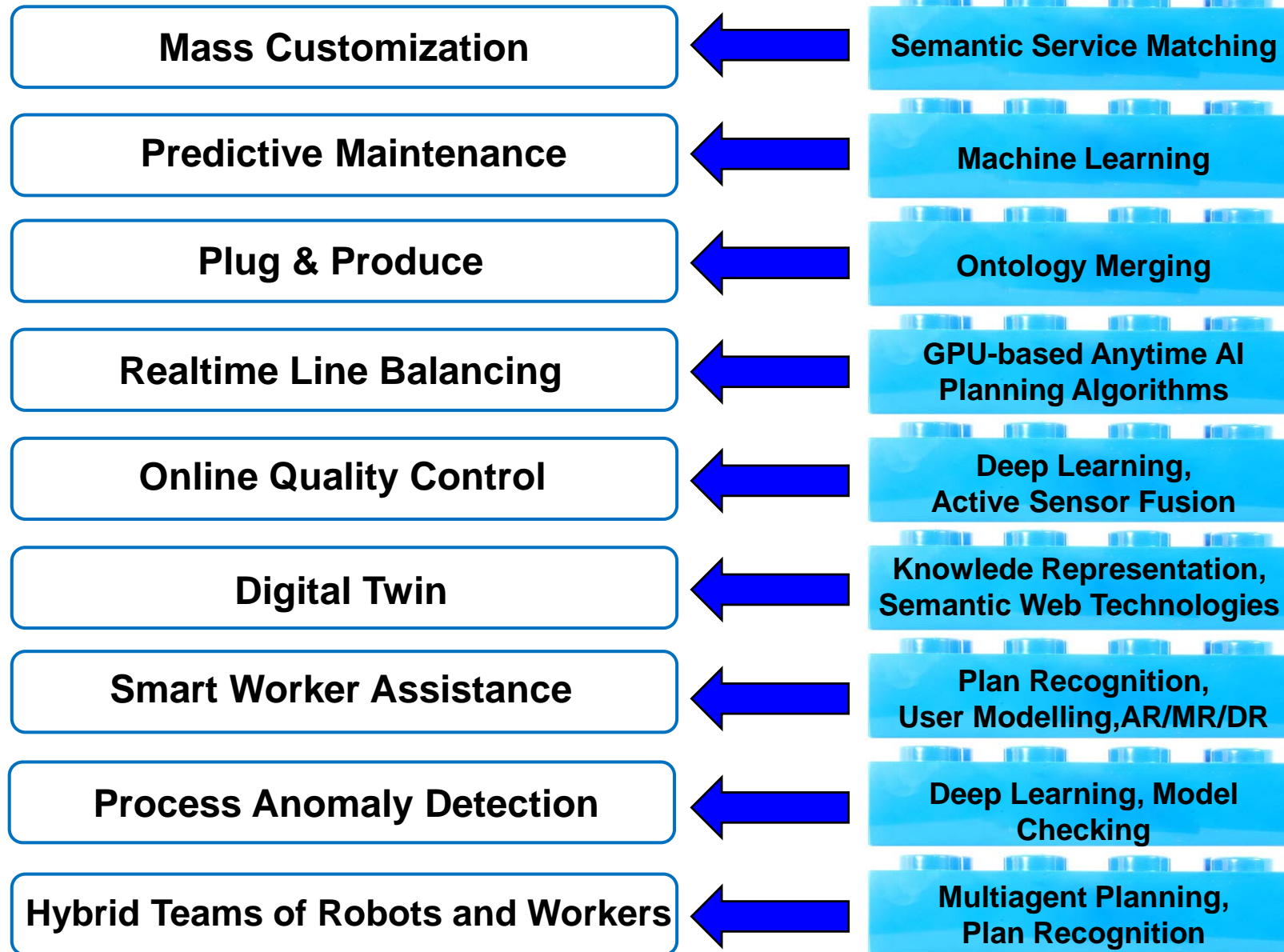


Integrated AI Technologies for Industrie 4.0



Industrie 4.0 Characteristics

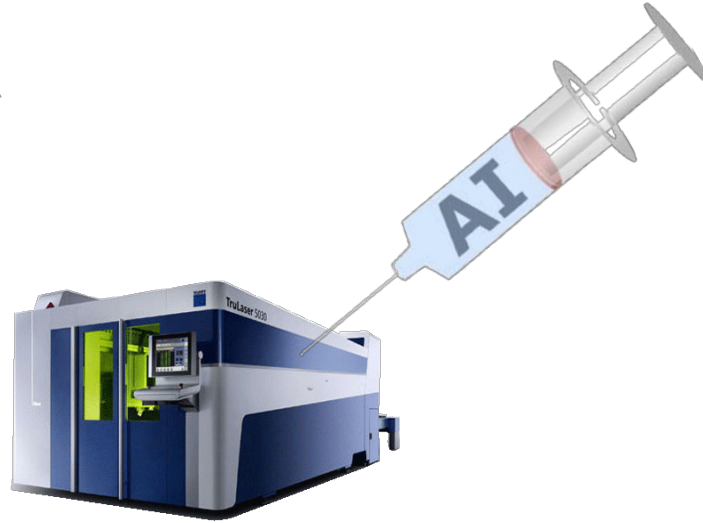
Demand for AI Solutions



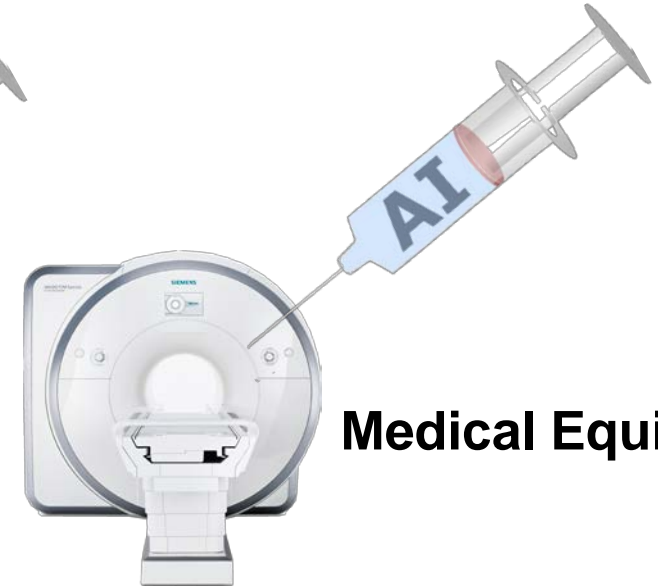
Boosting Economy by Injecting AI: Transforming Successful Export Products Into Smart Products



Cars



Manufacturing Equipment



Medical Equipment



Aircrafts



Home Appliances

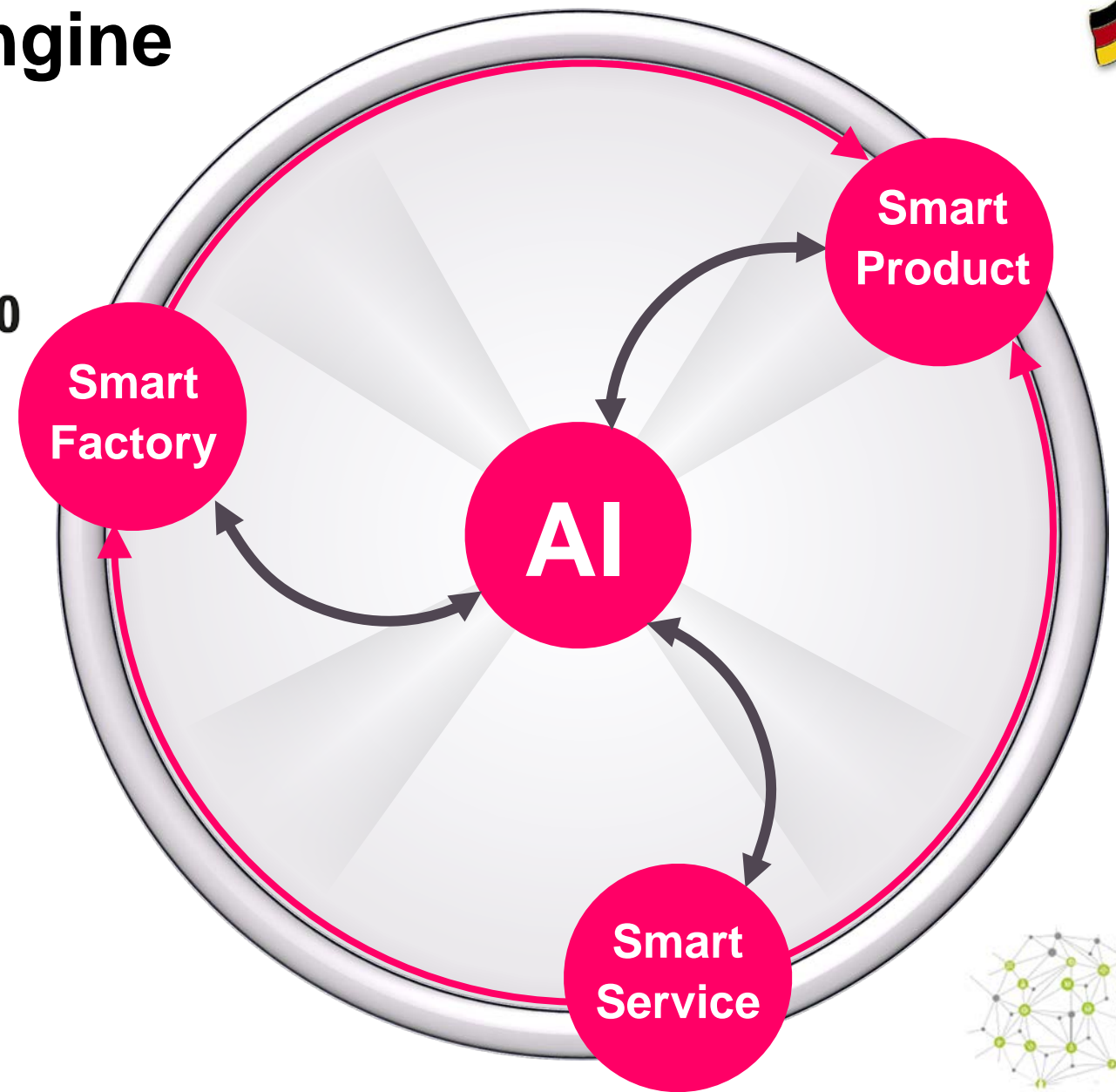


Agricultural Machinery



AI as the Core Innovation Engine

PLATTFORM
INDUSTRIE4.0



**Three Large-Scale German Future Projects for Disruptive Innovation:
Industrie 4.0 – Smart Service World – Learning Systems**

30 Years of AI Research at DFKI: The World's Largest AI Research Center



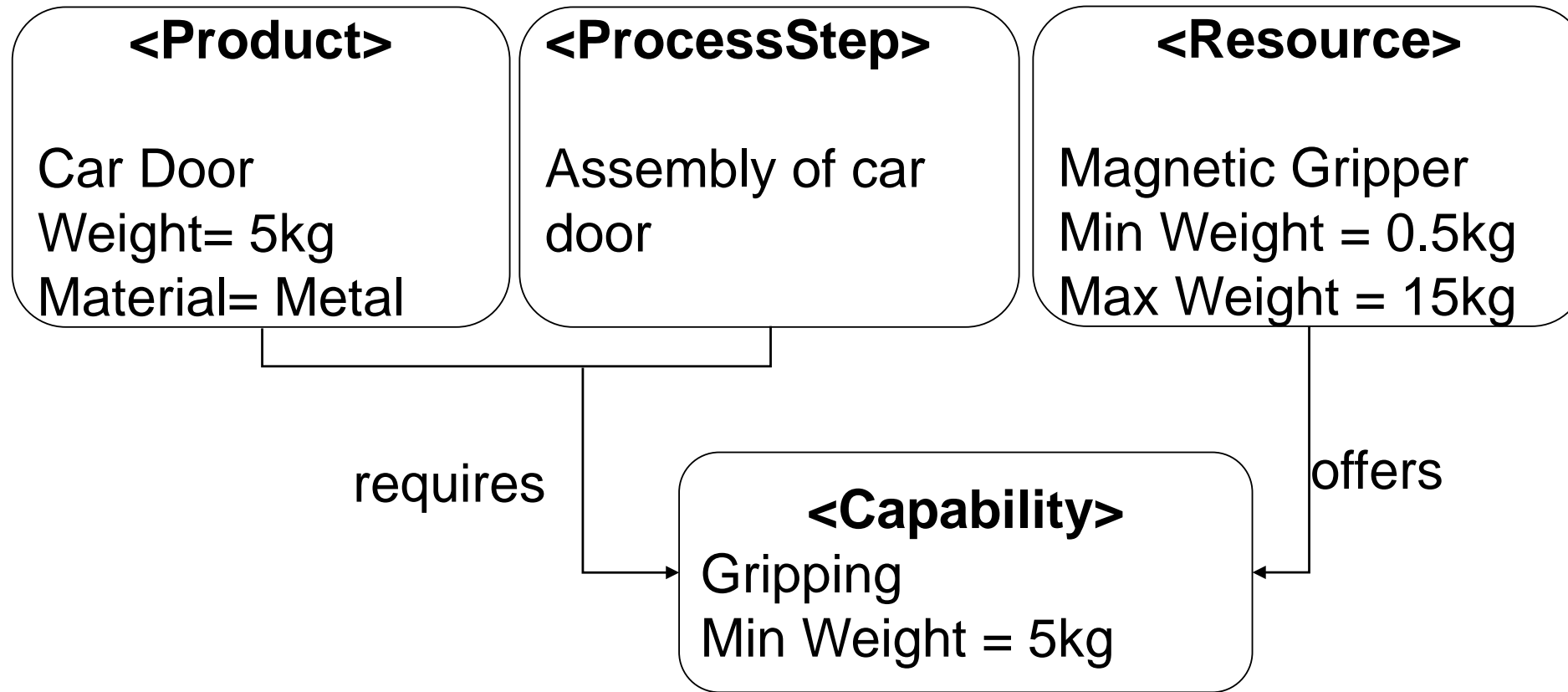
More than 80%
of all projects
based on
industrial
consortia



- > 600 AI Researchers, 30 AI Professors
- Project Budget in 2018: 122 Million
- > 1000 Employees
- 295 Ongoing Projects
- 22 Industrial Shareholders



BaSys 4.0: Process, Product, Resource (PPR) Model



- Capability Specification
- Capability Checking
- Feasibility Checking

New Steering Committee at the German Institute for Standardization (DIN): a Standardization Roadmap for AI (DIN – CEN – ISO, W3C)



18 Members from Industry, Academia, and Government

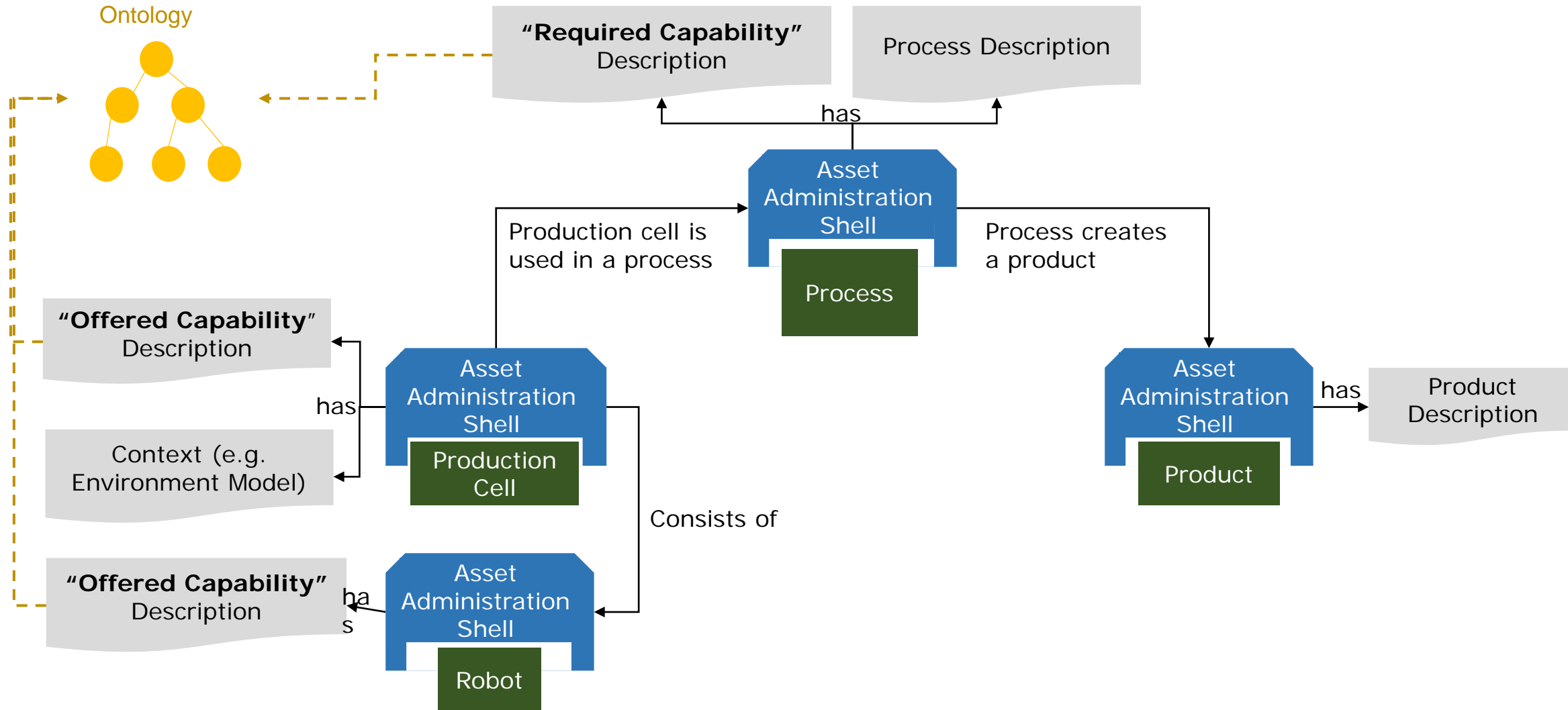
Chair: Prof. Wolfgang Wahlster

Deliverable: Standardization Roadmap at the German Government's Digital Summit in October 2020

Some Relevant Standards and Proposals:

OWL, RDF, OMM, USDL, FIPA ACL, SSML, VoiceXML, PDDL, EMMA,

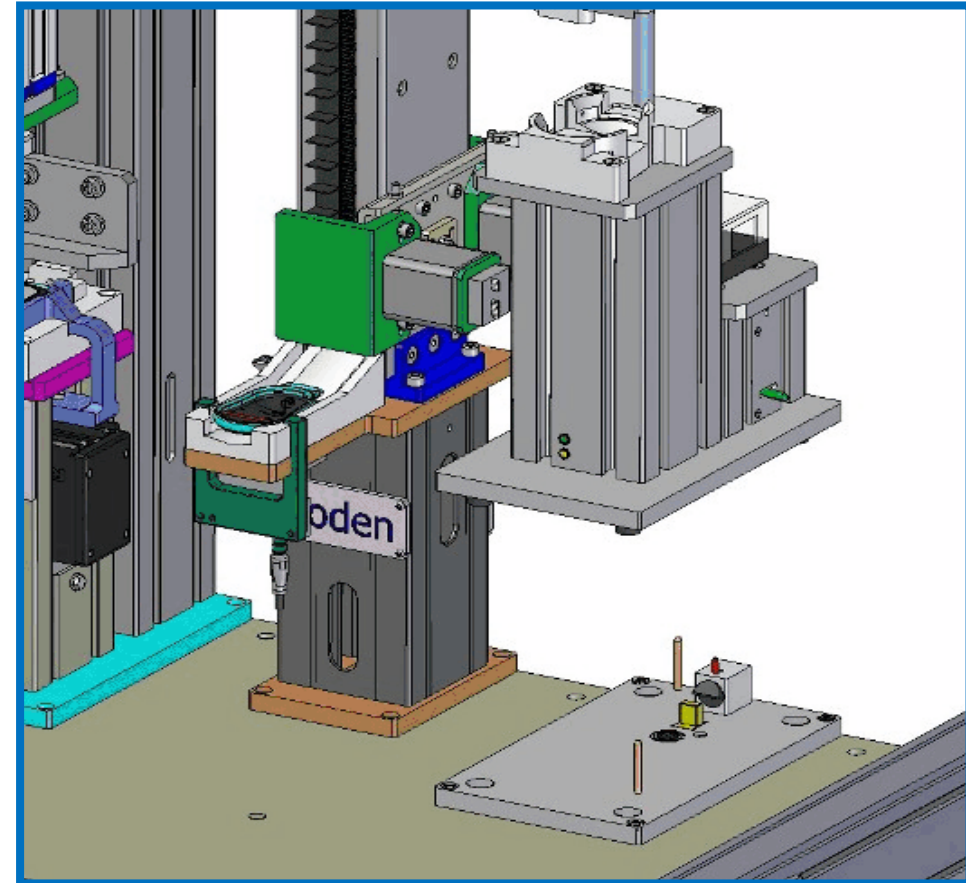
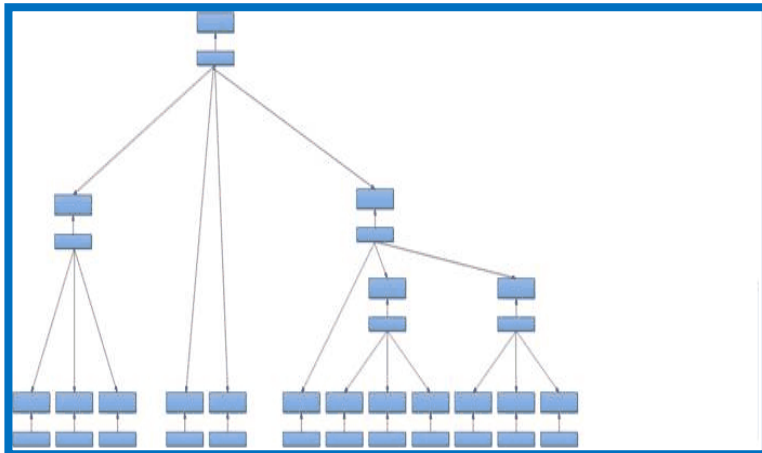
Capability Modeling in AdminShell (GMA 7.20 VDI/VDE)



Plug&Produce based on Adaptive Service Ontologies



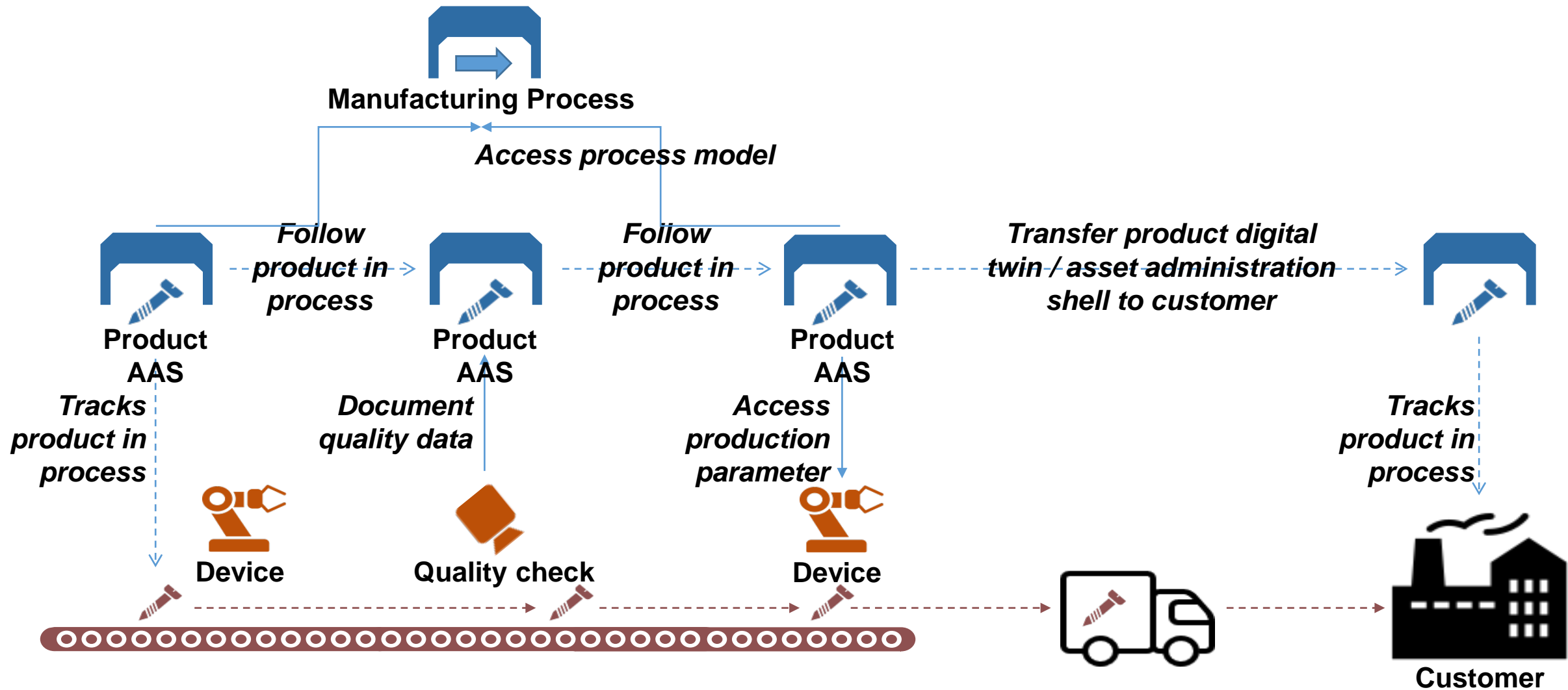
- Plugin of CPS production components on a physical, digital and semantic level
- Automated Expansion of the Service Ontology



New Assembly Component
is installed on-the-fly



BaSys 4.0 – Active Asset Administration Shells follow the Product Life Cycle as Digital Twins





Hybrid Teams: Robots Collaborate with Humans in Physically Challenging Overhead Assembly Tasks (Hybr-iT)



b a u a :
Bundesanstalt für Arbeitsschutz
und Arbeitsmedizin

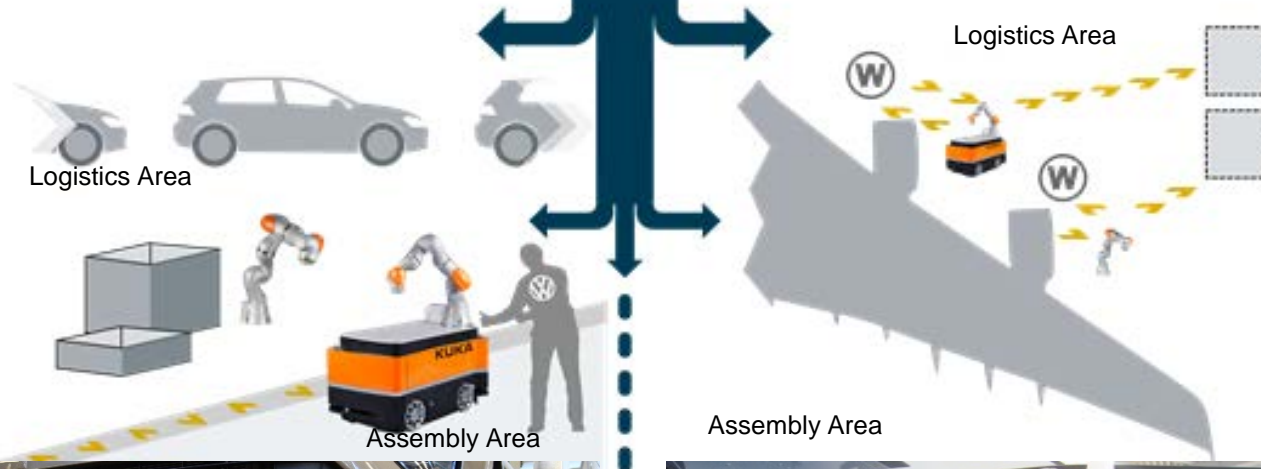


KUKA

VOLKSWAGEN



BROETJE
AUTOMATION



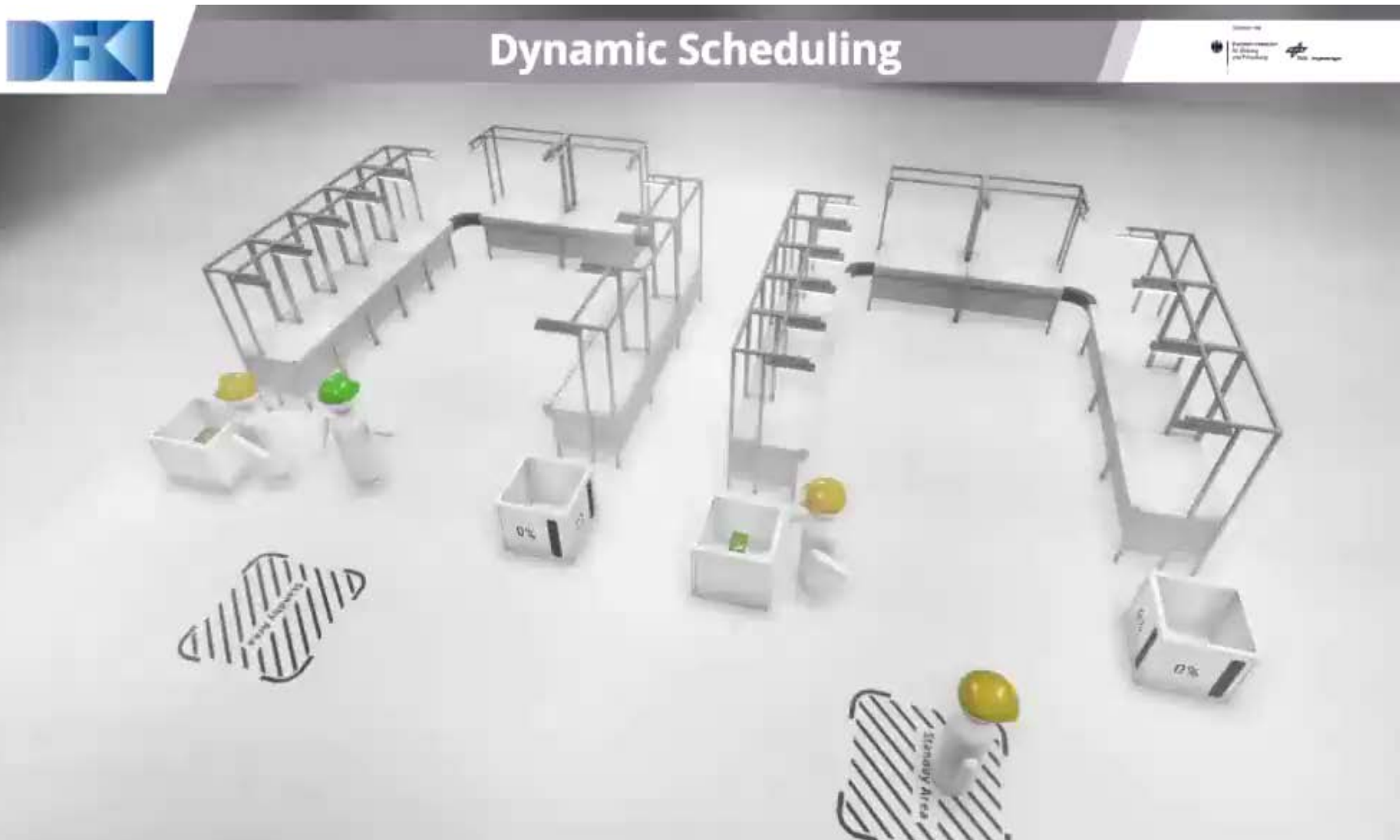
SPONSORED BY THE



Federal Ministry
of Education
and Research



AI-Based Real-time On-the-fly Planning of Hybrid Production Teams (Marcel Köster, DFKI)



SPONSORED BY THE



Federal Ministry
of Education
and Research

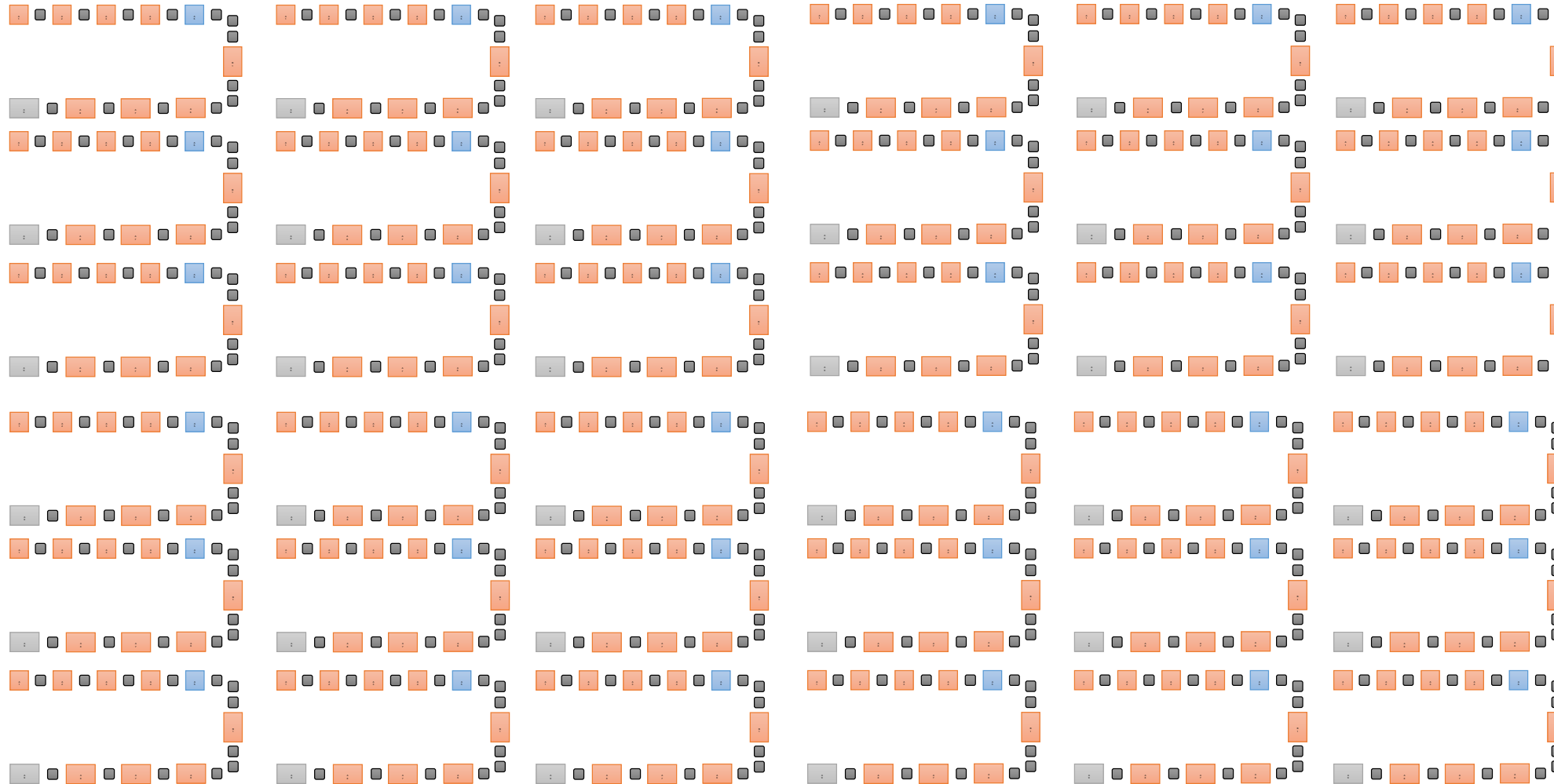
funded
by BMBF
in the
SmartF-IT
Project



Based on GPU Computing for Extremely Large States Bases



Hybrid Teamwork Planning: Anytime Algorithms and Just-in-Time Compilation for GPU Supercomputer Clusters based on DGX-2



**21 Production
Lines for
35 Product
Variants:
 10^{26} States**

NDA-based Research for Brownfield Factories of
ZF Group (Automatic Transmission) and Bosch-Rexroth

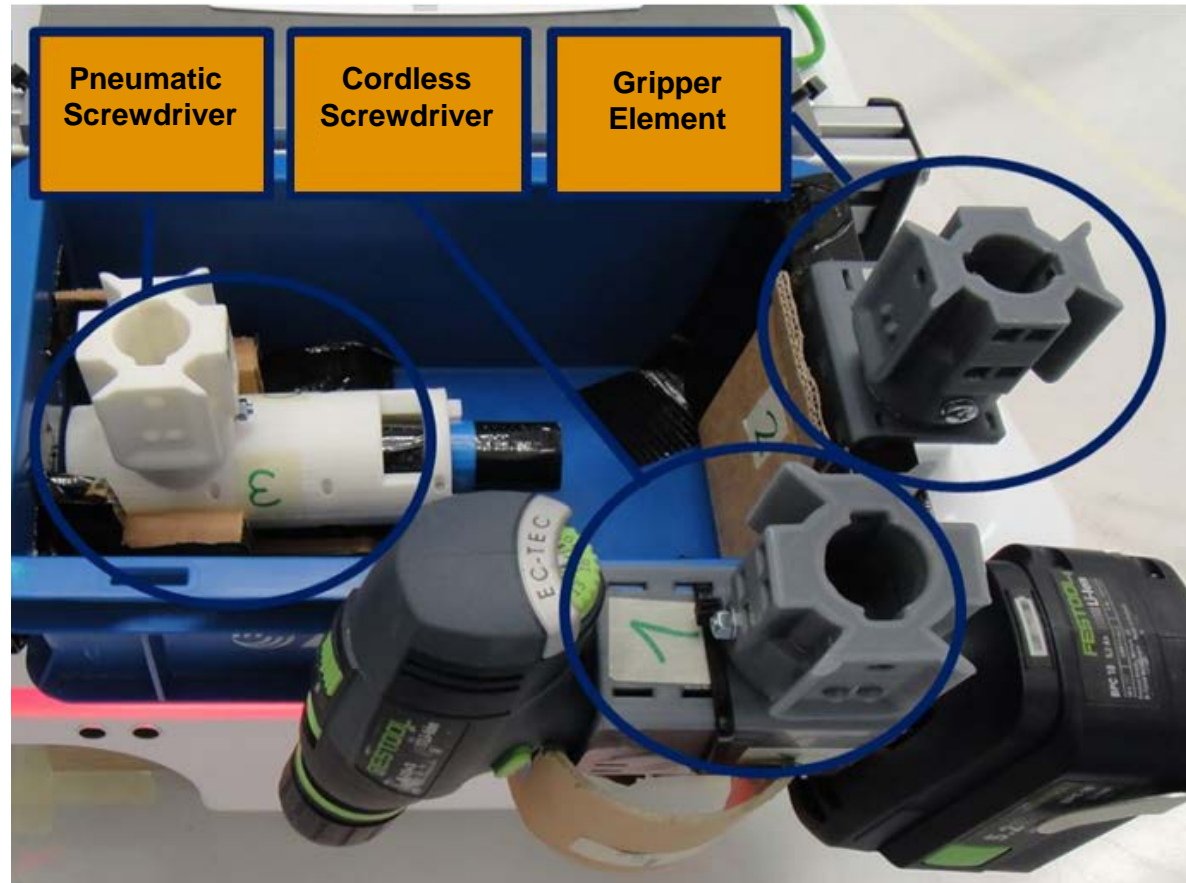
Team Robotics for Multiadaptive Manufacturing Tasks



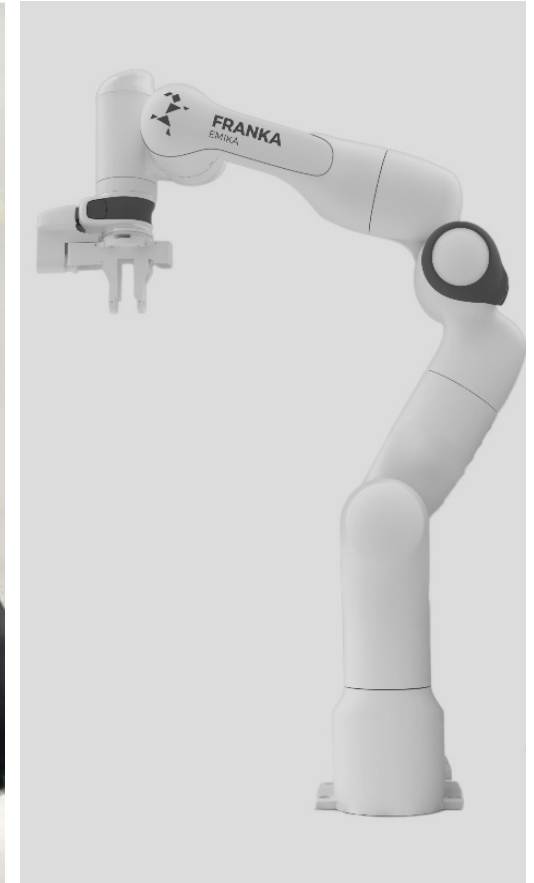
AI Enables Human Workers and Collaborative Robots to Use a Dual Toolbox



Worker



Shared Toolbox



Franka Panda Robot

Shared Workspaces for Human-Robot Collaboration

Assembly Assistance for Raceways for Airbus Wings with 4 different CoBots and a Human Worker



Wing Production
at Airbus Bremen

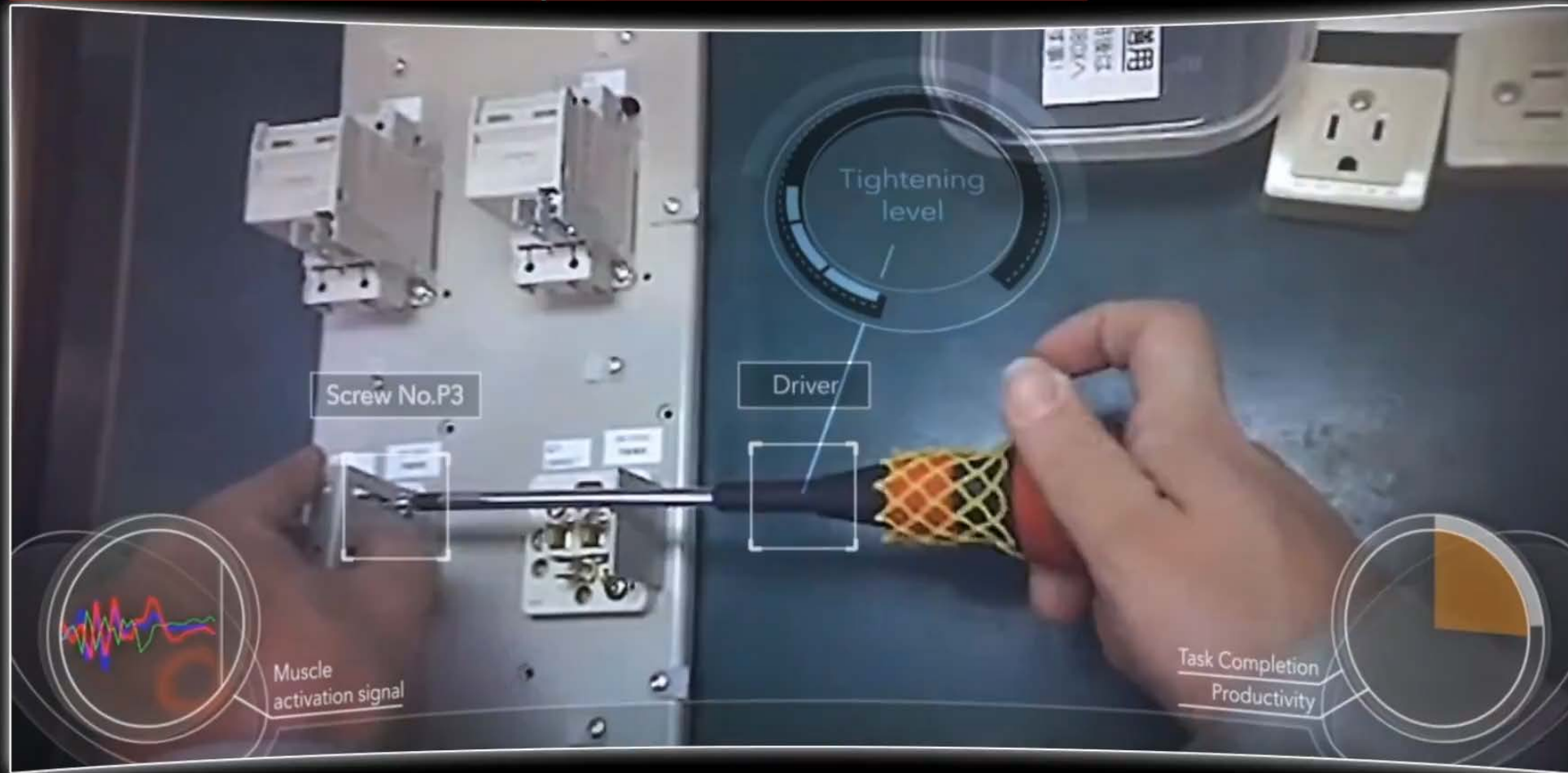
Hybr-IT project lead
by DFKI, Head: W.
Wahlster

Smart Worker Assistance as a Service: DFKI for Hitachi



A workplace of the future with AI

Human error prevention

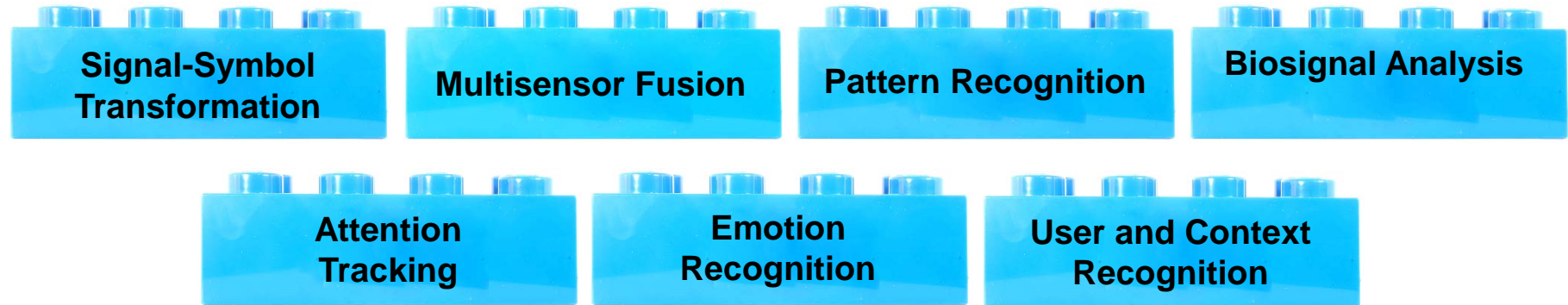


Recognize the tightening level by tracking a muscle activation signal

Building Blocks for Complex AI Systems: AI on Demand



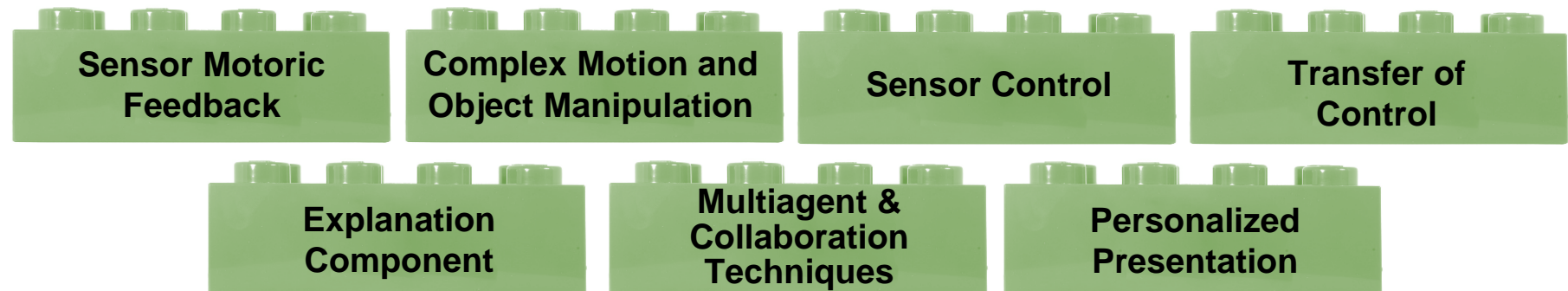
Sense



Understanding



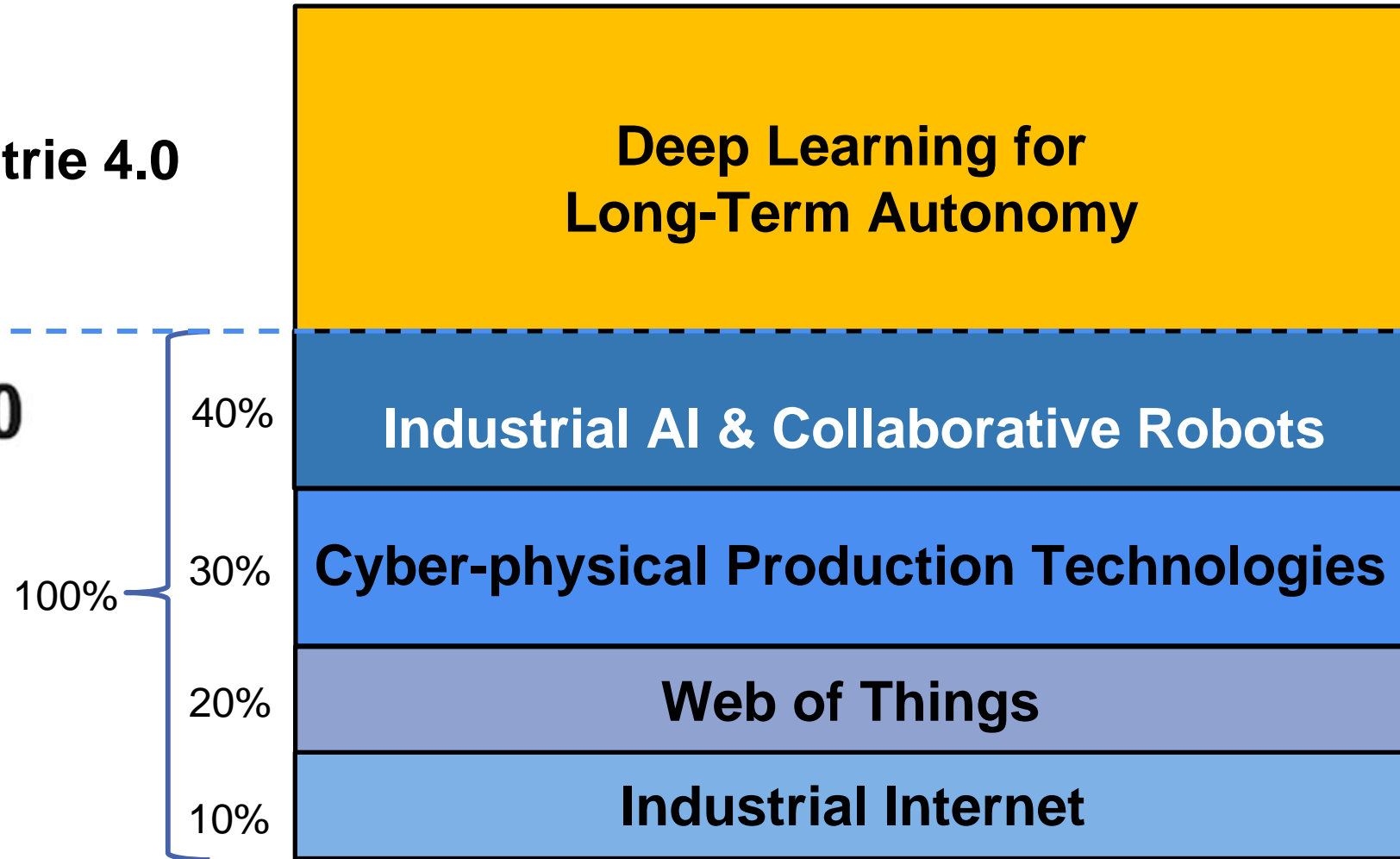
Act



Beyond Industrie 4.0: Long-term Autonomy



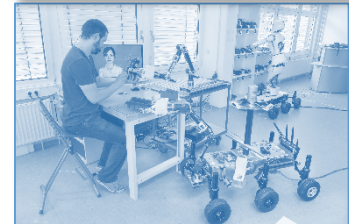
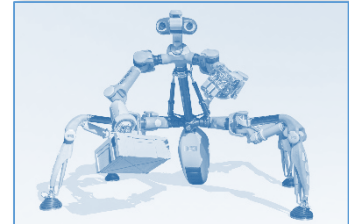
Beyond Industrie 4.0





Eight Major AI Project Lines 2019-2023 (BMBF for DFKI)

- 1. Emergent Machine Learning Systems**
- 2. Immersive Assistance Based on 5G Ultra-Connectivity**
- 3. Self-Controlled Systems for Long-Term Autonomy**
- 4. Hybrid Teamwork with Human and Machine Intelligence**
- 5. Wearable Artificial Intelligence Systems**
- 6. Credible and Trustworthy AI**
- 7. Resource-conservative Systems**
- 8. Interactive and Conversational Machine Learning**



Conclusions



1. **AI Technologies are a key success factor for Industrie 4.0: Deep Learning disrupts sensor interpretation for predictive maintenance and online quality control**
2. **Semantic Technologies guarantee interoperability in multi-vendor factories and are the basis for a disruptive SOA production logic.**
3. **Anytime, GPU based automated production planning in realtime is a breakthrough for flexible automation.**
4. **User Modeling, Plan Recognition as well as intelligent multimodal interfaces are the basis for a new generation of worker assistance systems.**
5. **Hybrid teams of cobots, softbots and people are a challenge for basic research in multiagent coordination, e.g. with an acceptable solution of the transfer of control problem.**
6. **Industrie 4.0 brings many AI subfields together in one of the most important fields of industrialized countries like Germany.**

Thank you very much for your attention.

