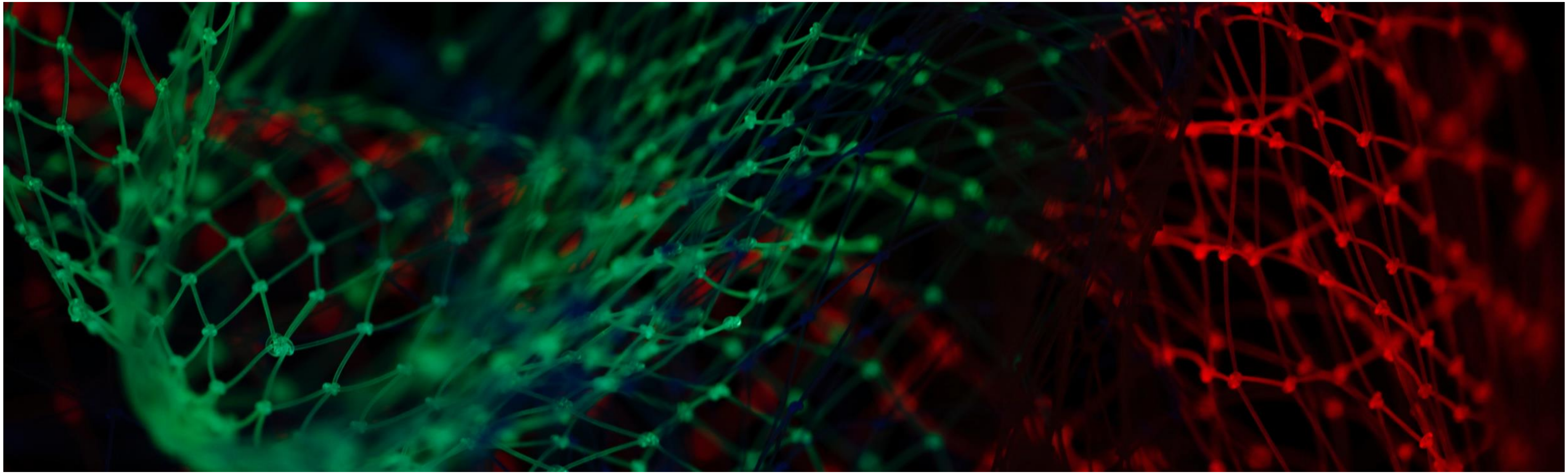
MACHINE LEARNING APPLICATIONS IN PRODUCTION ENVIRONMENTS – REFERENCE PROJECTS

Christian Blobner, November 25, 2020



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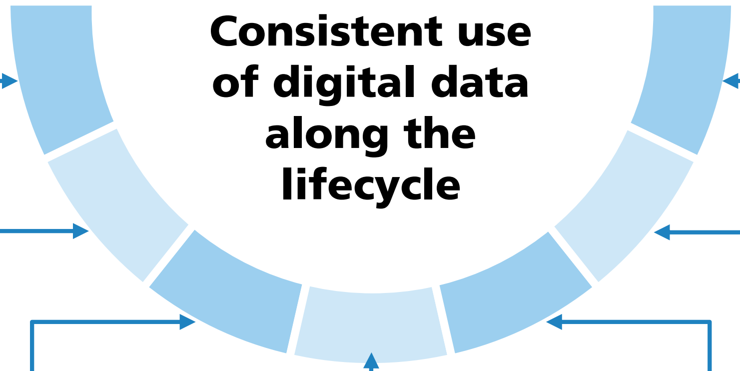
TAKE AWAY MESSAGE

- Manufacturing and process industries can massively benefit from tailor-made data analytics using machine learning and artificial intelligence
- Depending on the starting position, there are different options to make machine learning work
- It is getting easier to collect data in various manufacturing processes and production stages
- Access to data analytics for AI through cloud based services, such as Fraunhofer’s Virtual Fort Knox, helps companies in developing on algorithms
- Experience-knowledge can provide value-adding information to support to conventional machine learning methods

The Fraunhofer IFF as a production oriented institute has the experience and skills to address your needs in the field of machine learning applications in production environments

Digital Engineering and Operation

Consistent use of digital data as basis for machine learning applications



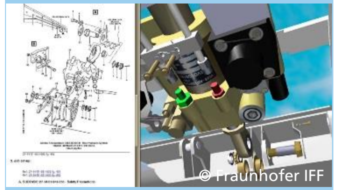
Design Review

Engineering, Manufacturing, Assembly, Maintenance

Functional Test

Mechanics, Electronics, Control systems

Technical Documentation



Visual inter-active catalogs, Electronic manuals

Job Preparation

Resource optimi-zation, Work scheduling, Lo-gistics functions

Factory Planning

Layout planning, Process planning

Education and Training

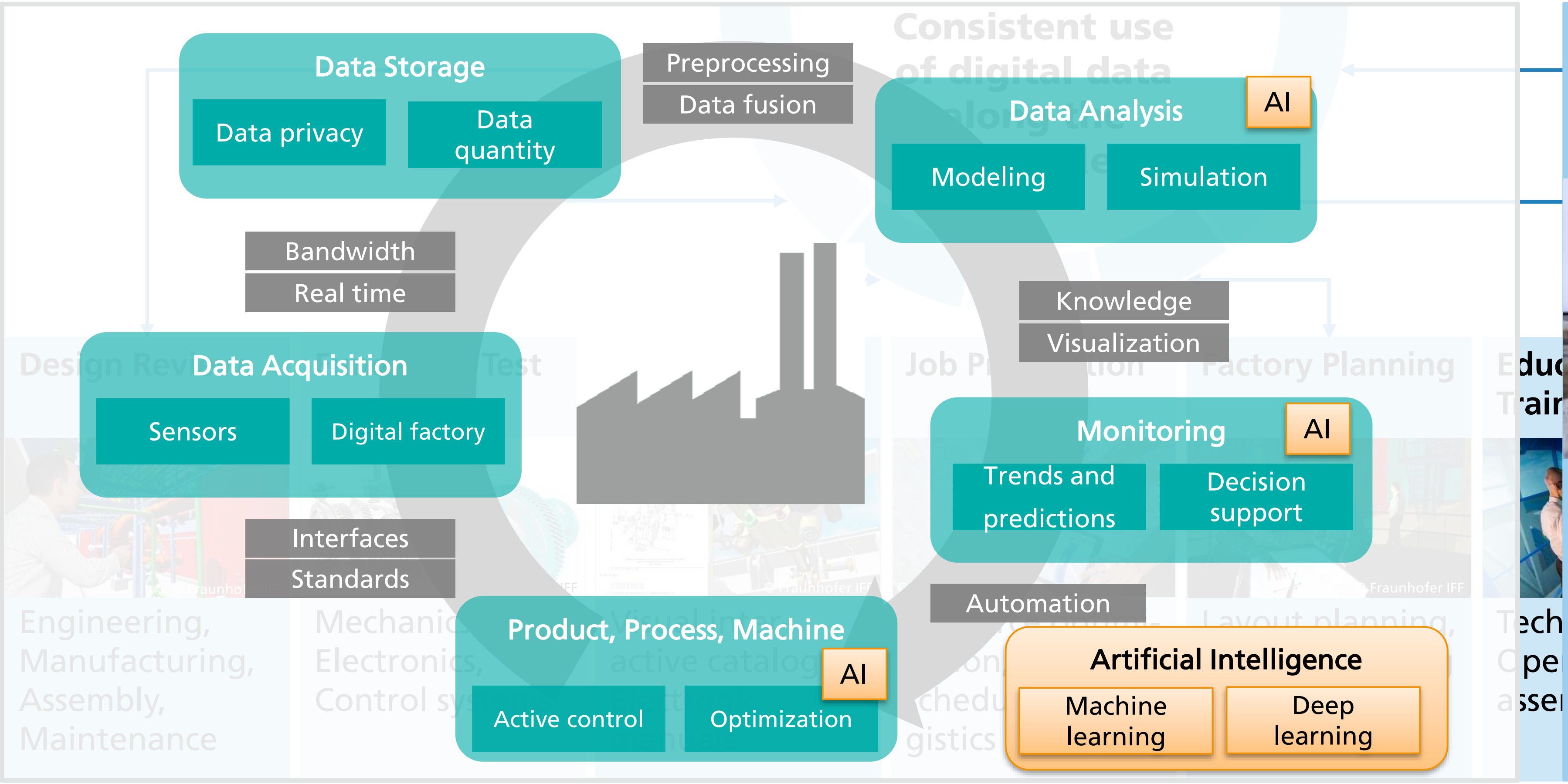
Technical staff, Operation and assembly service

Operations

Assistant sys-tems, Visual in-teractive repair instructions

Digital Engineering and Operation

Consistent use of digital data as basis for machine learning applications

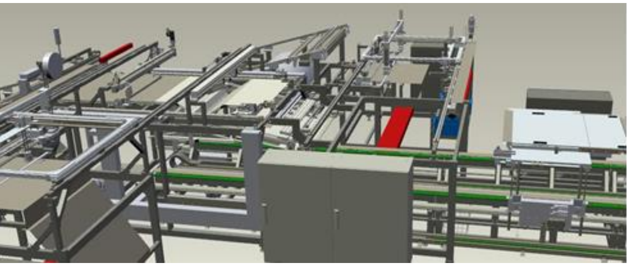


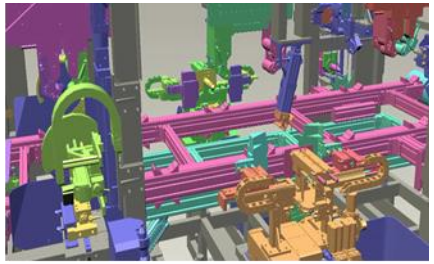
Operations

Assistant systems, Visual interactive repair instructions

Digital Twin – Cyber-Physical Systems

Integrated and Parallel Product and Manufacturing System Design for LANXESS AG

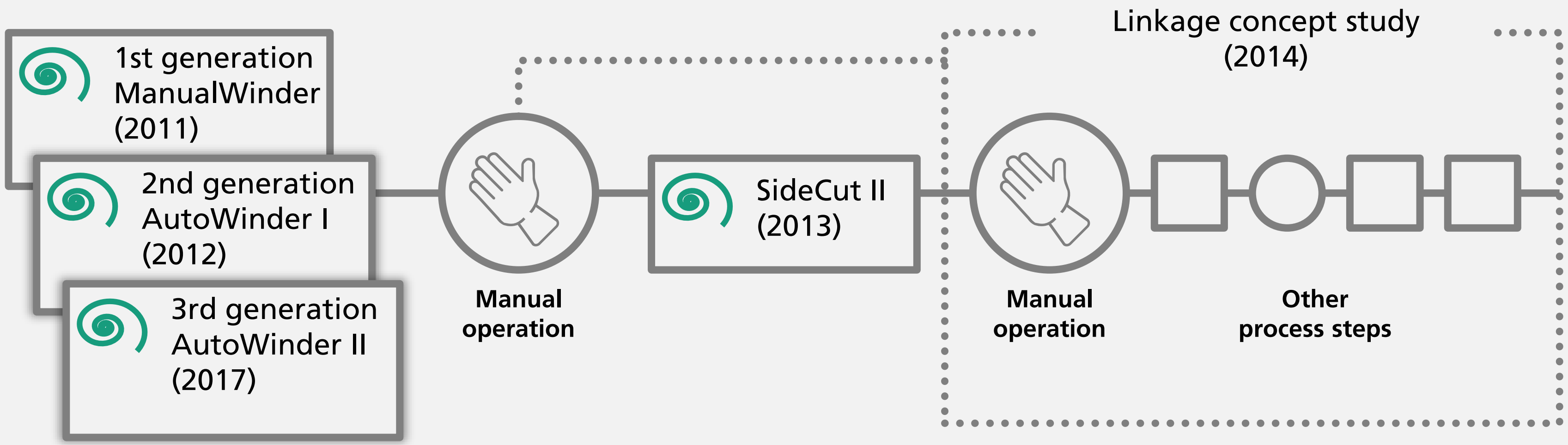




- Use of virtual models and digital tools to plan, develop and prototype the manufacturing system for innovative water filters in parallel to the product development process

Planning and development of several (semi) automated manufacturing systems

Goal: Fully automated production facility (2020)

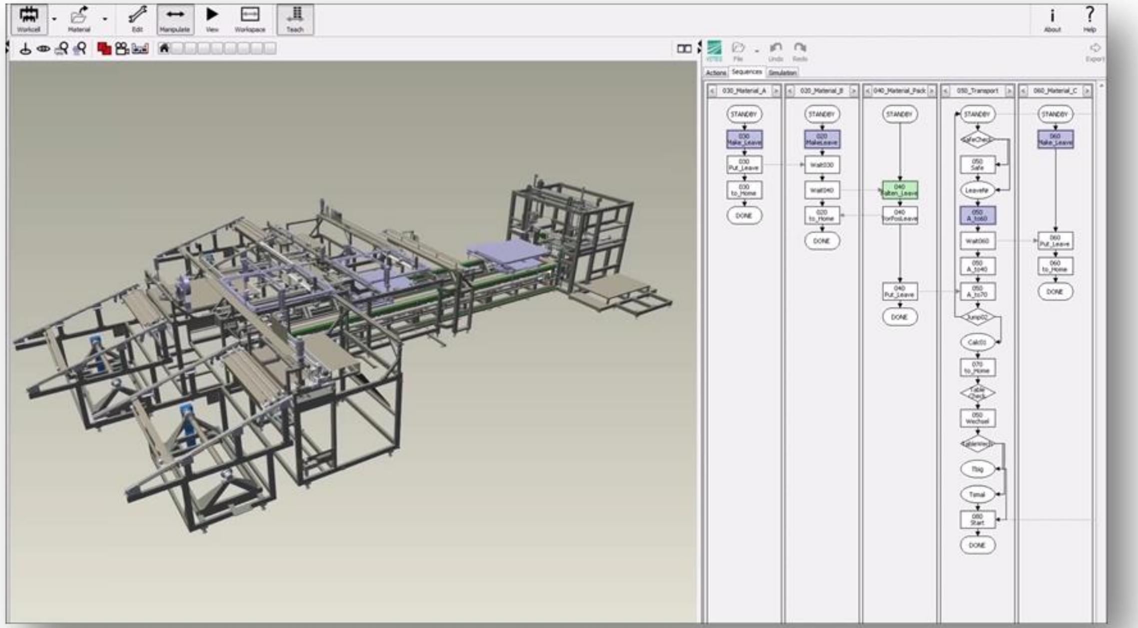


- Manufacturing system is in productive use at customer
- Manufacturing system is equipped with intelligent components (sensors, actuators, electrical drives), which provide data
- Data can be used for production run simulations, predictive maintenance, machine learning
- Workers can use data through assistance systems

Fully functioning Cyber-Physical System

Digital Twin – Cyber-Physical Systems

Working digital twin system in operation



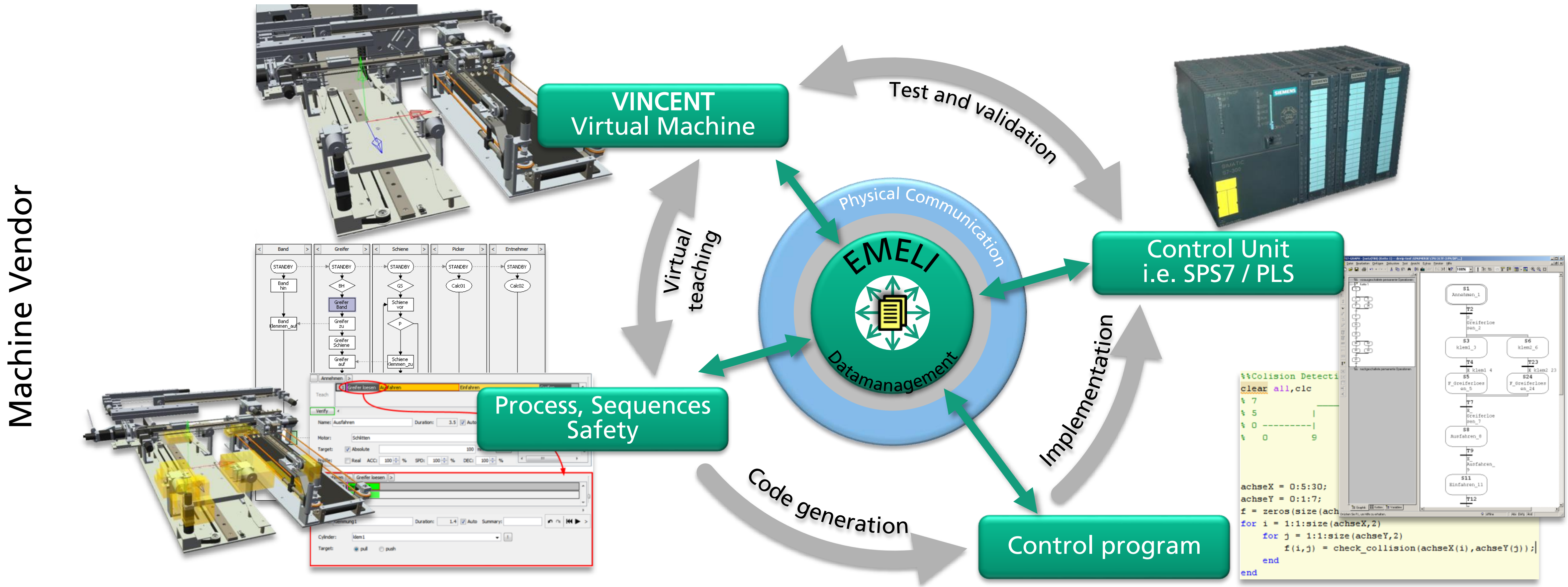
- Virtual system with parallel control visualization

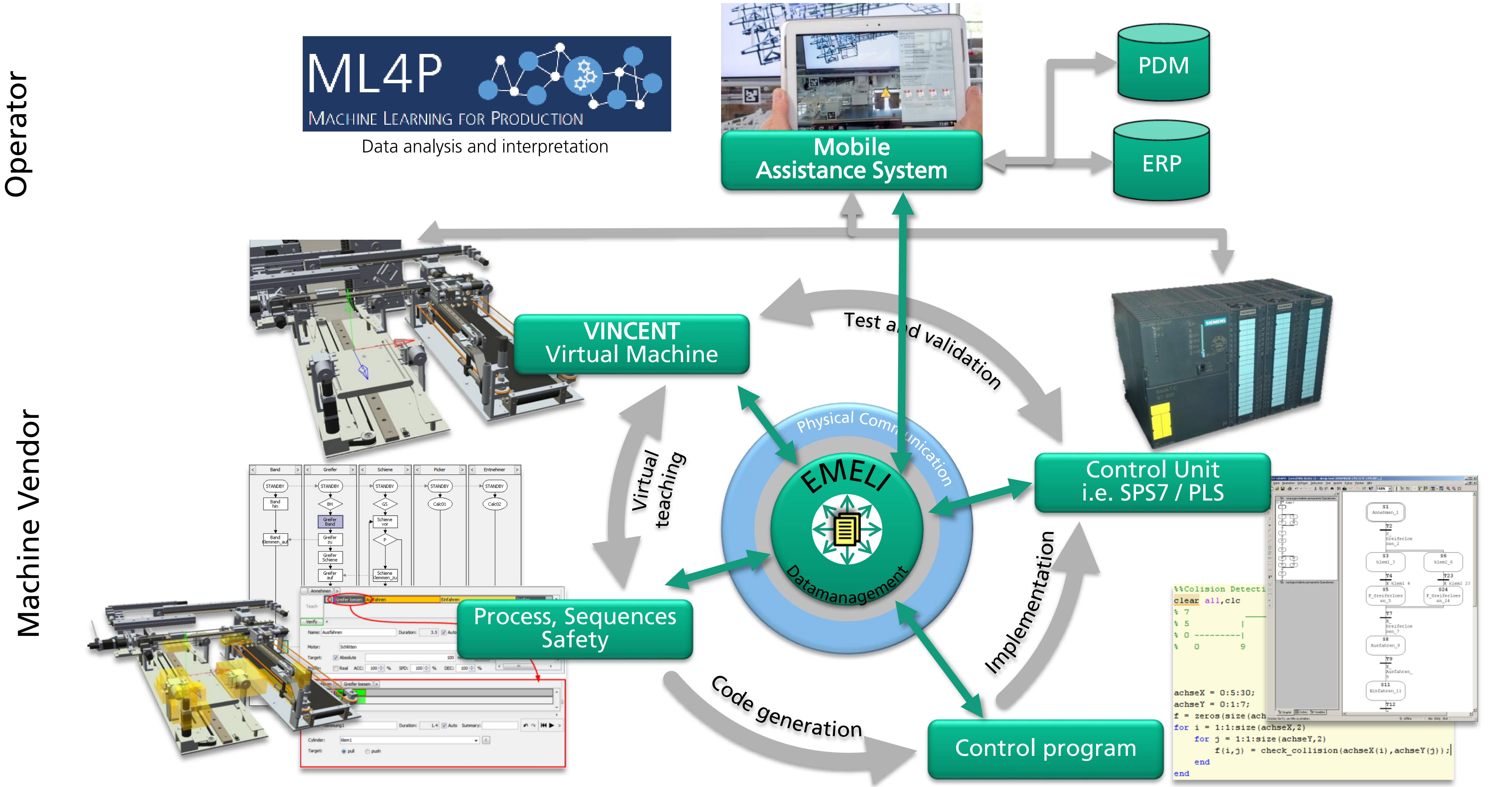
Source: Lanxess // New Lewabrane® Ultra Low Pressure (ULP) RO Membrane Elements

- Real system in operation at customer site

Digital Twin – Cyber-Physical Systems

Digital workflow for virtual prototyping




Operator
Machine Vendor
ML4P
Machine Learning for Production
Data analysis and interpretation
Mobile Assistance System
PDM
ERP
VINCENT
Virtual Machine
Test and validation
Virtual teaching
Physical Communication
EMELI
Datamanagement
Control Unit
i.e. SPS7 / PLS
Process, Sequences
Safety
Implementation
Code generation
Control program
%%Colision Detecti
clear all,clc
achseX = 0:5:30;
achseY = 0:1:7;
end

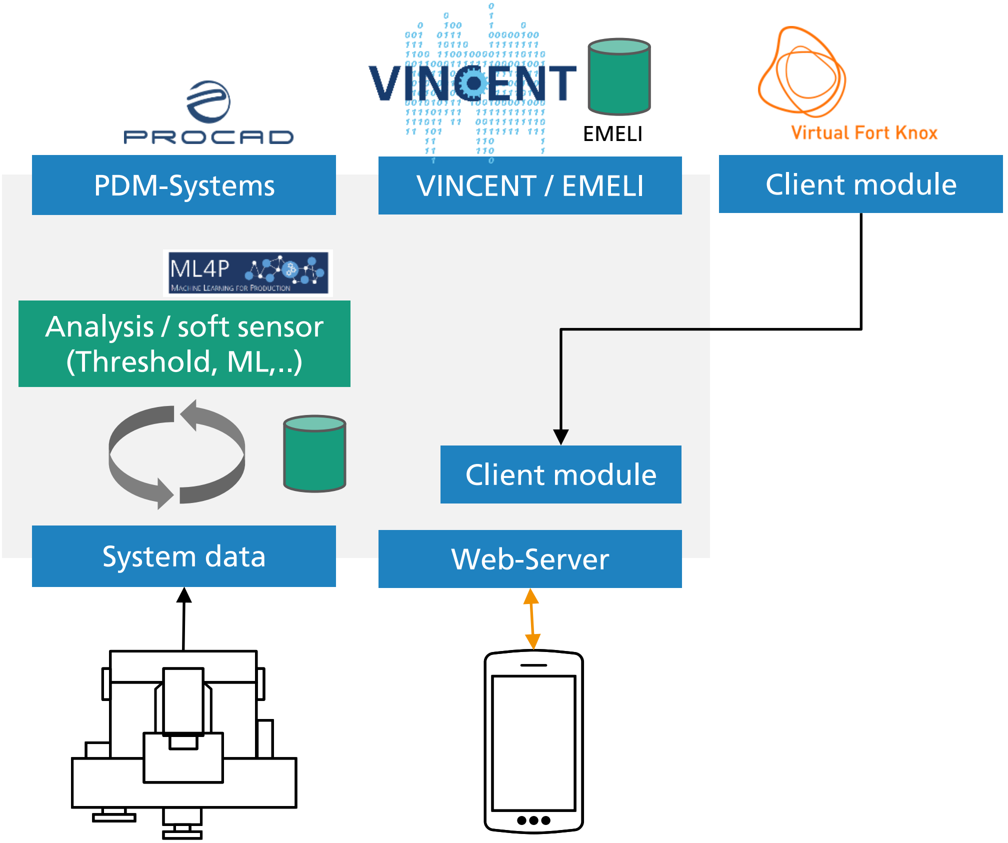
Digital Twin – Cyber-Physical Systems
Assistance systems supported by machine learning

Use case: Considering machine learning applications already in the engineering stage

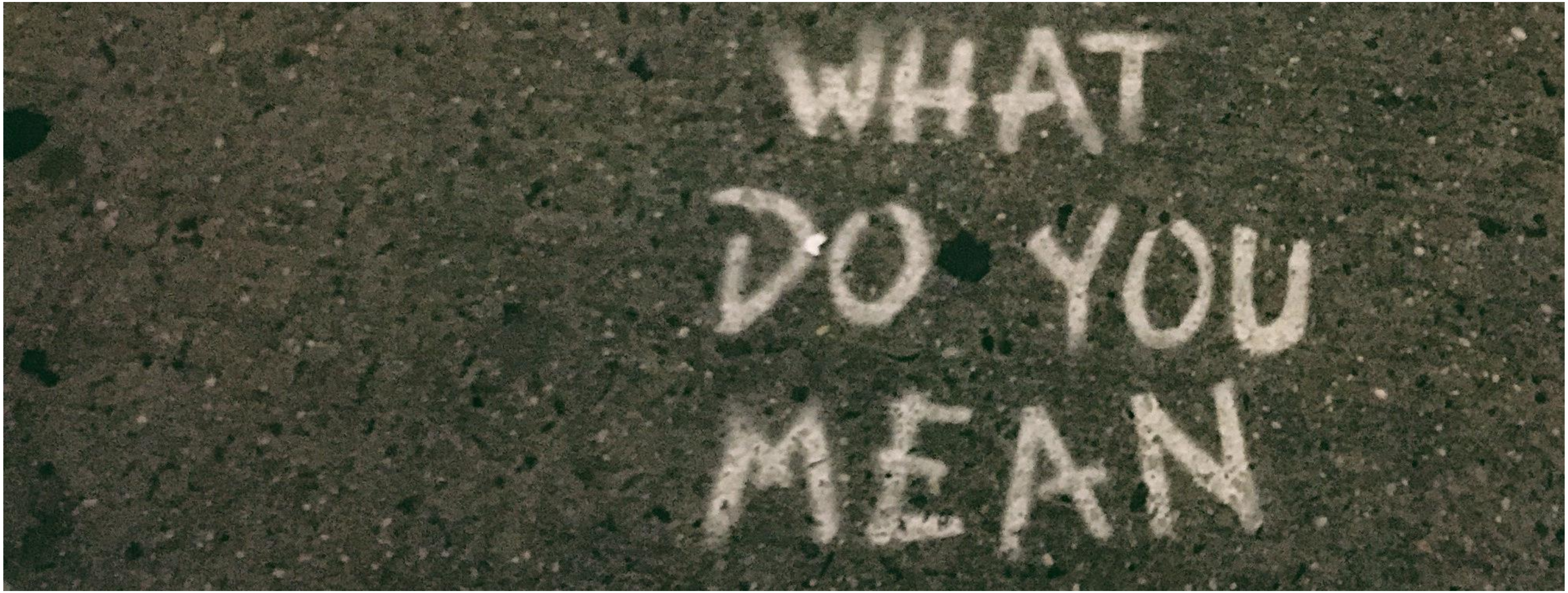
- Administering and updating of machine learning models in maintenance
- Planning for data interfaces and necessary sensors during the planning stage

Implementation: Scalable, modular framework for assistance systems

- Agent-based method
  - Exchangeable server services for knowledge systems
  - Client modules for customizable information presentation
- No compulsory cloud use, esp. for data and know-how
- Working with system condition states
  - Recording directly in system vicinity
  - Analysis via simple rules-based analysis (similar to Excel, threshold values, etc.)
  - Analysis via online-machine-learning applications



WHAT IF YOU DO NOT HAVE A DIGITAL TWIN LYING AROUND?



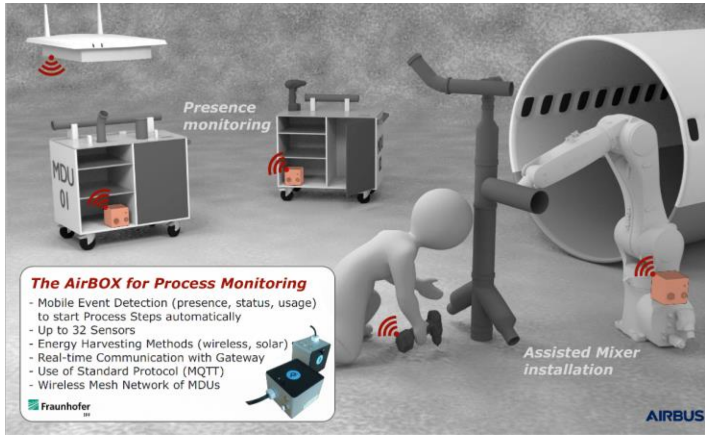
Sensor networks & machine learning
Fraunhofer IFF AirBox

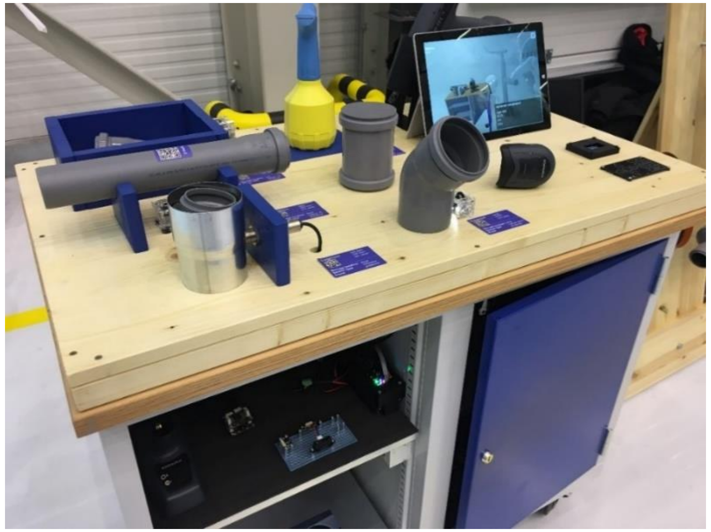
Fraunhofer IFF AirBox to generate process data

- Easy set-up of distributed sensor networks
  - Equipped with six standard industry interfaces
  - Fraunhofer IFF AirBrick also to house sensors
- Already included smart components and logic for mobile event detection (presence, status, usage)
  - Supporting intelligent and hierarchical process monitoring
  - Threshold activation, definition of working bandwidth
  - Autonomous initiation of process steps
- Energy harvesting methods (wireless, solar)
- Wireless real-time provision of process data for machine learning services

Sensor networks & machine learning
Upgrading of existing processes

- Objective: real-time progress monitoring of manual tasks
  - Current state and forecasting for production planner
  - Assembly tips for workers
- Indirect activity monitoring based on machine learning
  - Presence, taking, assembly of parts
  - Use of tools
  - Sensor types: infrared, ultrasound, optical, pressure, temperature, …
- Prototype-Hardware Development: IFF-AirBox
  - Wi-Fi-Sensor Network in production
  - Cloud-based visualization (Partners: e.g. Siemens, T-Systems)





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Sensor networks & machine learning
Use case – Installing doors in aircraft fuselage

Problem

- Time-consuming process (1d)
- Installation depends on "micro-properties" of the door and the frame
- Manual logistics
- No progress control

Objective

- Reduction in process time (2h)
- Partial automation
- 3D assistance functionality
- Sensory, digital monitoring
- Real-time progress control

Machine vision & machine learning
Safe human robot collaboration

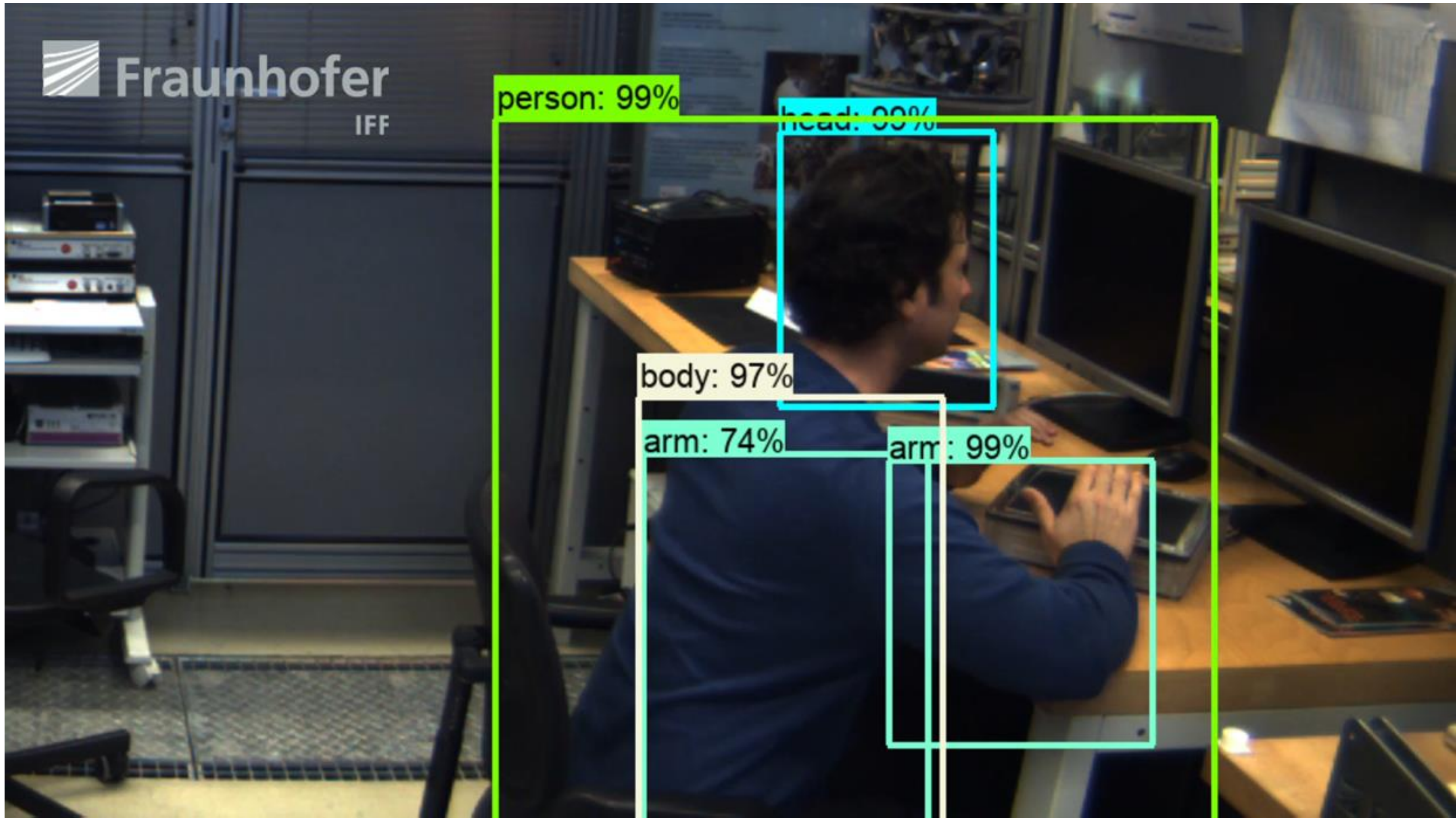
Objective: Safe collaborative workspaces with interactions between humans and robots

- Mobile robot platform
- Collaboration on joint project
- (in-)direct contact between human and robot
- Robot working following the intention of human
- Safe working environment needs to be ensured

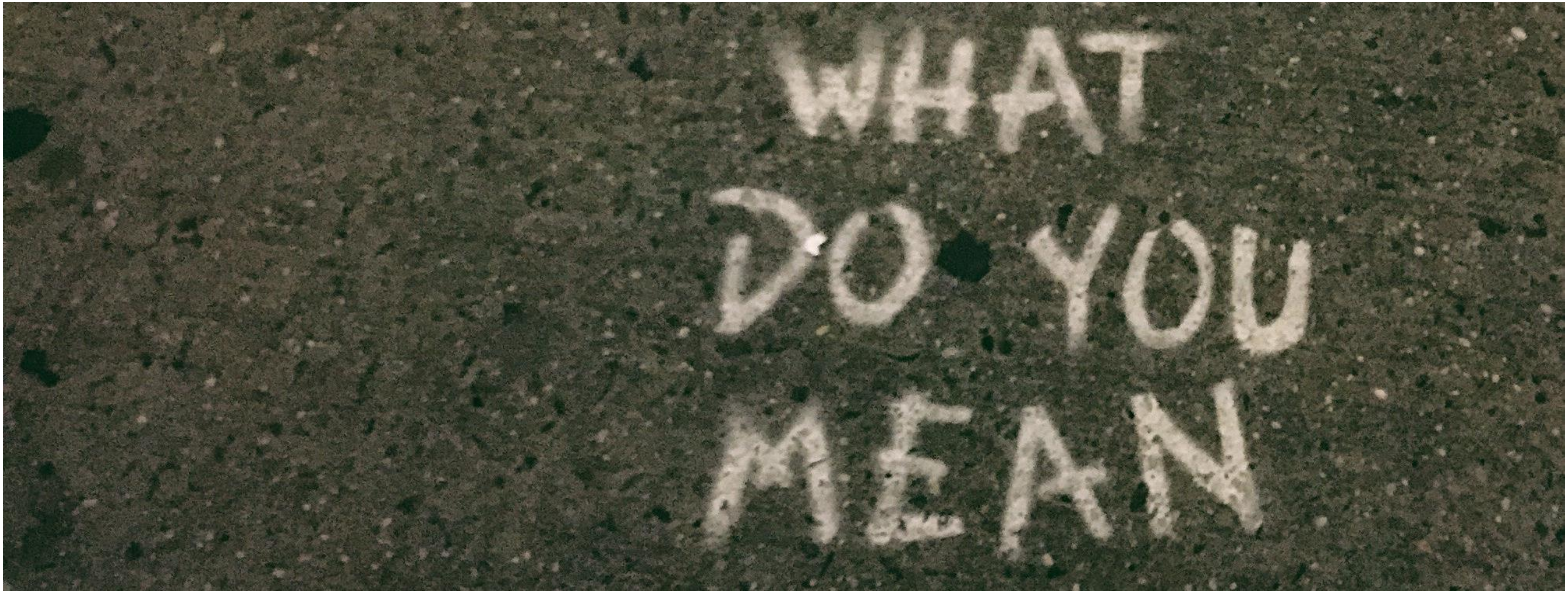
Machine vision & machine learning
Safe human robot collaboration

Objective: Safe collaborative workspaces with interactions between humans and robots

- Supporting machine vision through machine learning
- Algorithms for detection of humans
- Algorithms for detection of individual body parts



HOW DOES MACHINE LEARNING PROVIDE INSIGHTS?



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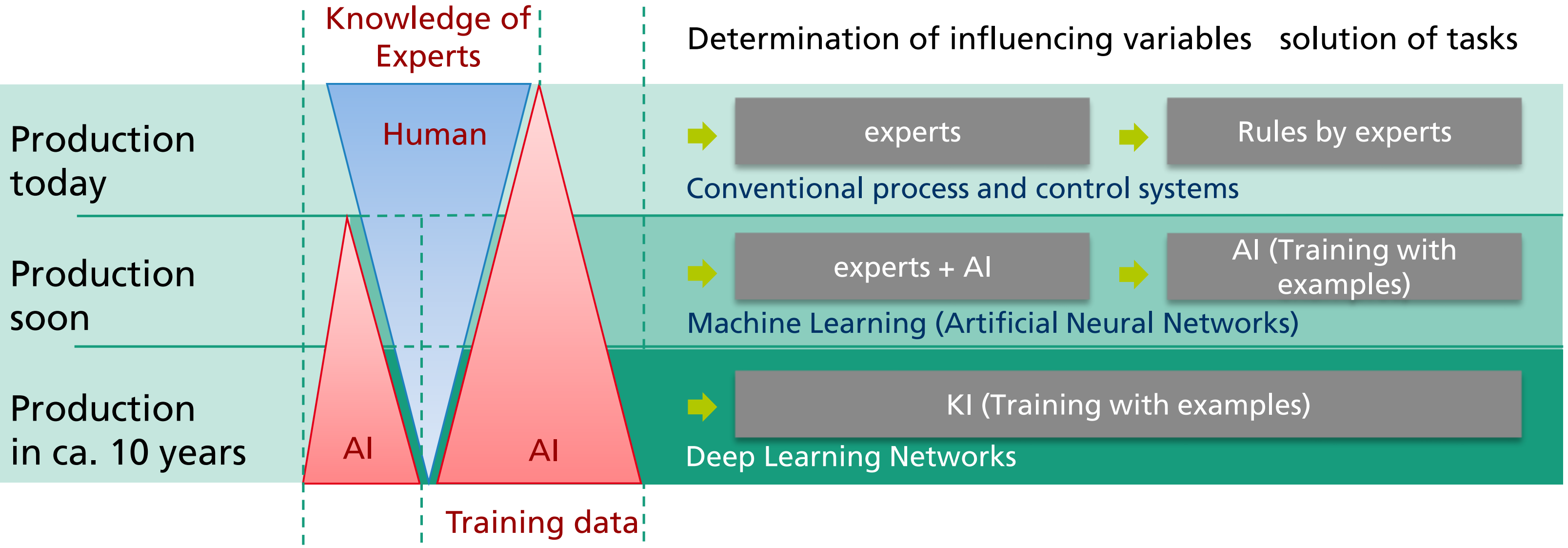
Machine learning & insufficient data

Evolution in data processing



- Test AI-based forecasting system
- Process analysis and causalities
- Data integration and process understanding
- Feature extraction

- Self-learning control algorithms
- Networked automated production and logistics systems
- Result evaluation with digital factory

- Autonomous Factory

[Wahlster, 2001]

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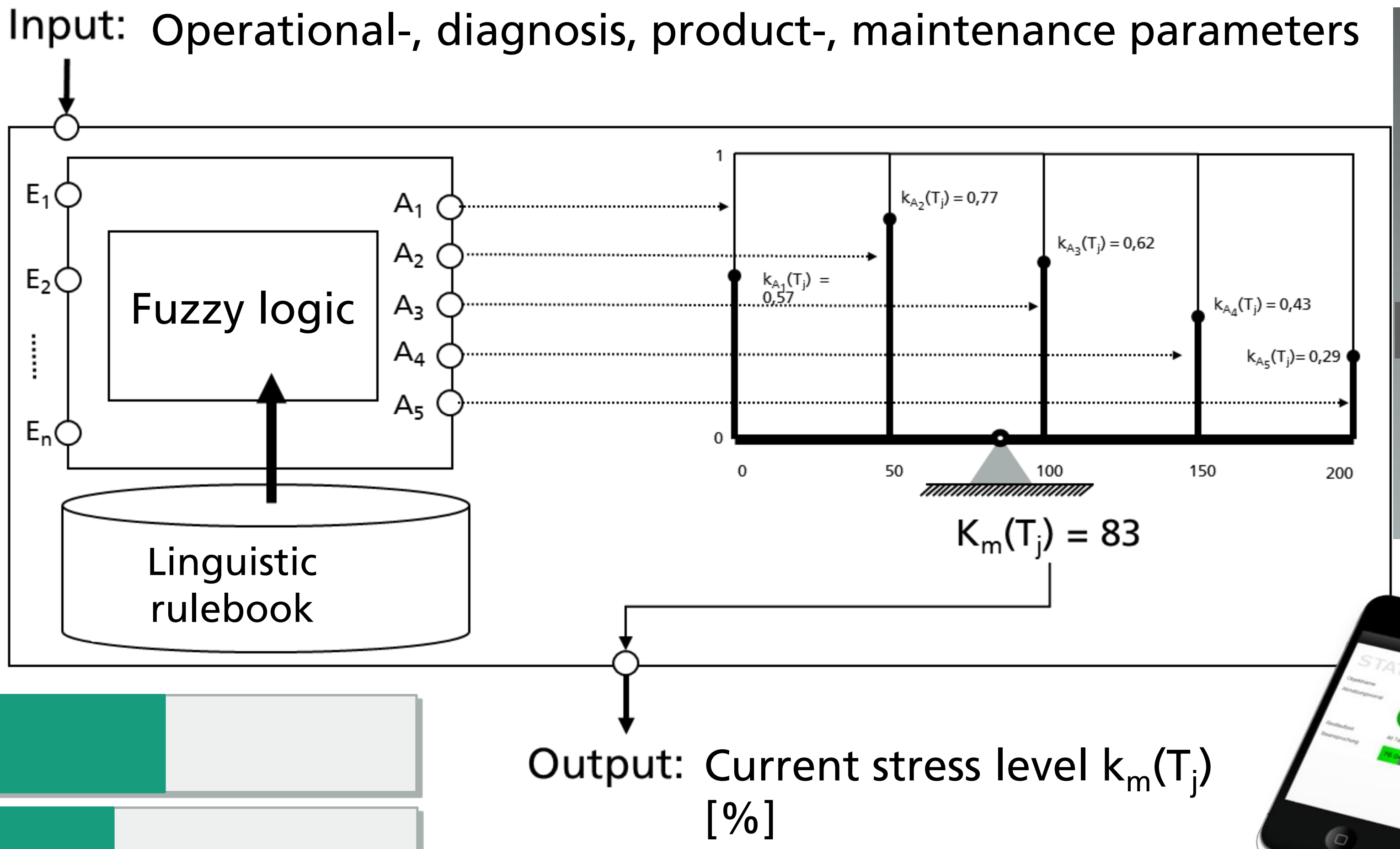
Machine learning & insufficient data

Predictive maintenance with humans in the loop



STATE Logger

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Machine learning in production environments

The concept of soft-sensors

Process
- Active control
- Optimization

Reference measurement
- expensive
- slow
- Expert
- Lab analysis

Sensor or sensor networks
- inexpensive
- fast

Soft sensor model
- Classification
- Regression

Control unit

Product, Process, Machine AI
- Active control
- Optimization

Monitoring AI
- Trends and predictions
- Decision support

Example Soft-Sensor Application

Measuring Product Quality in Process Industry - DOW Chemical

Case Study:

Butadiene-Plant

Objective:

Soft-Sensor for Product-Quality

Data Base:

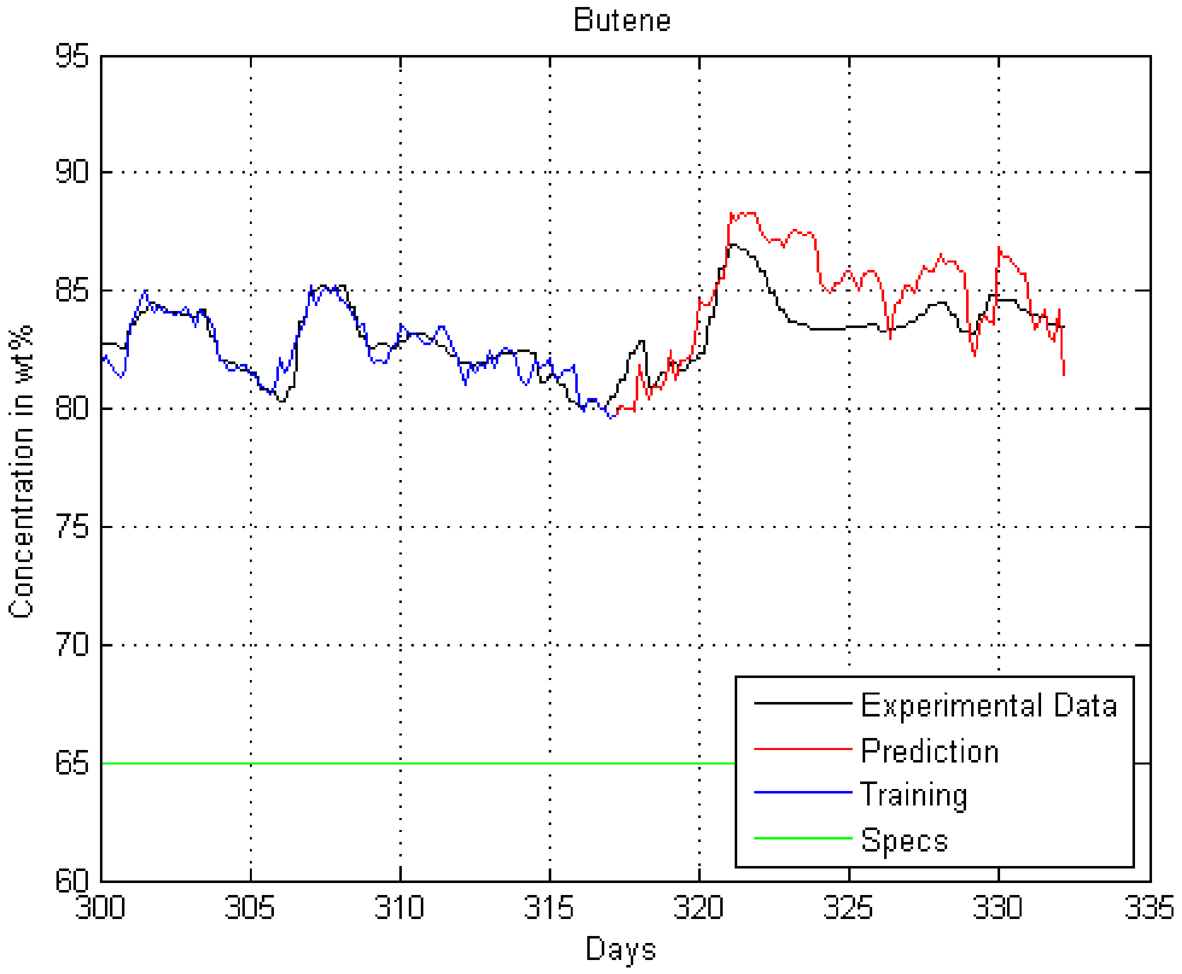
Operational Data of one Year (approx. 1 MB)

Expenses:

Approx. 5 Man-Days

Result:

Average Relative Error 1,5%



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Failure Prediction
Prediction of clogging

Framework conditions:

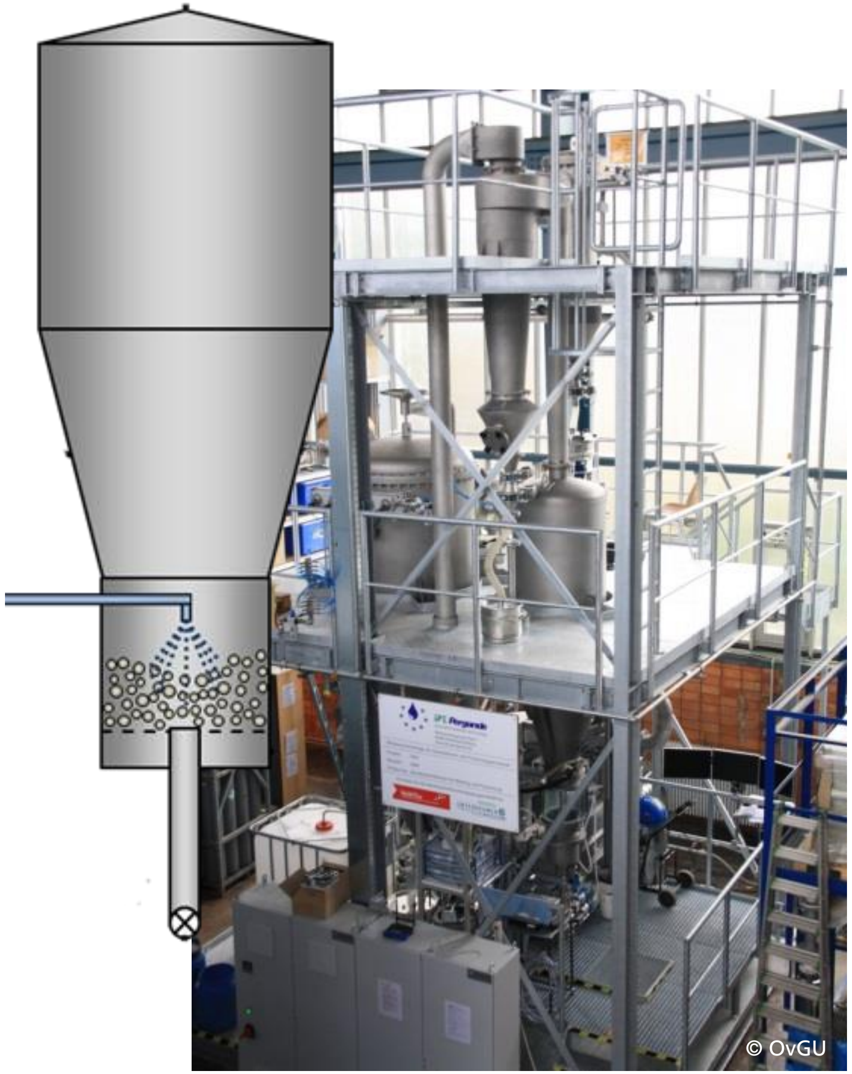
- Process industries with continuous production
- Relative small numbers of incidents

Objective:

- Prediction of clogging of a two-fluid injection nozzle

Data:

- 14 instances of clogging
- 1 Hz data acquisition rate
- Pressures und flow rates of compressed air and liquid



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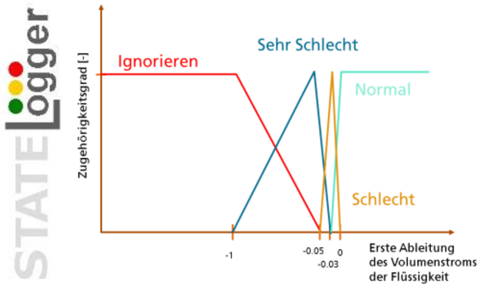
Failure Prediction

Combining machine learning and fuzzy logic

Input data

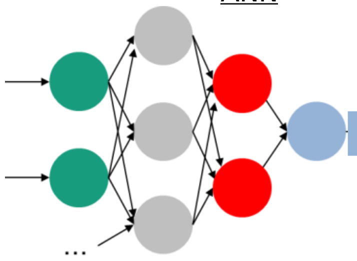
Operational data & derivations

- Dispersion air pressure [bar]
- Volume current of liquid [l/min]
- Liquid pressure [bar]
- …

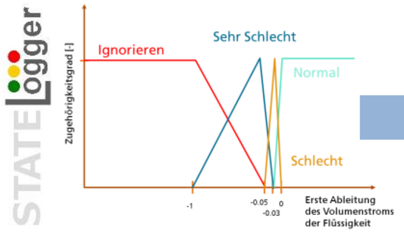


Assessment tool

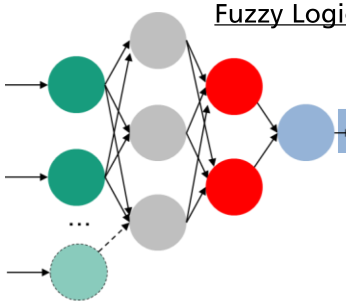
ANN



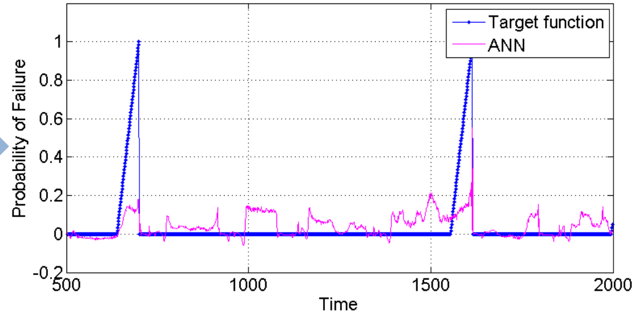
Fuzzy Logic

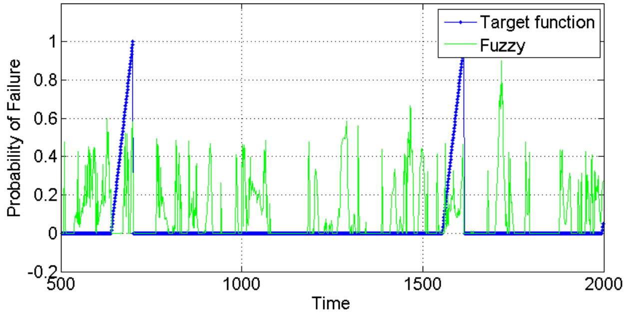


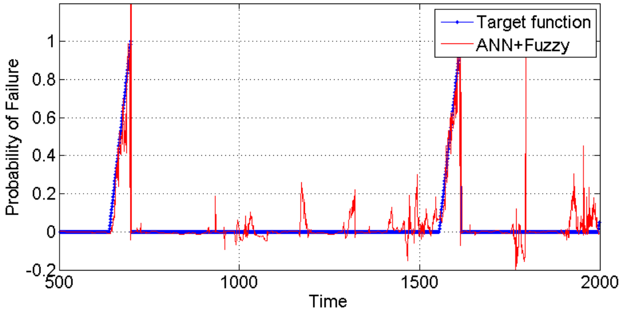
ANN with Fuzzy Logic



Failure probability





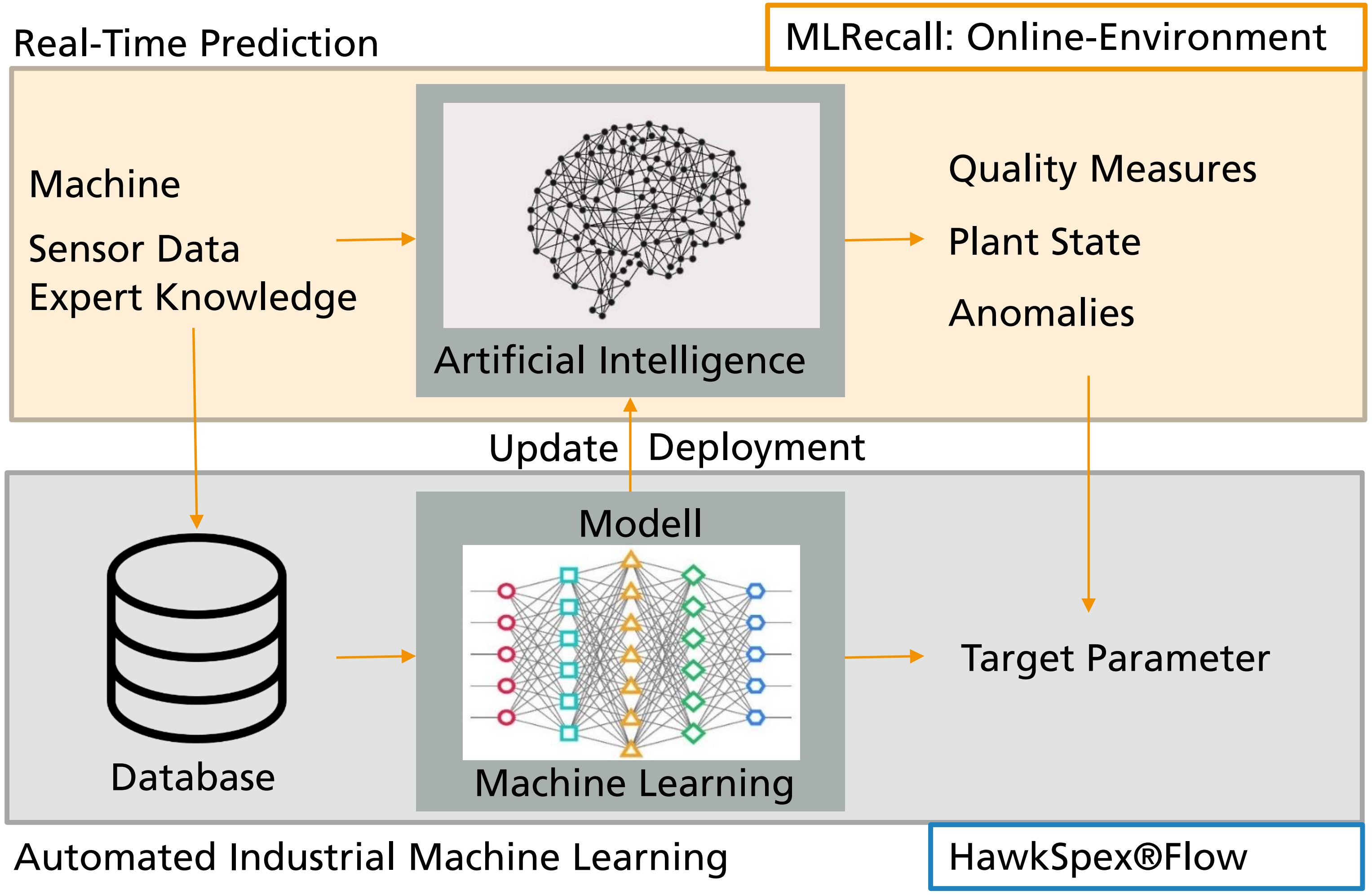


Online machine learning analytics
Cloud-based algorithm development

Objective:

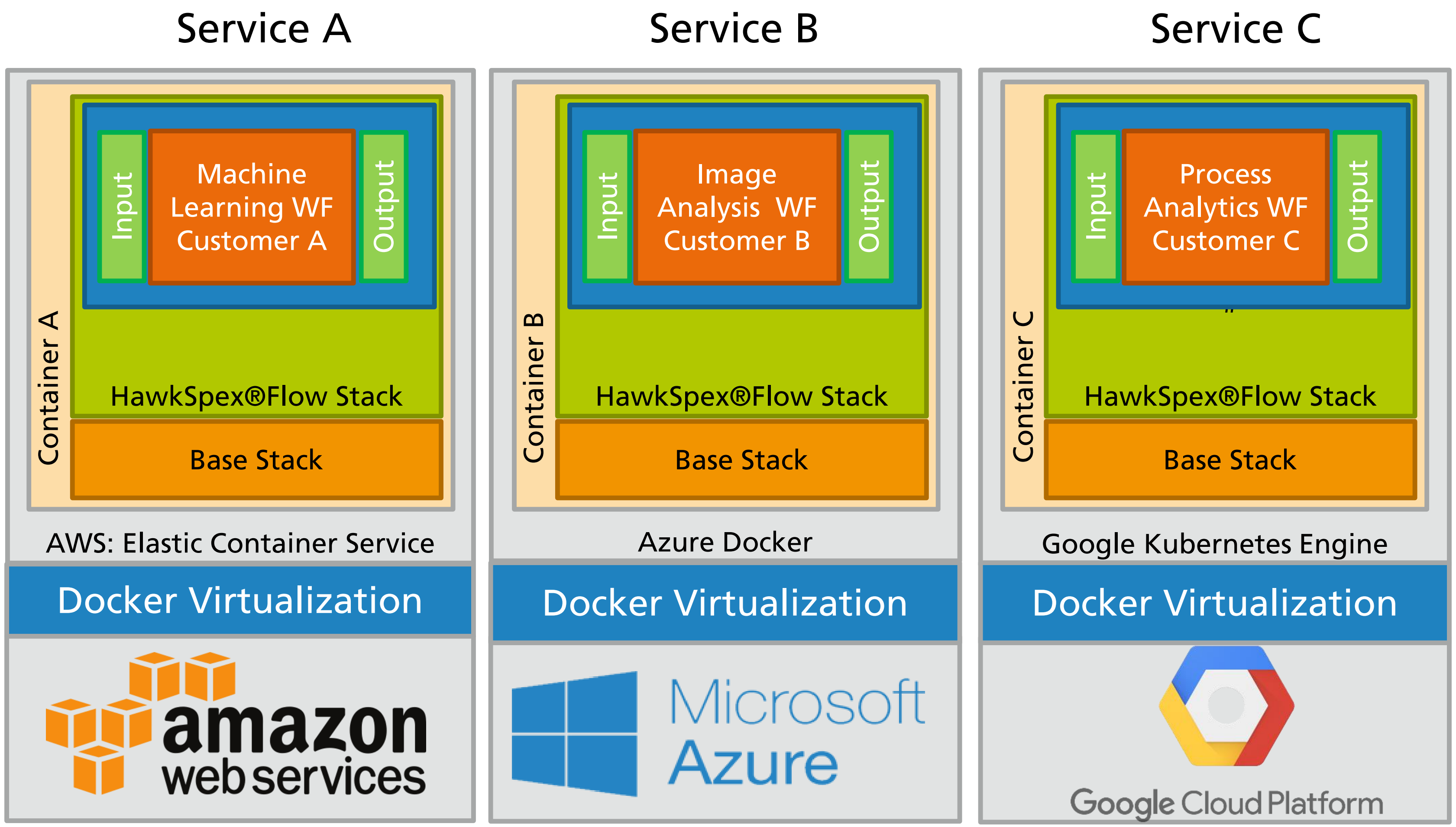
Providing a distributed machine learning environment using cloud-based services

- MLRecall online environment used as client to provide real-time prediction capabilities
- AI in MLRecall based on machine learning models established on VFK cloud environment running HawkSpex®Flow



Online machine learning analytics

HawkSpex®Flow – Develop with us, Run Anywhere



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