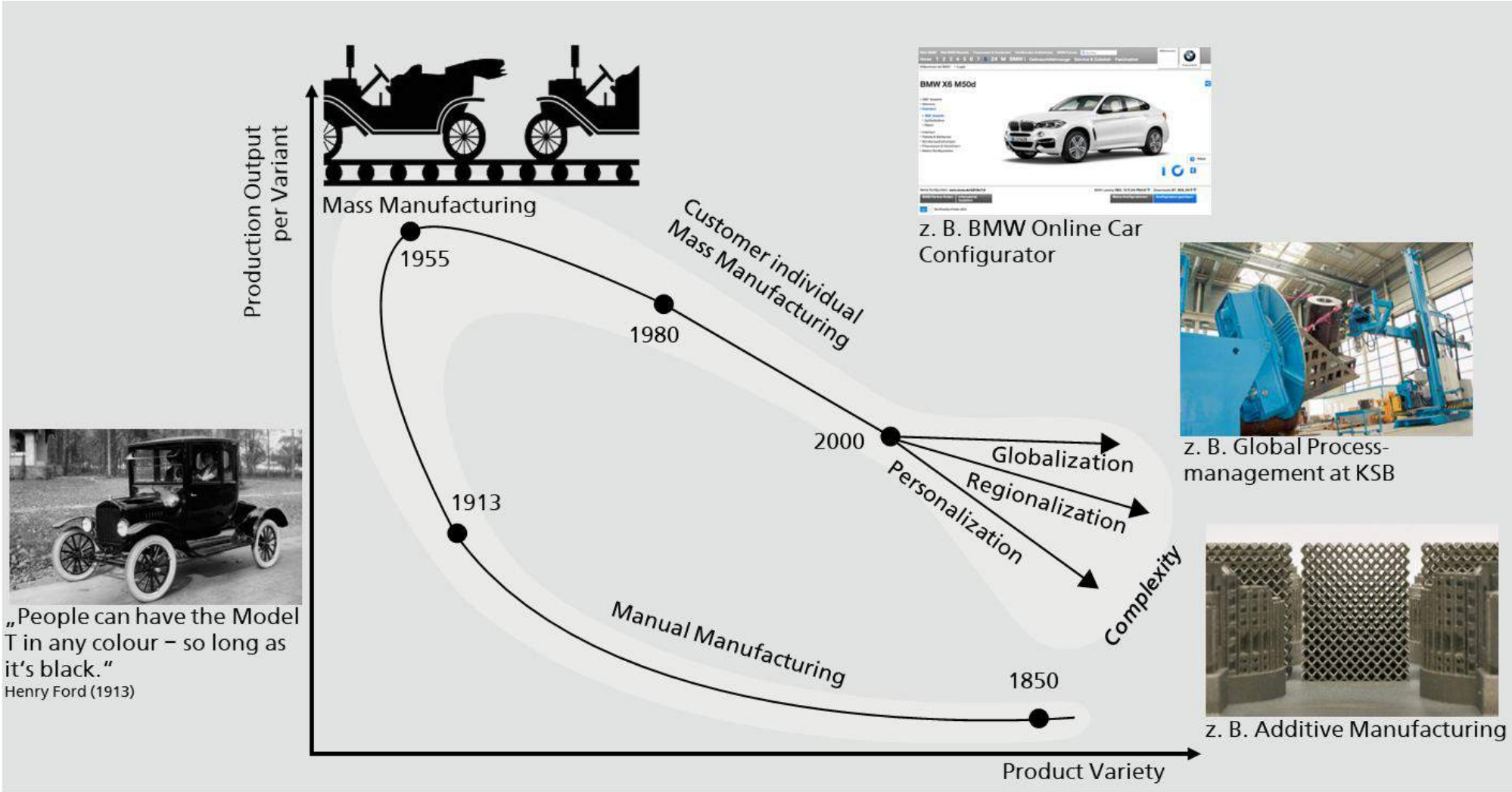
How about the major reason behind the 4th (R)evolution



In Anlehnung an: The Global Manufacturing Revolution; Quellen: Ford, beetleworld.net, bmw.de, dw.de

And how a Newcommer and now Market Leaders managed this

Source Tesla

Tesla Model Y 2023
Entire Dashboard

4 Variants

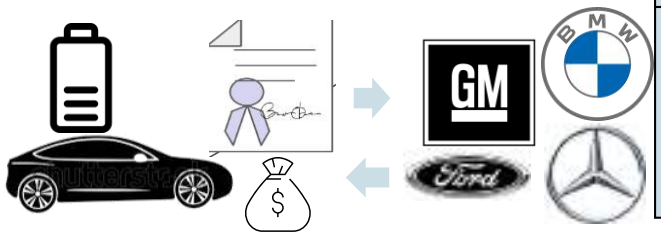
Source: Autobild 2025

Porsche Cayenne 2005
Just Internal Light

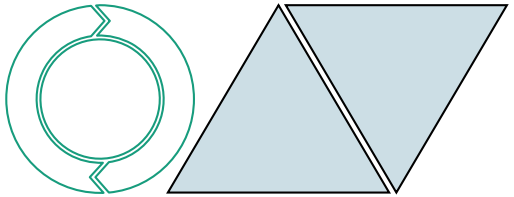
1.000 Variants

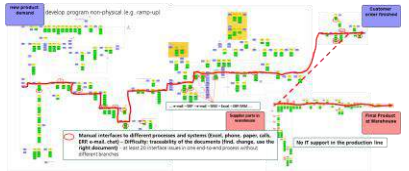
Breaking Rules – Legal Options we are using in front of our SME Partners

Open AI Chat GPT



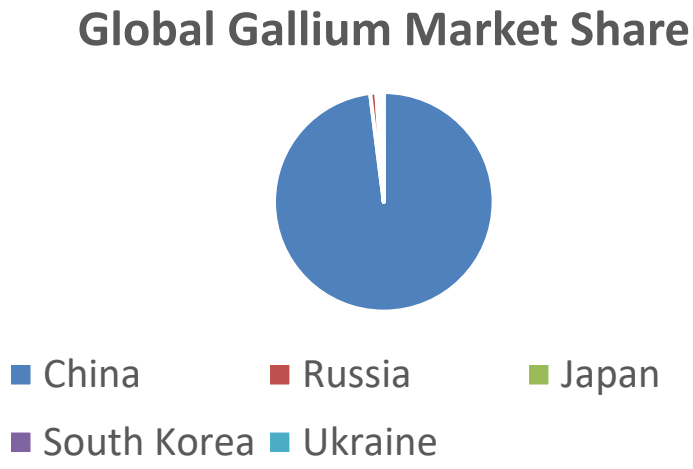
Question current accepted framework and conditions	Investigate into the opposite of current "best Practices"
Systematic steal from other sectors	Die Fast
Drastically extent Technological Limits	Understand and Reduce Complexity radically
Innovative Business Models instead finding Application for a given Technology	Use Playgrounds for fast Prototypes





Example Influence to SME: Circularity to be competitive in Future Markets

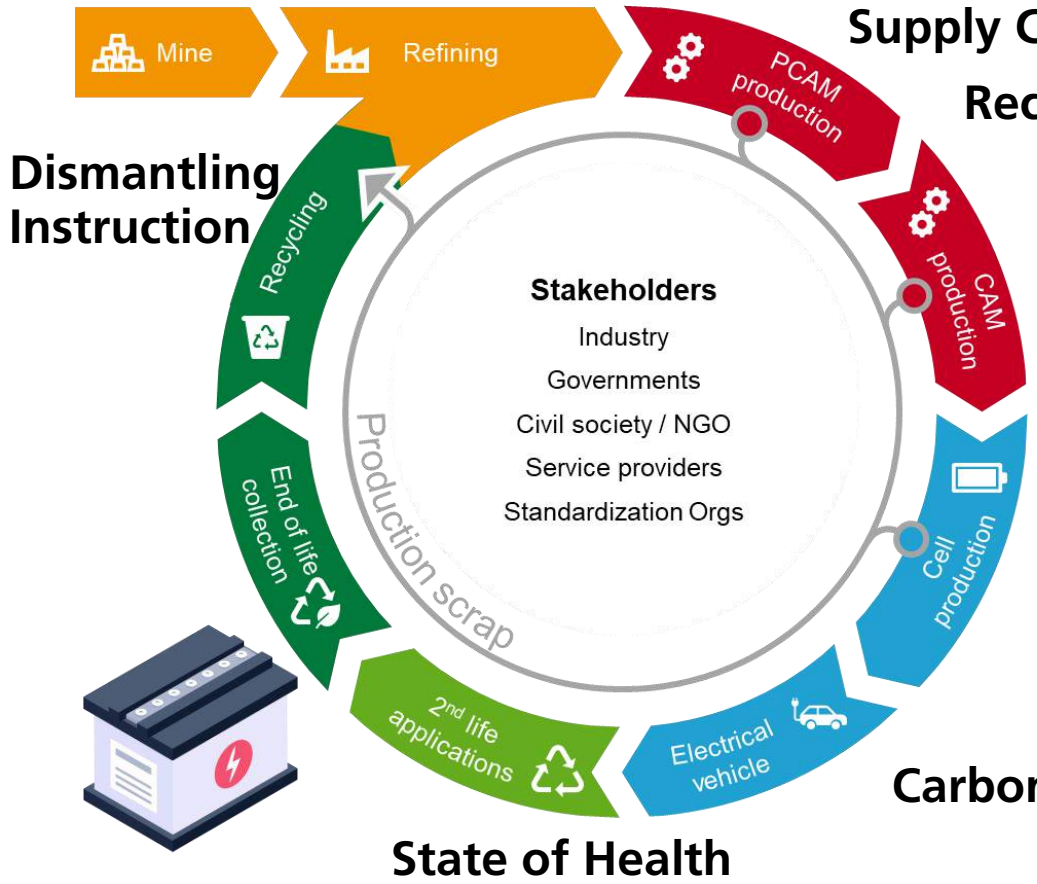
Example Gallium – Key Material for Chip Industry



Why Circularity requires Digital Product Passport (DPP)?

Combine Circularity with the other Sustainability Aspects – Example Batteries

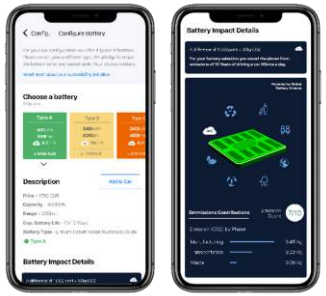
Mandatory Data in Battery Passport



Supply Chain Due Diligence

Recycled Material

Dismantling Instruction



Carbon Footprint

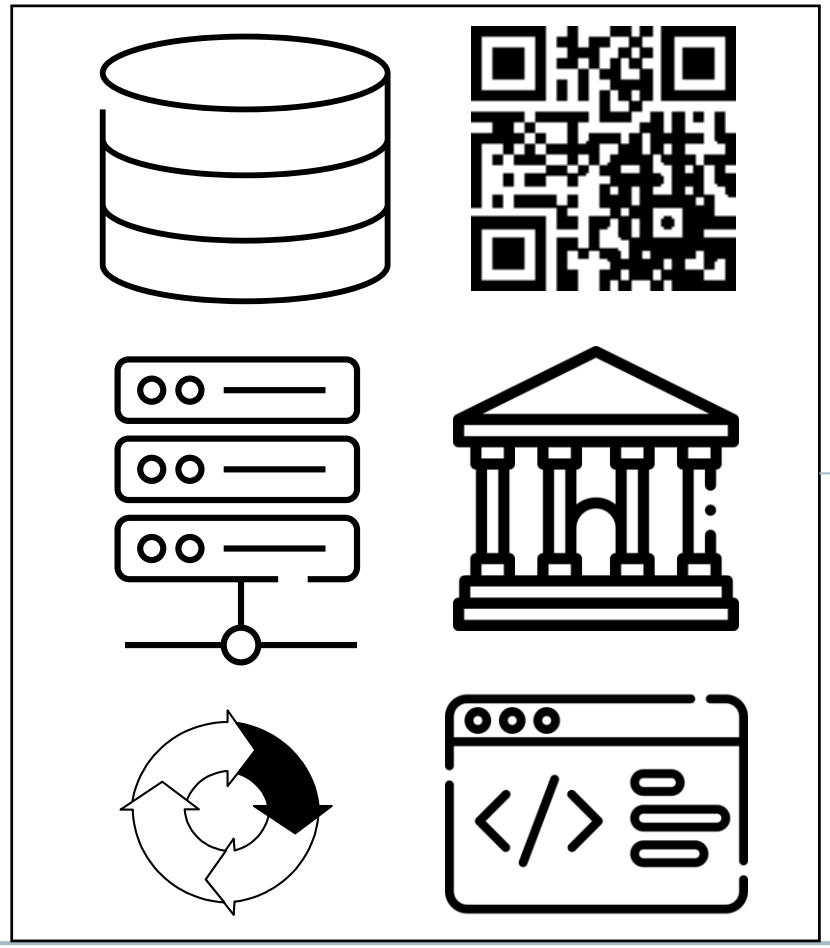
State of Health

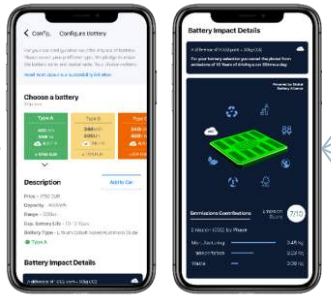
Source: BASF, Torsten Freund

DPP is not only for Large Companies and has to be considered Cross-Sectorial

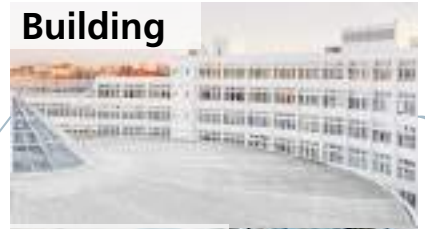
Separation between Technical DPP System and DPP Data

Harmonized Technical DPP System





Sector oriented DPP Data



Textile

Electronics

Battery

Cement

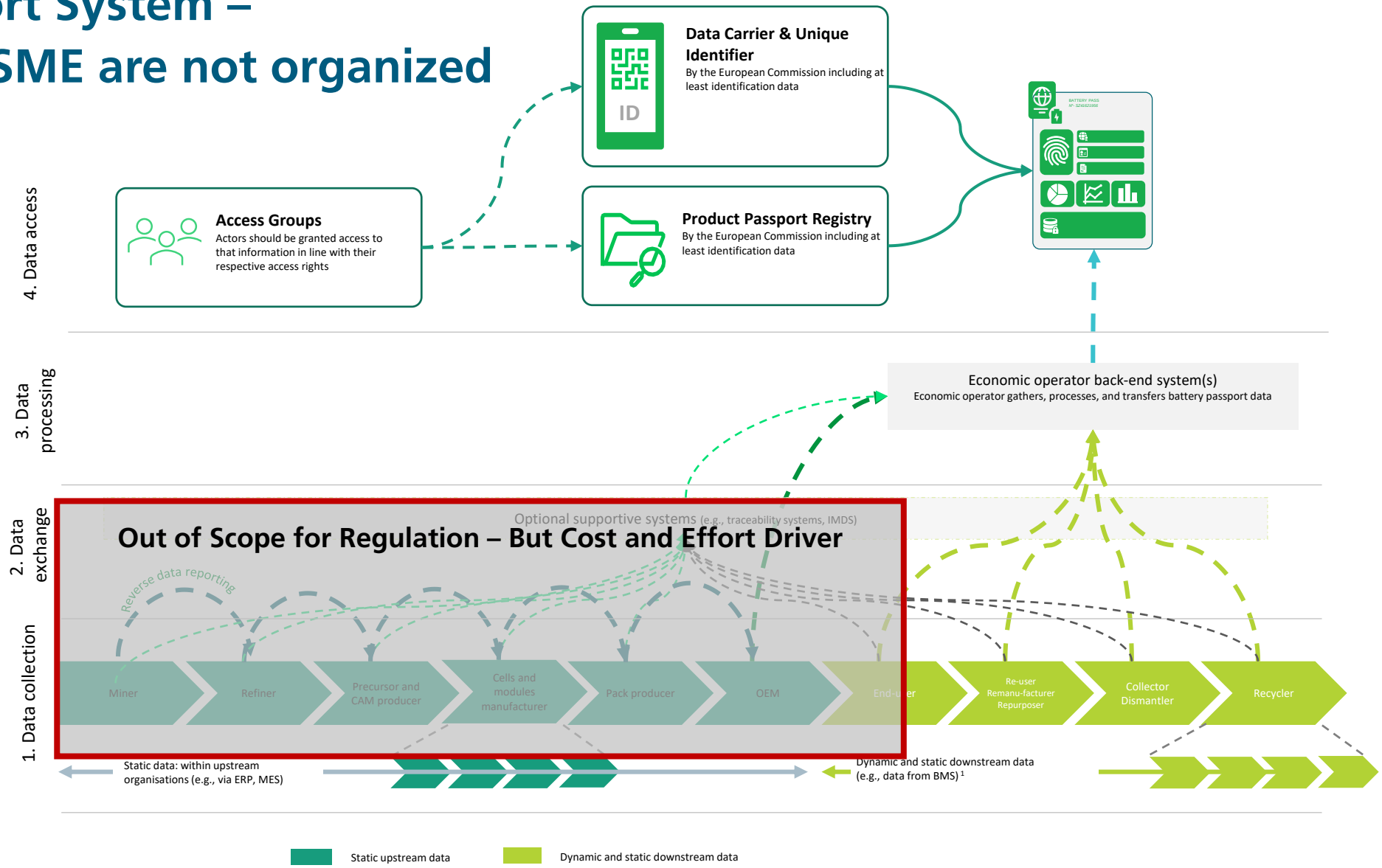
Handled by Individual Regulations

The Battery Passport System – Major Aspects for SME are not organized

The digital battery passport

Electronic record for batteries (“battery passport”), which shall contain information relating to the battery model and information specific to the individual battery. (Article 77)

The European Commission defines a digital product passport (DPP) as “a structured collection of product related data with predefined scope and agreed data ownership and access rights conveyed through a unique identifier”



Very huge Vision Impact on Economy but …

GHG, Human Rights, Child Labor Protection, Circularity

Complexity &
Non-Interoperability

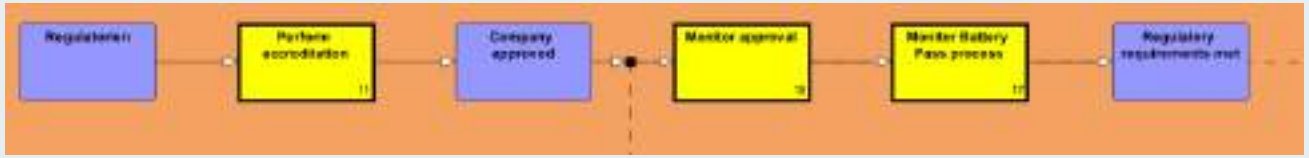
SME

Use Play Grounds for Fast Development - Battery Pass Prototype

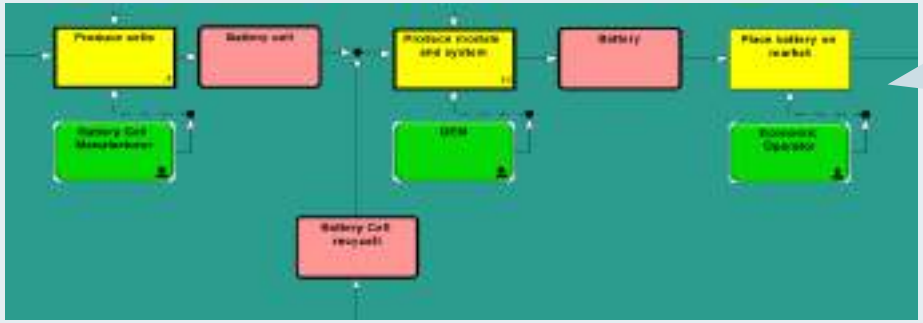
Model based System Configuration for SME Adoption – Material Cost: 72,30 €

Battery Pass Prototyp

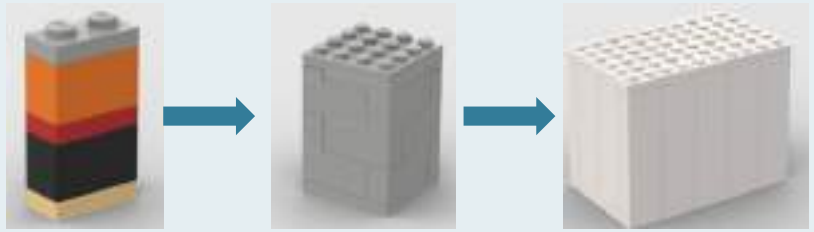
MO²GO System Models



Automatic Konfiguration



Physical Playground Implementation



Contains

- Data Points
- Roles
- Value Stream
- Information Processes
- Standards
- Products (1000 Variants)
- Governance

Learn Factories and Serious Games at Fraunhofer IPK – Creator of Playgrounds

1906 - Start

Georg Schlesinger

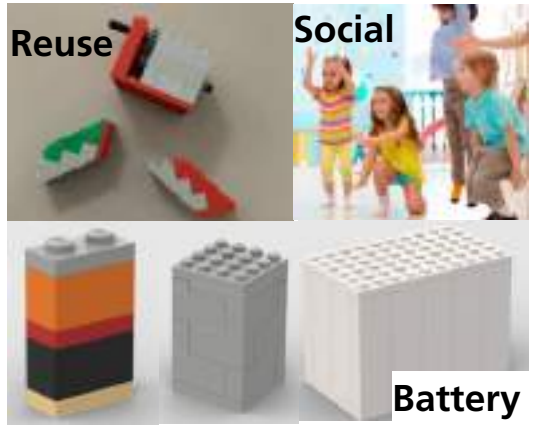
First Learn Factory in Berlin

1996
Make untouchable things touchable

- Understand Factory Planning and Digitization
- Become sensible for success factors

Combine Playing, Competition and Theory

2020
Method Exploration



- Understanding Complexity
- Factory Planning - Reality Check
- Assess Technical Solutions

Sustainable Development

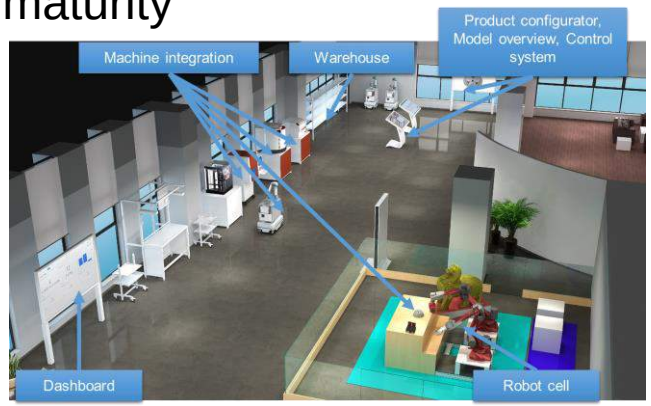
The Integrated Learn Factory in Nanjing

Technology –
Additive Manufacturing

How to improve behavior

Digital Transformation practically applied in three production lines with different maturity

Serious Game –
How to Collaborate interdisciplinary



How to integrate heterogeneous technologies

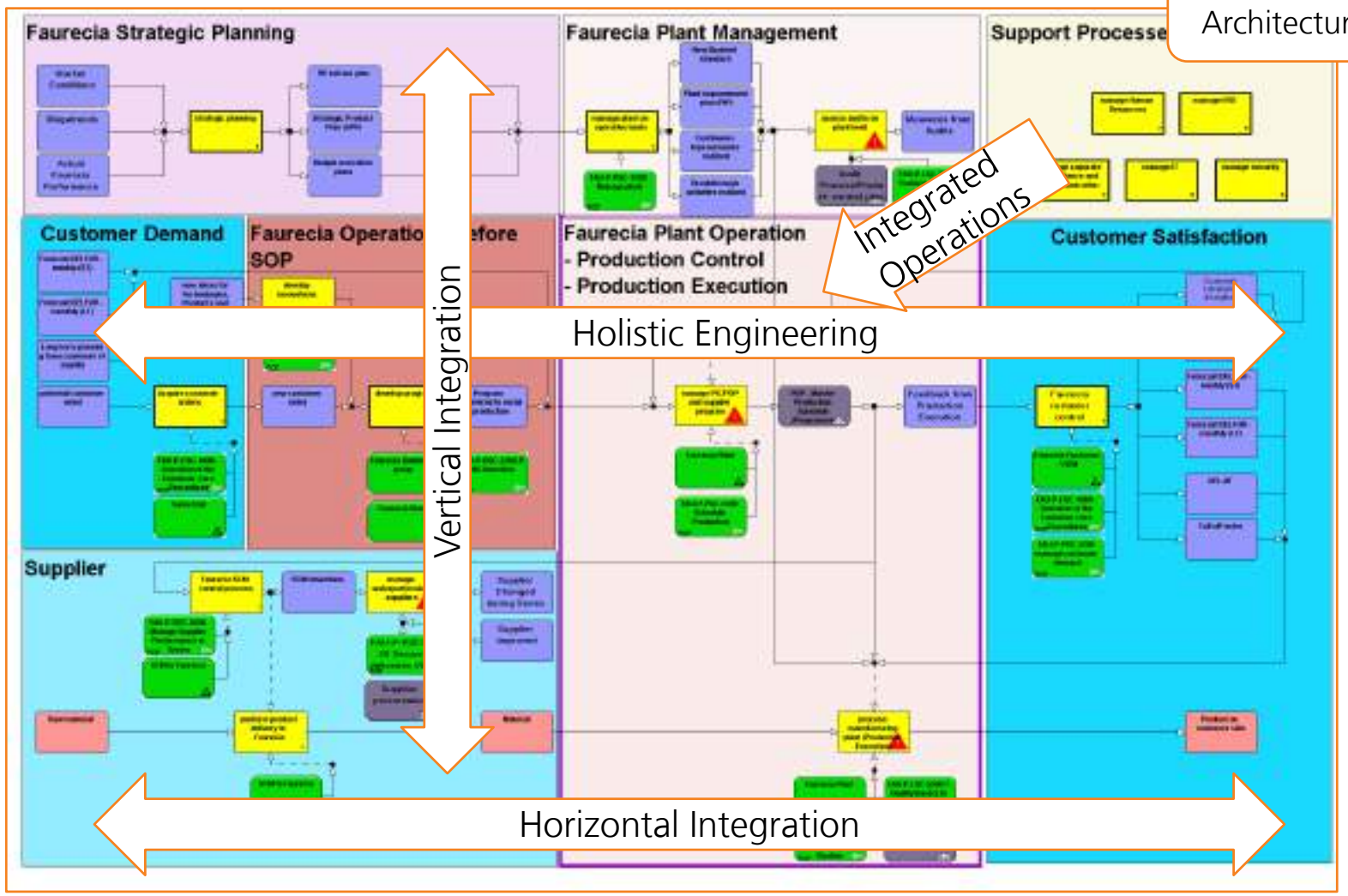
Coming back to Core Ideas of 4th Industrial (R)evolution and align Technology

Business Value

- Horizontal Integration along the value Chain from Sub- Supplier to Customer
- Vertical Integration from Top Management to Sensor
- Holistic Engineering
  - Fast Feedback to design
  - Front Loading instead of phase based engineering

Technologies and Concepts

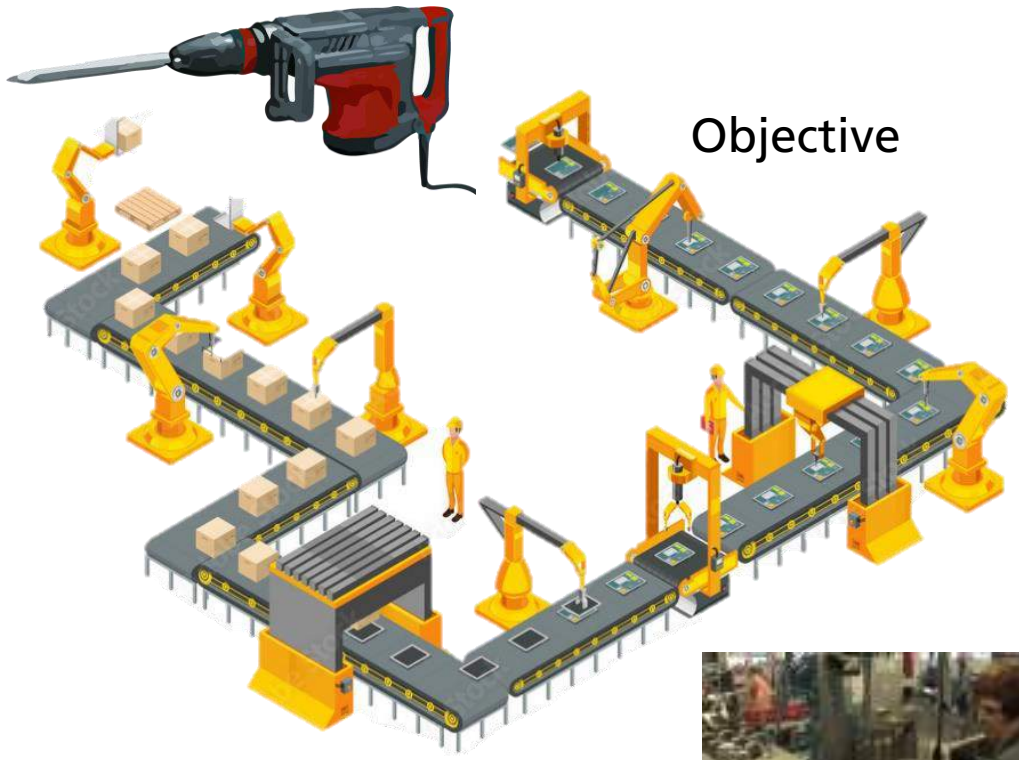
- Cyber Physical Systems and IoT
- Big Data and AI based Analytics
- Digital Twins



The Challenge - Automation of complete Assembly Lines for typical SME Expensive and time consuming

- **Long Time and Effort:** Lots of critical tasks – difficult for automation
- **High Risk:** Validation of physics and control when entire line is available
- **Less Flexibility:** Existing Automation Environment not suitable for additional tools, molds, fixtures
- **High Cost and Complexity:** When integration of additional sensor technology into existing line is necessary
- **But: stay on manual work is not an option:**
  - Less Availability of blue collar worker
  - High Cost for Manual Handling and Assembly

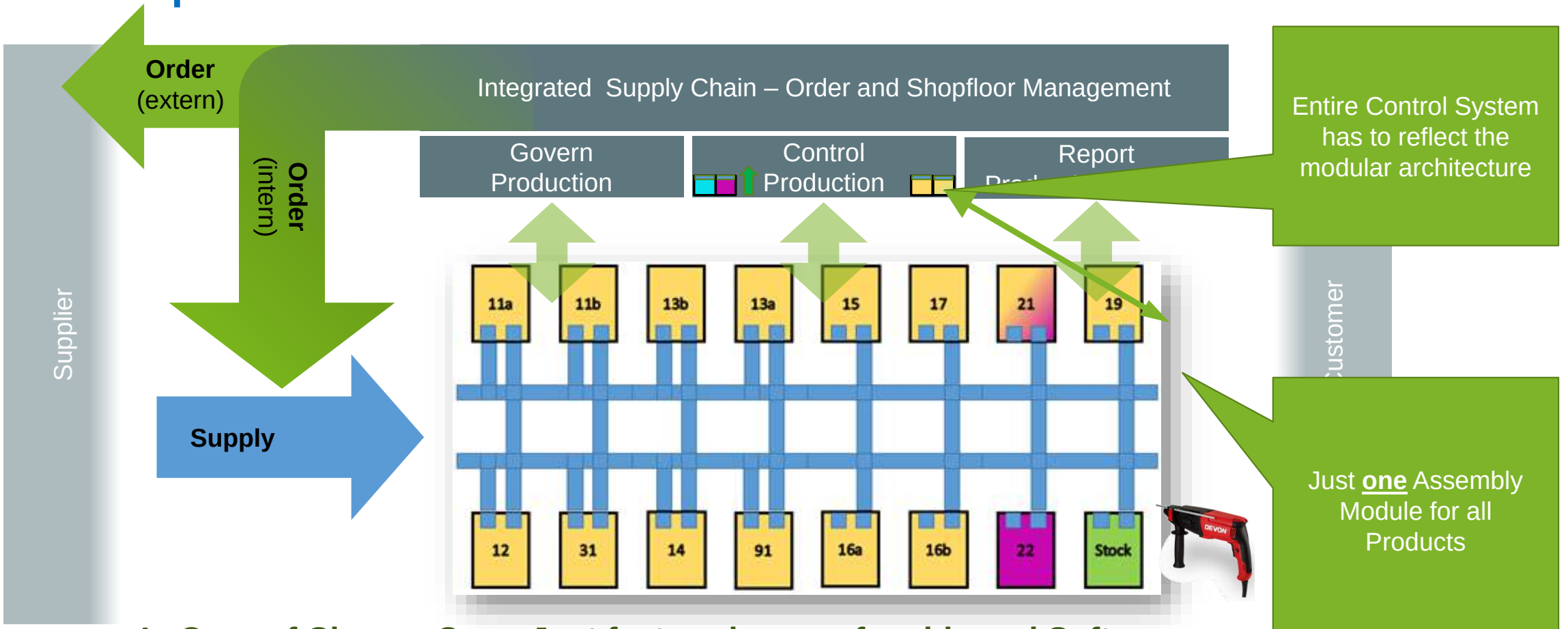
High Mix/Low Volume



Objective

Reality

First Idea – Creating a Modular Production Environment – able for assembly of very different products (more than 1.000 Variants) – but integrated with connected processes

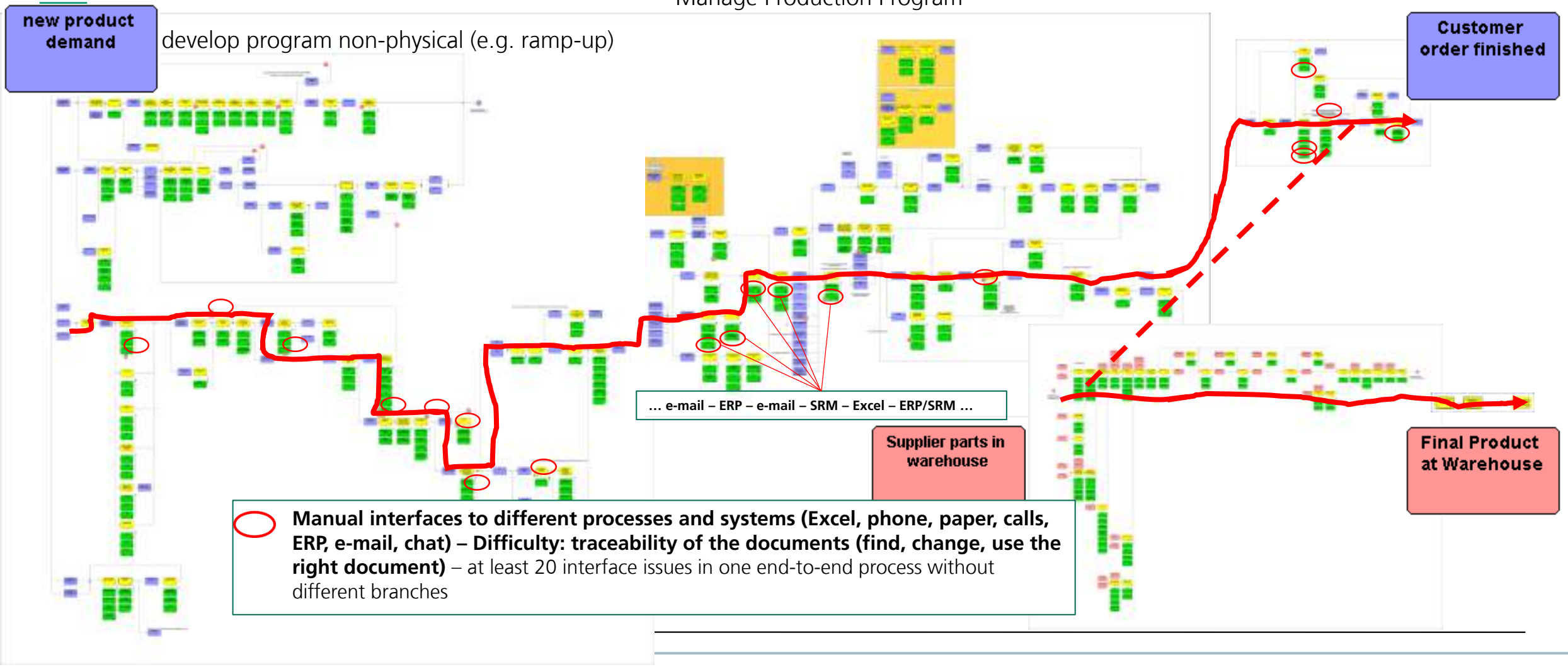


In Case of Change Over: Just fast exchange of molds and Software

Horizontal and Vertical Integration – just by using Models without IT

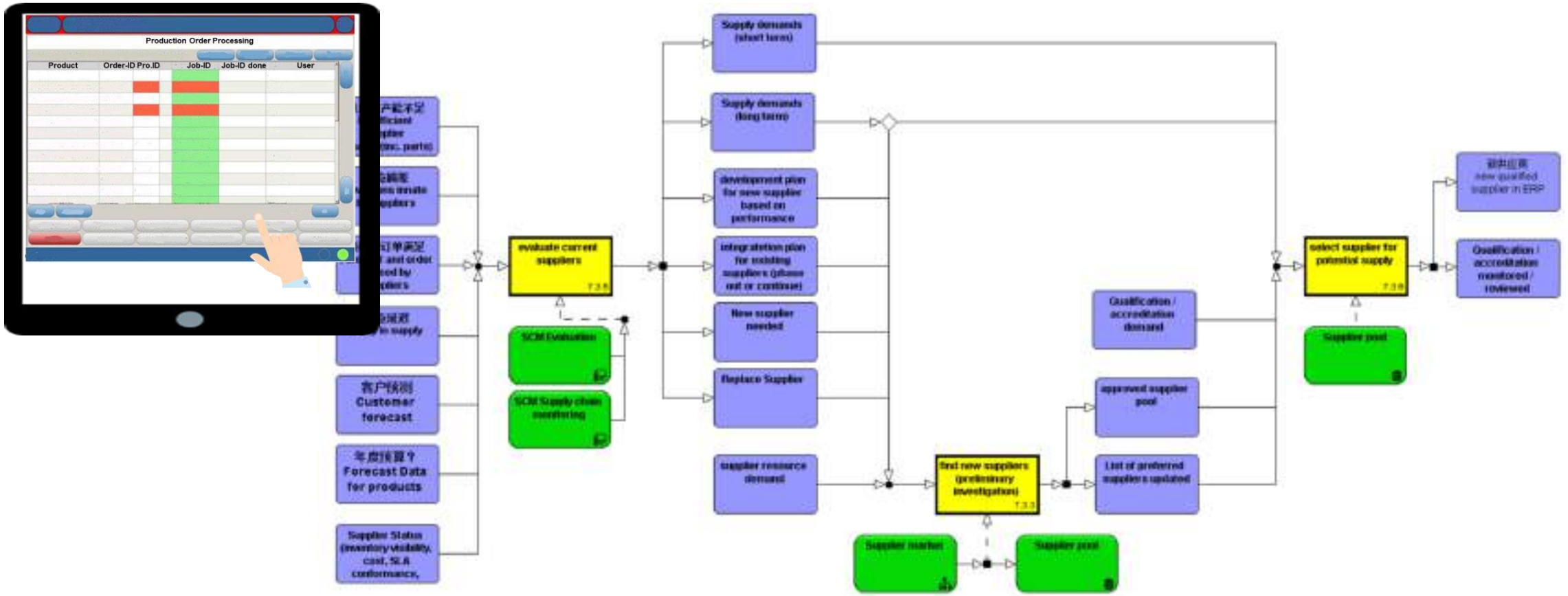
As Is Model for Integrated Order Management – Electrical Power Tool

Manage Production Program



Implemented Model after cleaning – with prototype solution

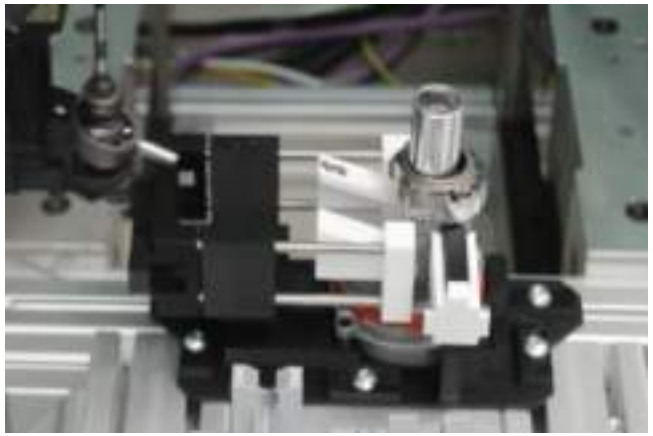
Integrate Top Floor and Shopfloor, Supply Chain and Customer Relation



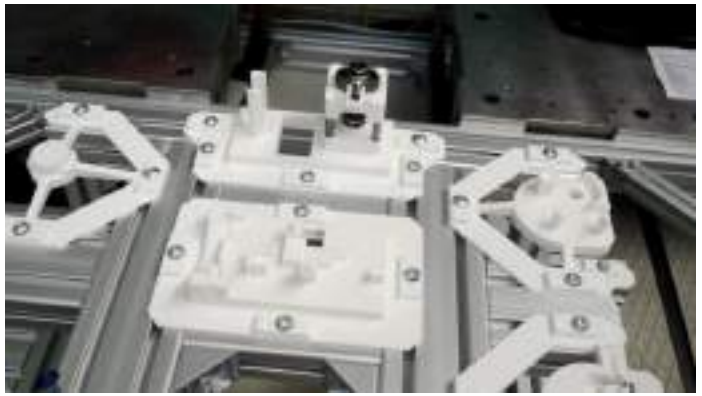
Using advanced Playground to extend limits
Automated assembly line by extended robotics and model based Shopfloor IT

Advanced Human Interaction

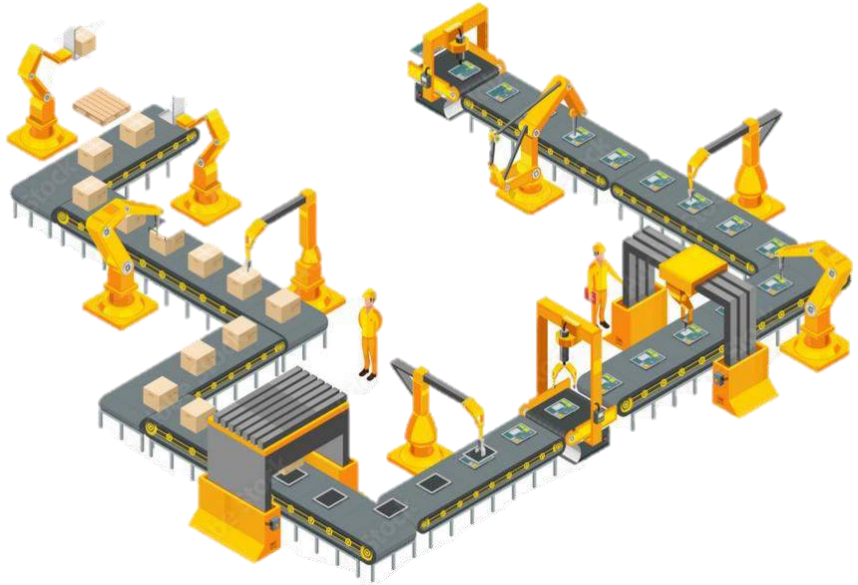
Model Based modular Shopfloor Control (Soft SCADA)



Intelligence for Robustness



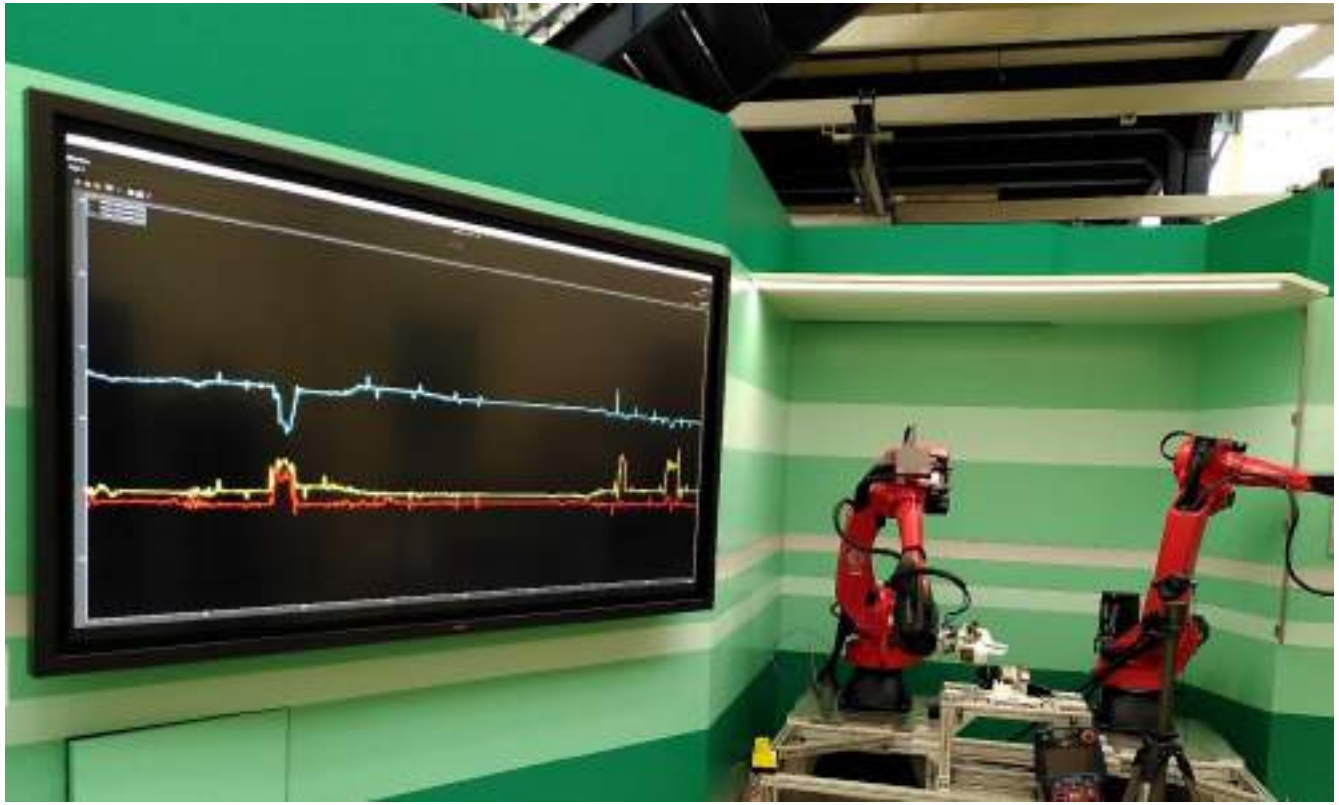
Develop and Optimize Fixtures and Molds



Optimize Collaborative Robotics

Integrated Digital Twin for Fast Development

- Data driven engineering leads to **10 times faster development** than traditional approaches
- Integrated Shopfloor IT is **generating** control logic (digital master) and recieves execution data (digital shadow) **automatically**
- Integrated Sensor Engineering leads to low cost solutions for production
- **Intelligent algorithms** use real-time process data for **automatic problem solving**



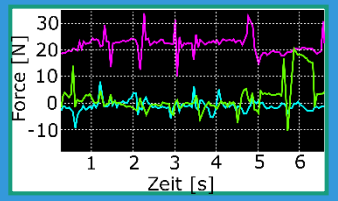
Application of Technology Twin for Research and Engineering

Create

Digital Master

Robot Cell

Target Force Data



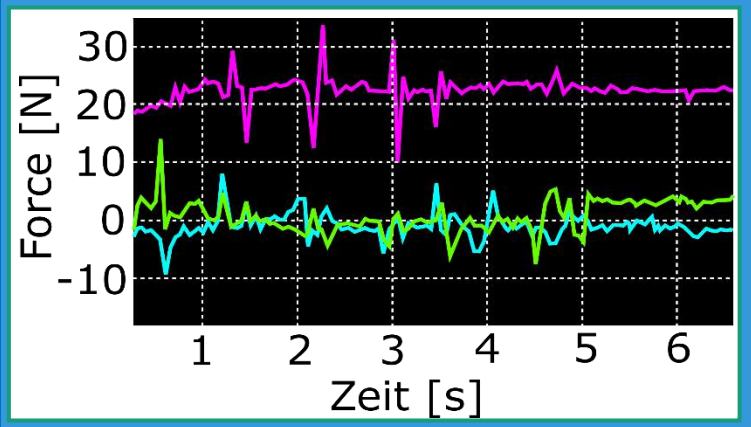
Process Model

Reality

Robot Cell with Force Sensors

Digital Shadow

Shadow Force Data



Increase Robustness by Intelligent Algorithms

Feedback to Design

The Benefit - Make Automation of typical non-Automatable Process happen

Manual Assembly

Automation with Digital Twin

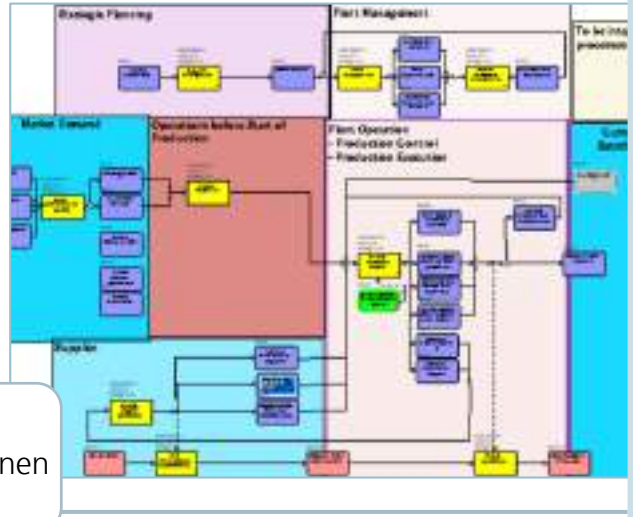
With Digital Twin

6 Times faster development speed
Improve reliability by appr. 30%.
3 Times Faster speed in serial operations

Technology Twin

Fraunhofer
IPK
INSTITUT
PRODUKTIONSANLAGEN UND
KONSTRUKTIONSTECHNIK

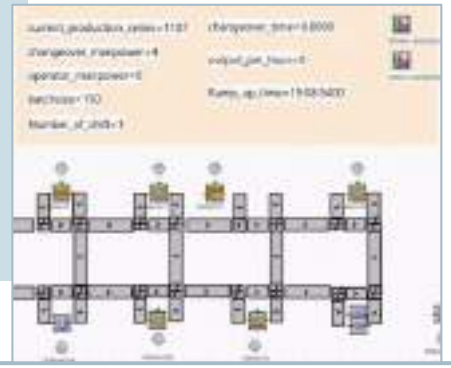
Model based connected digital twins to integrate different disciplines for Front Loading – applying 30 Years old Concepts - HLA



- Prozesszeiten
- Stationen + Positionen
- Nachfolger

Diskrete Event Simulation (here Plant Simulation)

- Process Simulation
- Production Layout

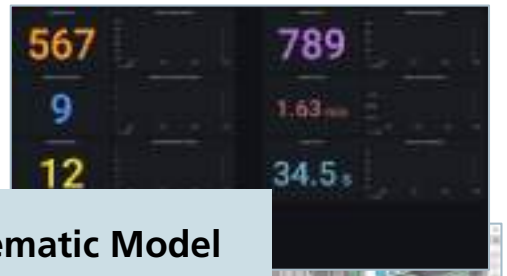


- KPI
- Simulation

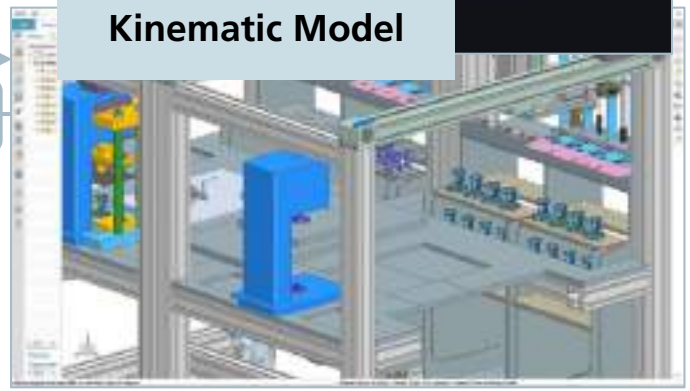
Blue Print Plant Model (BPPM)

- Factory System (Processes, Technologies, Products, Organisation, IT)
- AP-Interface for integrating
  - Business Models
  - Technology Models
  - Process Simulation
  - Risik Analysis
  - Shopfloor IT (Soft SCADA)
  - KPIs

Process Time



Kinematic Model



Szenario

Simulation Result

Szenario based Economic Analysis (Business Model Canvas Validation – BMV)

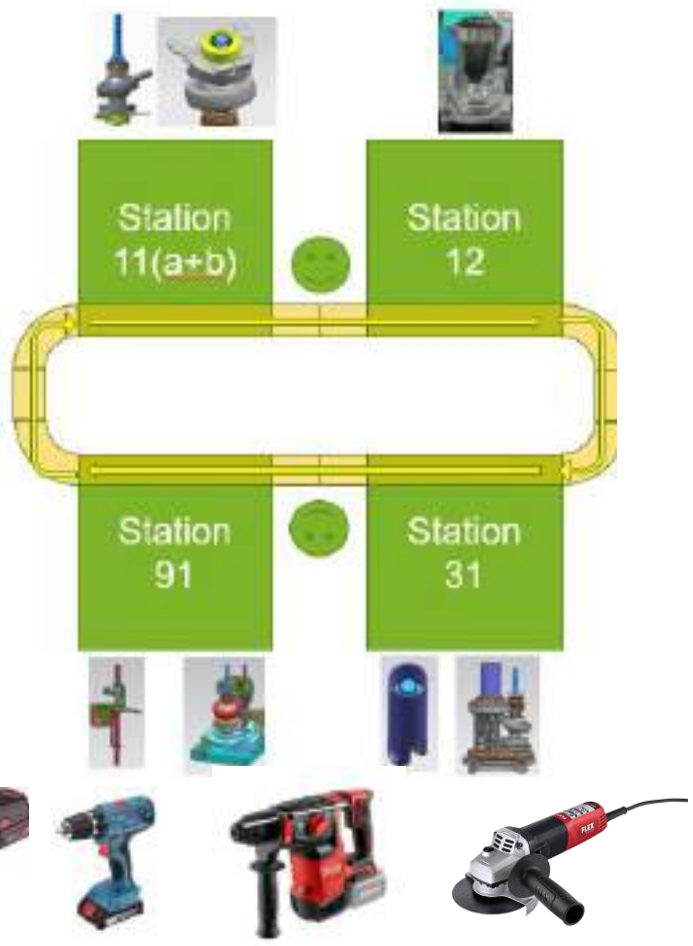
Outcome core Modular Production Environment – able for assembly of very different products (more than 1.000 Variants)

High Mix low Volume Capability

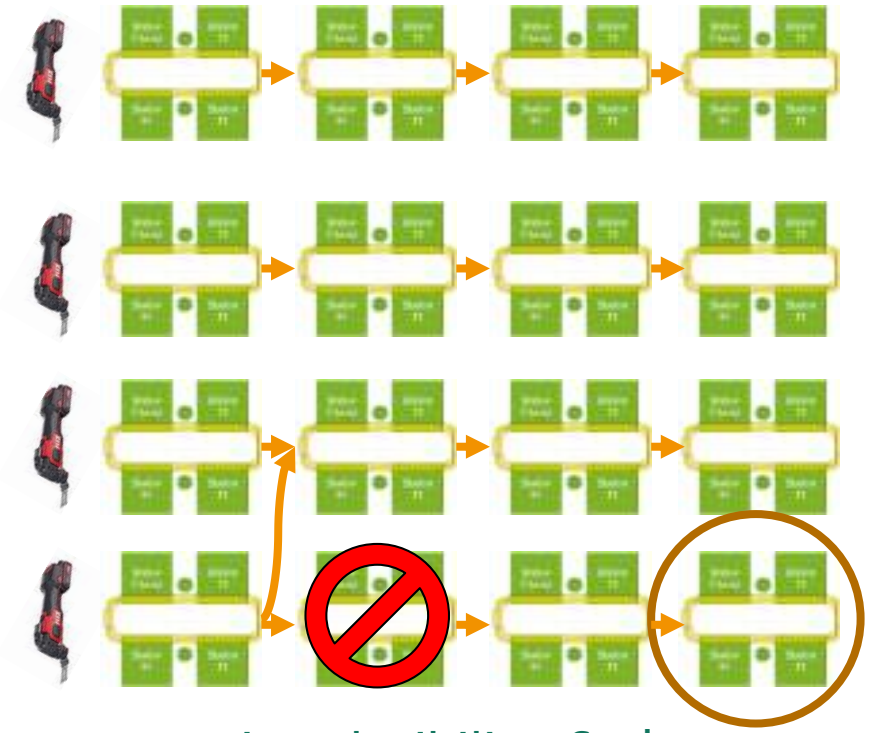
Fast adaptation to new products

Economically viable

Change Over: 2h → 15 min.
Automation: 5% → 45%

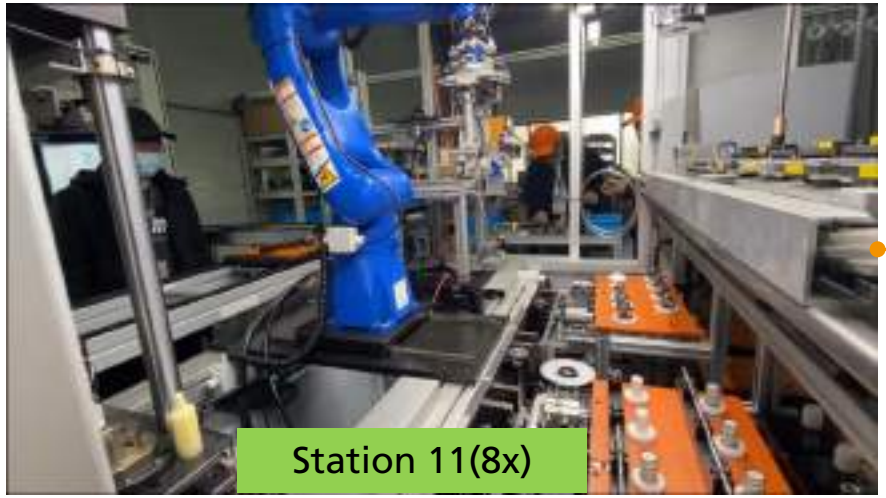


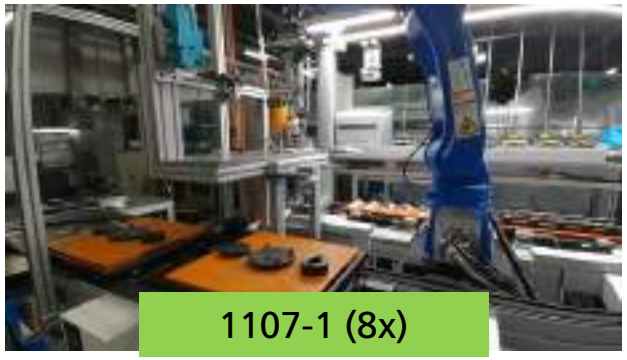
Volume und Routing Flexibility

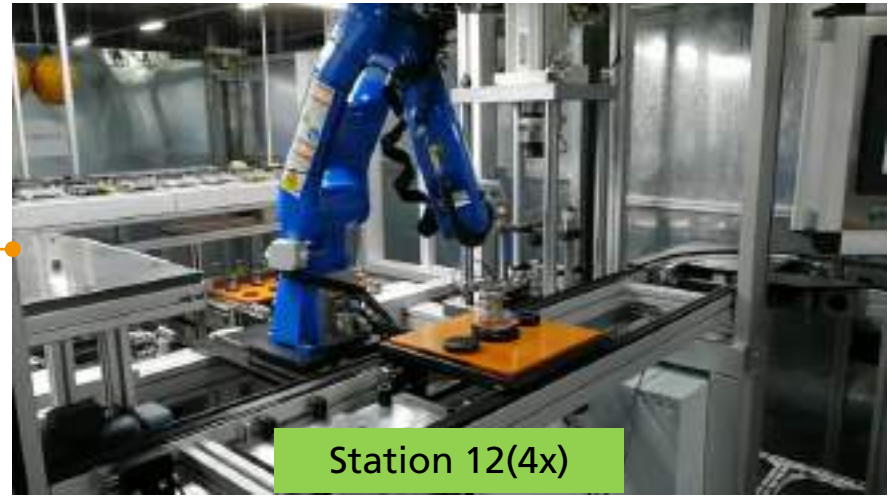


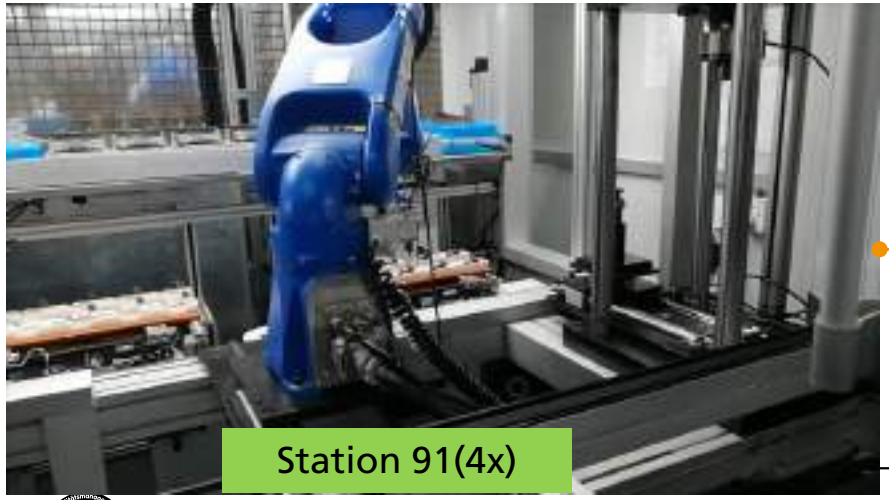
Routing Flexibility Scale

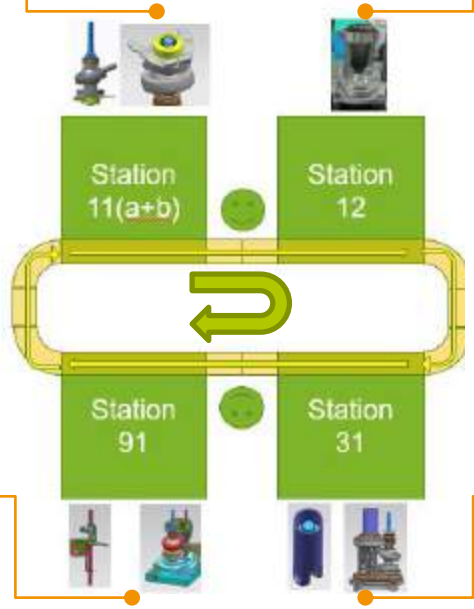
As Implemented

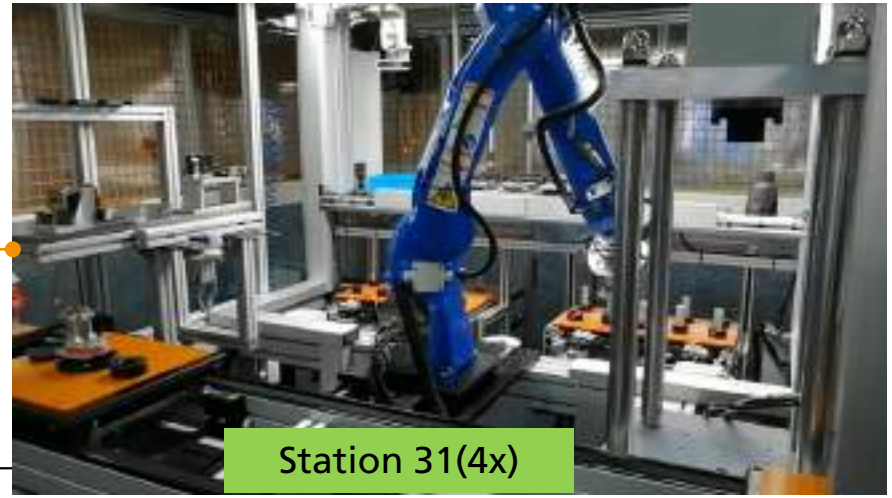




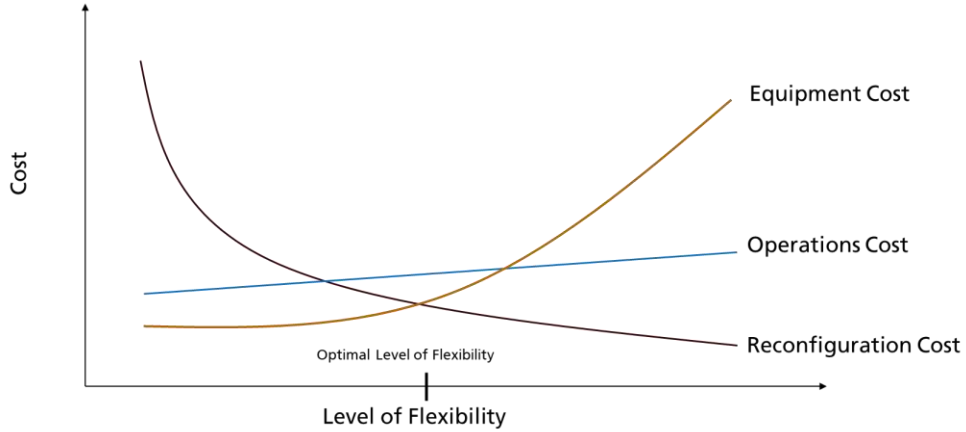


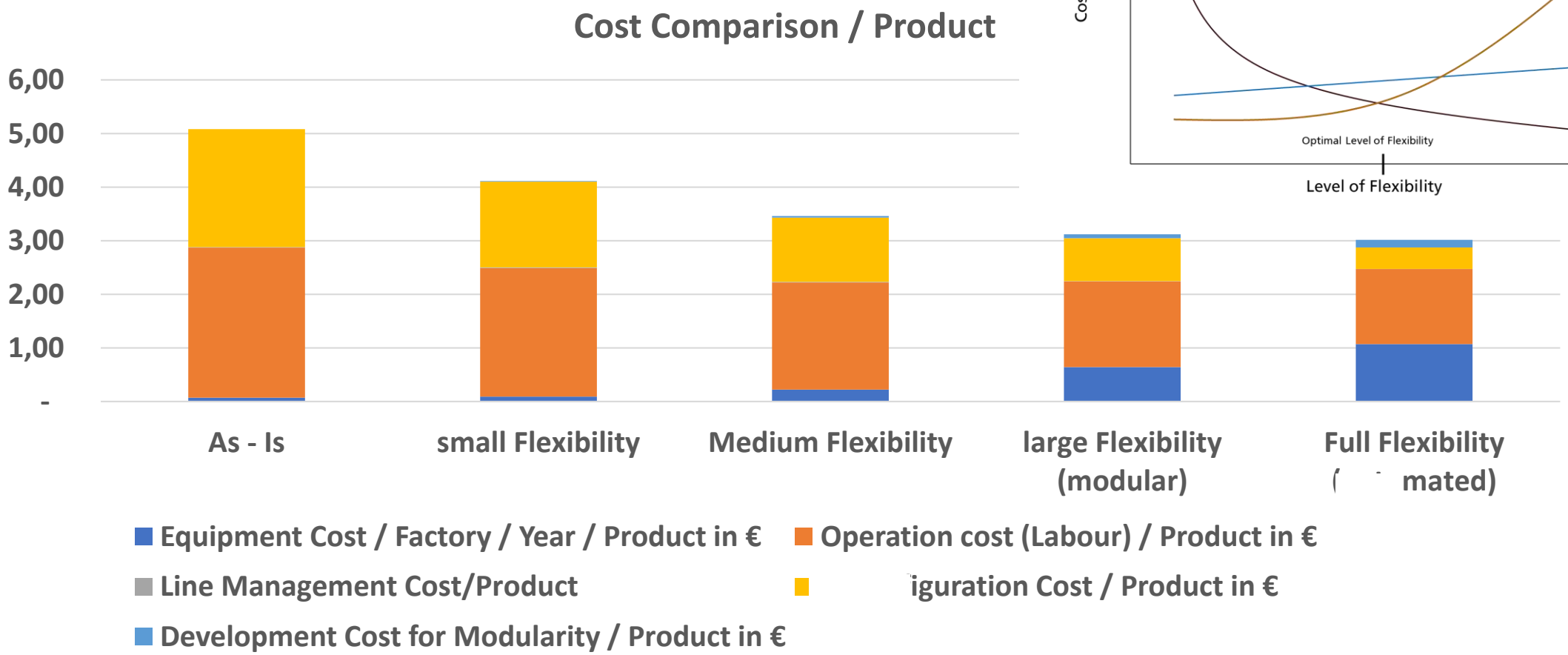




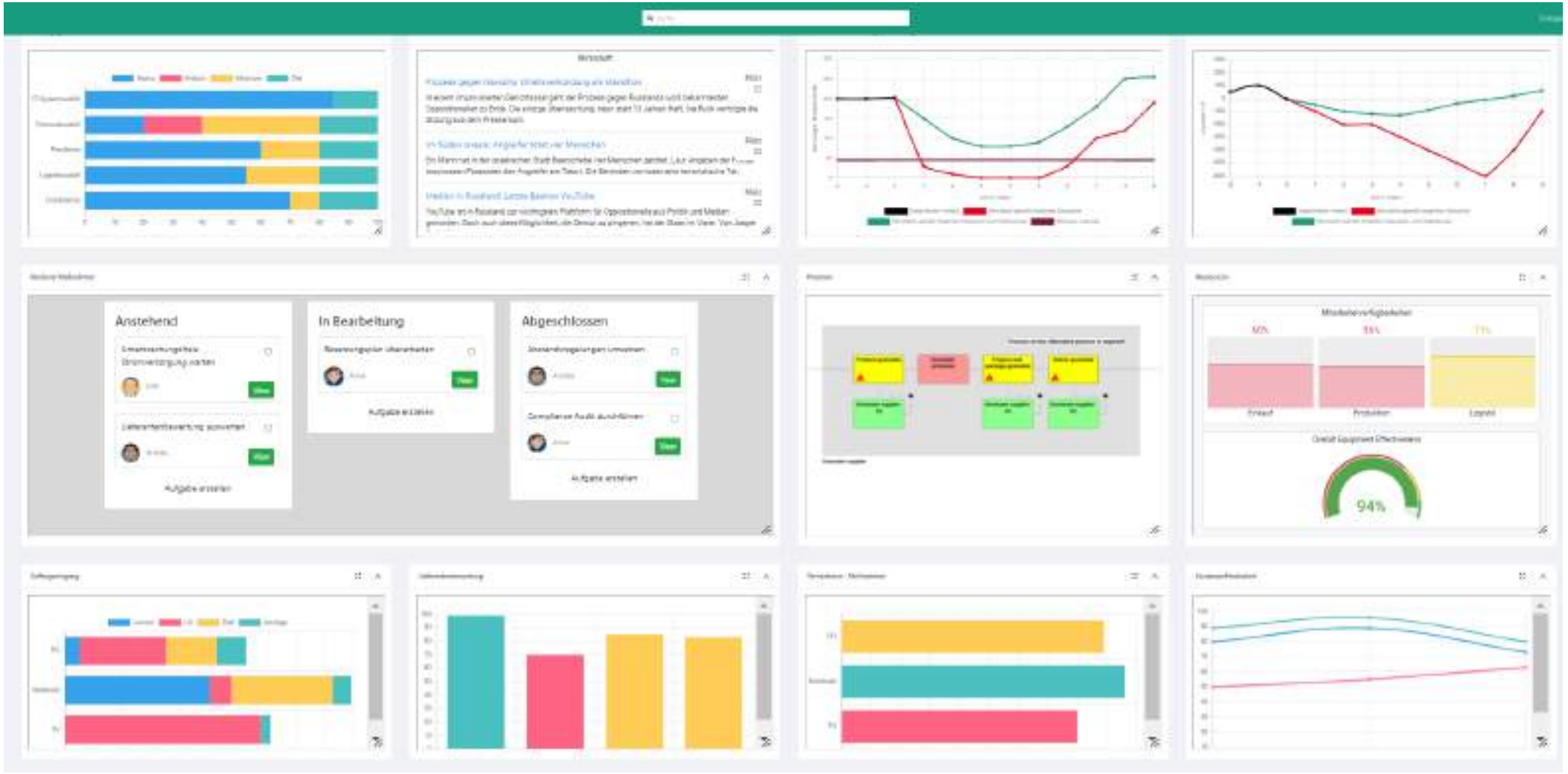


Breaking Rule Attitude helps to overcome typical Framework Conditions Economic Model for Automation





Machine Learning enabled Situational Awareness – The Company Twin



Interoperability - Analytics in complex Production Processes – made easy

Ad Hoc Networking of Machines and Equipment for the Tracking of Special Orders

Industry 4.0 out of the box

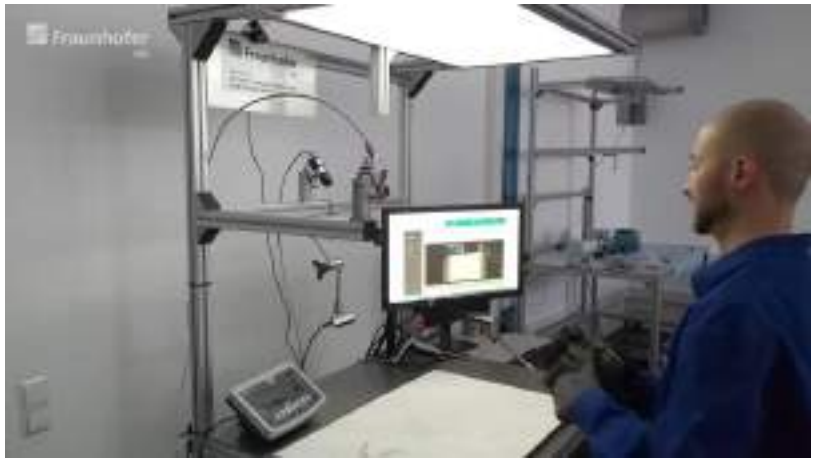
- Mobile application for digitization
- Flexible tracking of production parameters along the process
- Implementation of ad hoc quality assurance measures
- Minimal planning, implementation and investment cost
- Applicable for training on digitization technologies

Fraunhofer
IPK
INSTITUT
PRODUKTIONSANLAGEN UND
KONSTRUKTIONSTECHNIK

Current examples of breaking Rules coming from our Institute

Creating plastics for generative Manufacturing out of waste

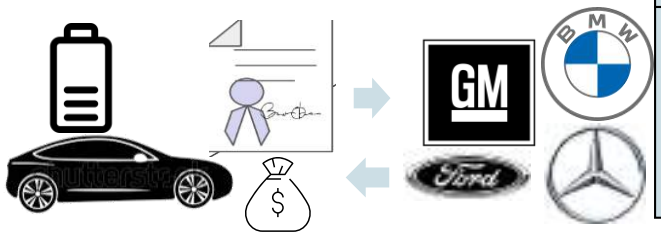
Cobots for Assembly for Motor Cycle
e.g. Finding the screw



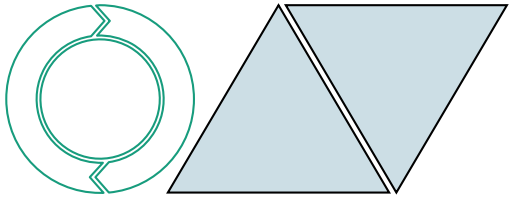
AI based recognition and identification of old parts

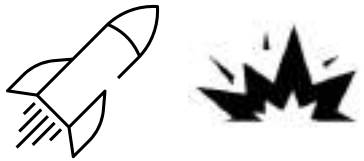
Industrial Breaking Rules Attitude – Still there is no real systematics on that Lets develop together – We have to debate more and challenge approaches

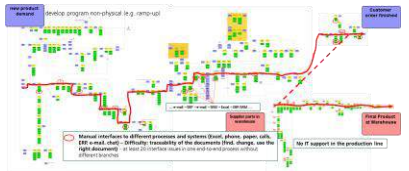
Open AI Chat GPT



Question current accepted framework and conditions	Investigate into the opposite of current "best Practices"
Systematic steal from other sectors	Die Fast
Drastically extent Technological Limits	Understand and Reduce Complexity radically
Innovative Business Models instead finding Application for a given Technology	Use Playgrounds for fast Prototypes







Federated, Decentralized Standardization for Systems Integration in Industry 4.0

Nenad Ivezic
Senior Research Advisor Associate
National Institute of Standards and Technology, USA

Agenda

- I4.0 Systems Integration Challenges to Achieving Interoperability
- A New Integration Approach to Achieving Interoperability
  - What is the concept
  - What is provided?
  - Why do we want it?
- Demo
- A New Idea: Decentralized and Federated Standardization
- Concluding Remarks

I4.0 Systems Integration Challenges to Achieving Interoperability

The Industry 4.0 Integration Complexity

Source: https://www.intelegain.com/the-ultimate-guide-to-iot-driven-digital-transformation-in-manufacturing/

Integration Challenges to Achieving Interoperability: An Illustration

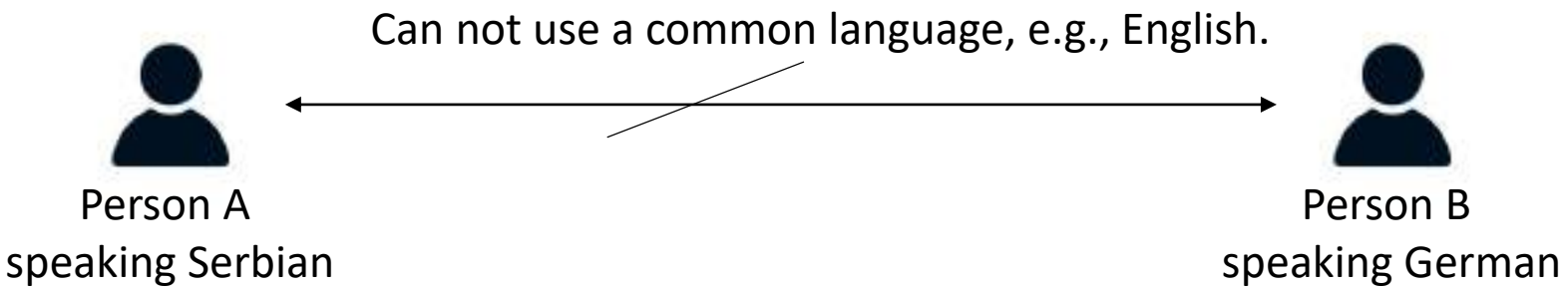
Person A
speaking Serbian

Integration Challenges to Achieving Interoperability: An Illustration

Person A
speaking Serbian

Person B
speaking German

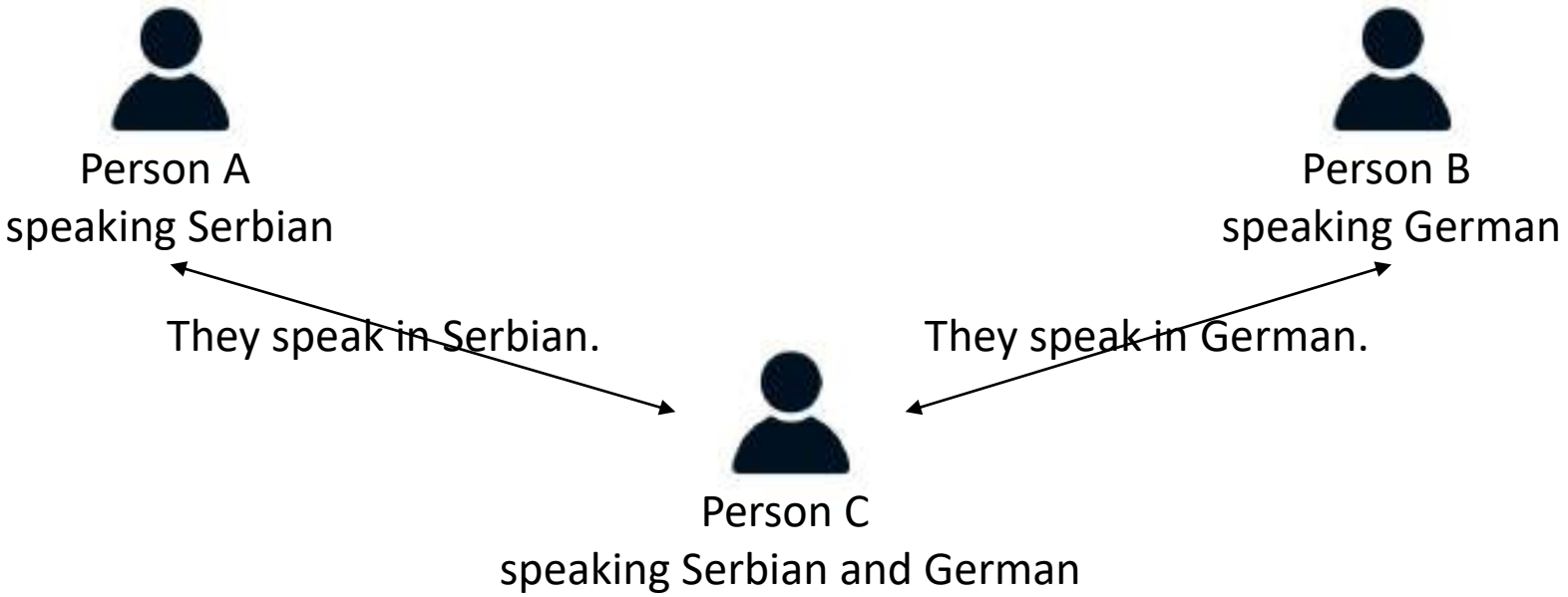
Integration Challenges to Achieving Interoperability: An Illustration



Integration Challenges to Achieving Interoperability: An Illustration

Option A:

3 Corner Model



Integration Challenges to Achieving Interoperability: An Illustration

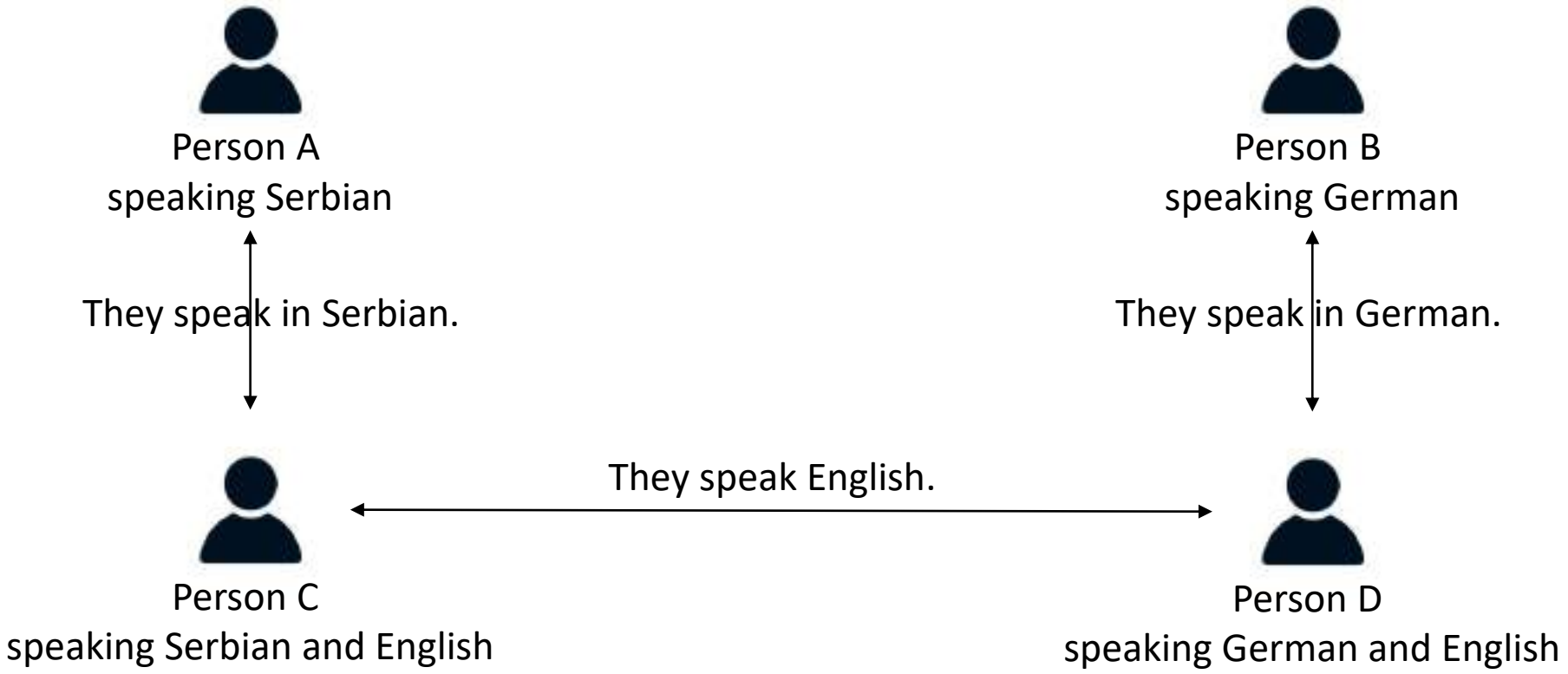
Option A:

3 Corner Model

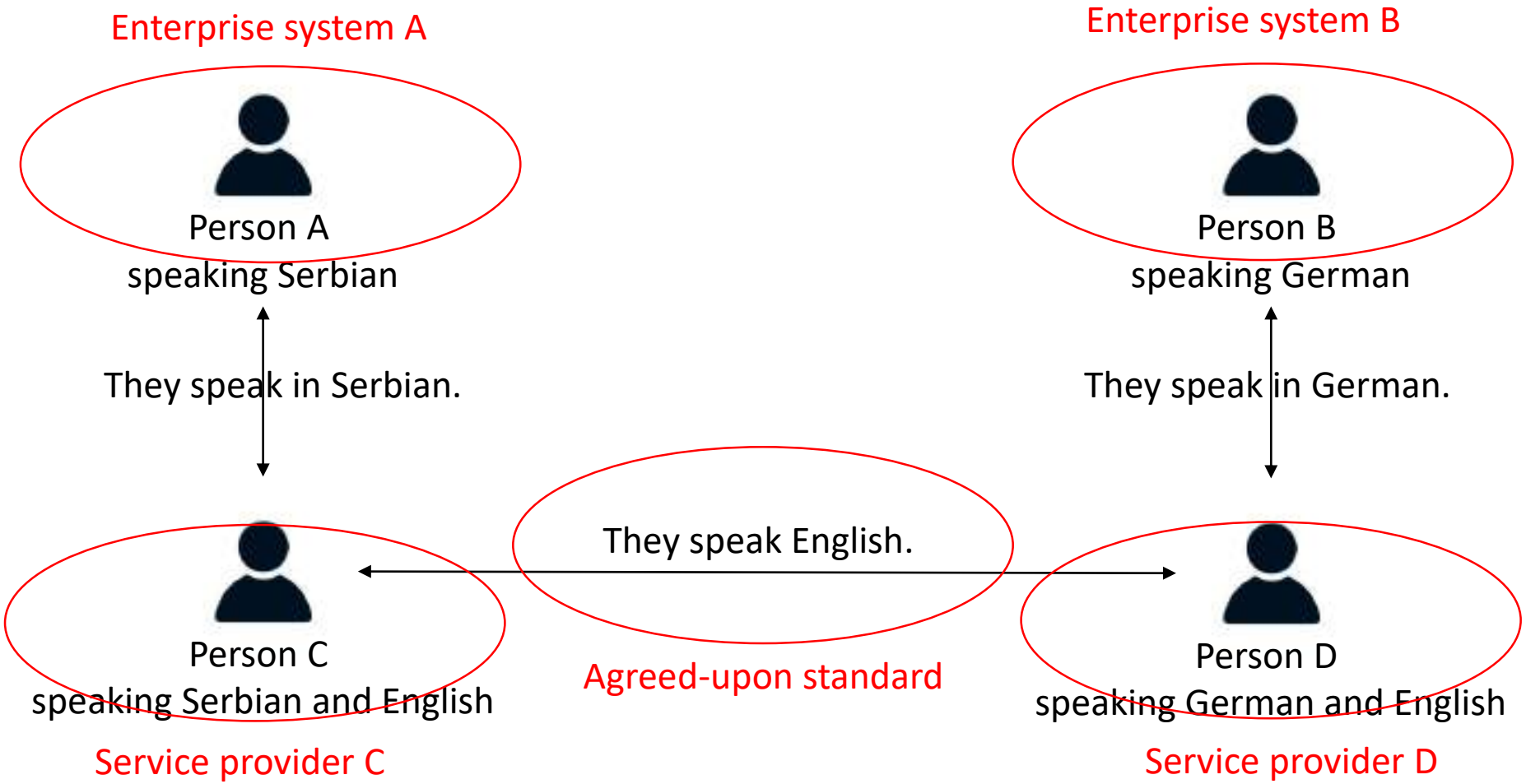
Integration Challenges to Achieving Interoperability: An Illustration

Option B:

4 Corner Model



Integration Challenges to Achieving Interoperability: An Illustration



Option B:

4 Corner Model

What is ‘the catch’ with the standards?

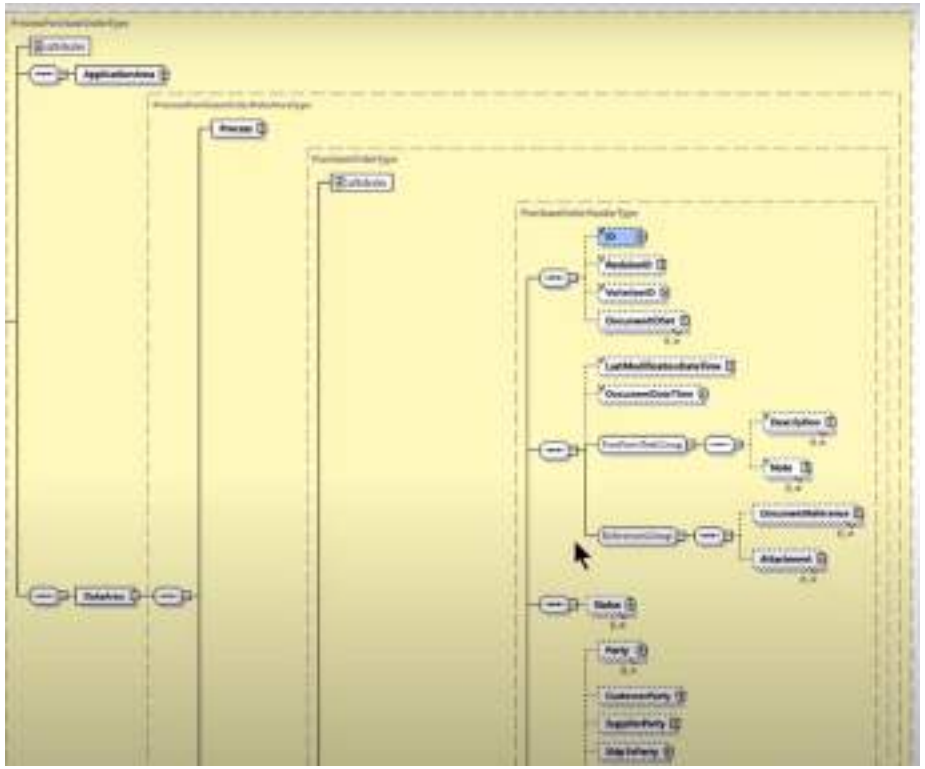
- Standards do not include all “the right” elements
- Standards contain a huge number of optional elements
- Standards usage has complex ‘grammar’

What is ‘the catch’ with the standards?

- Standards do not include all “the right” elements
- Standards contain a huge number of optional elements
- Standards usage has complex ‘grammar’

In an integration effort, a manufacturing company used a data exchange standard

They needed to ‘**profile**’ a Party structure “from roughly eight thousands (8000) data elements to a handful of only the necessary data elements”



Is it possible to have such a proficient service provider and a comprehensive standard?

Is it possible to have such a proficient service provider and a comprehensive standard?

We say – No, it is not possible… with traditional methods… to achieve scale, efficiency

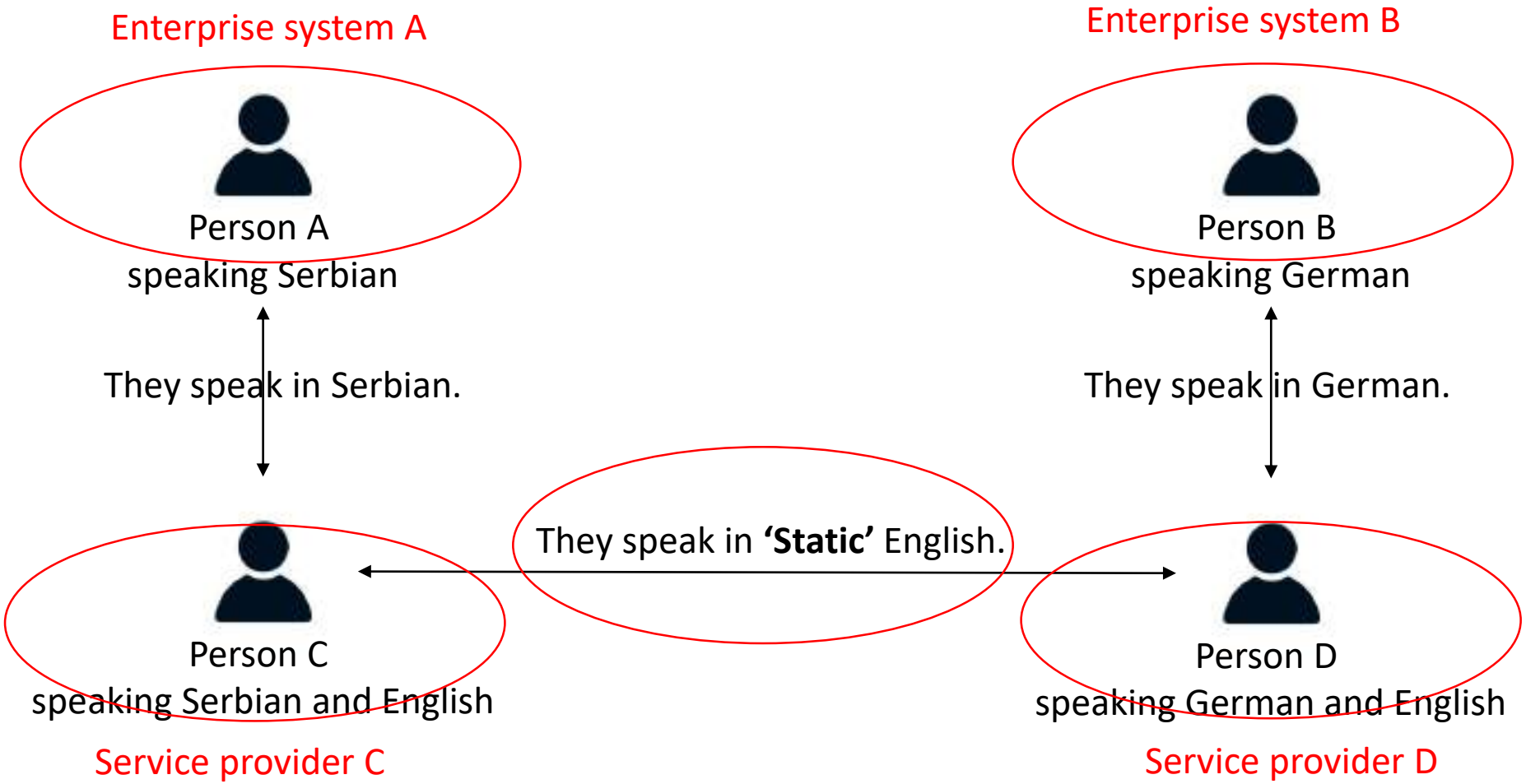
Is it possible to have such a proficient service provider and a comprehensive standard?

We say – No, it is not possible… with traditional methods… to achieve scale, efficiency

However – It can be constructed incrementally to ‘grow’… with a new method

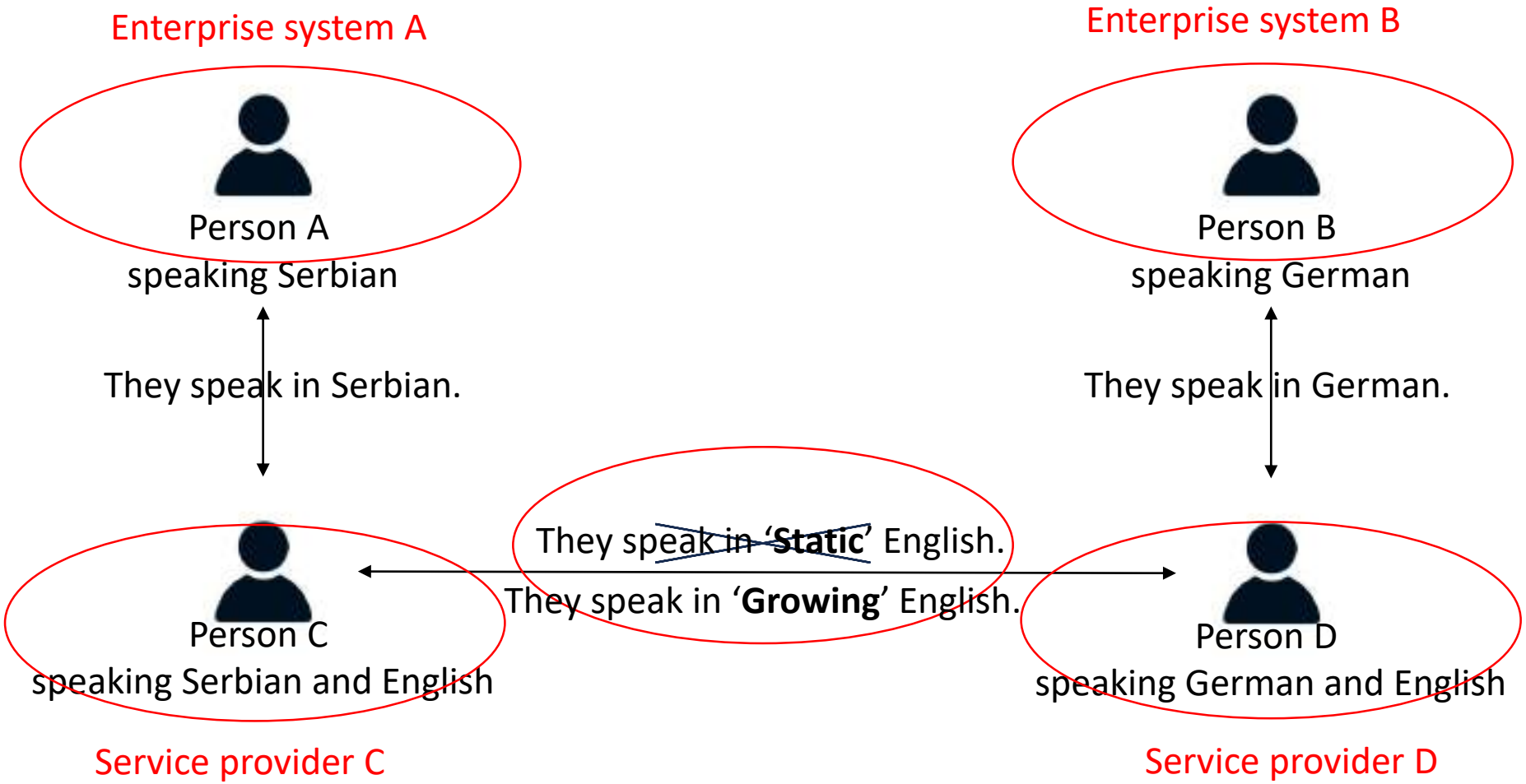
A New Integration Approach to Achieving Interoperability

A New Integration Approach to Achieving Interoperability



Option B

A New Integration Approach to Achieving Interoperability



“Static English” vs. “Growing English”

- “Static English” standard is a slowly changing English
  - The way that traditional standards are developed
- “Growing English” standard is a dynamically growing English … just like real English… but much faster… **immediately** accommodating new terms
  - Basis for the way that the novel standards would work

A New Integration Approach to Achieving Interoperability

- The terms in the “Growing English” can be
  - Created immediately from the interface specifications of the systems being integrated,
  - Included immediately into the “Growing English” standard, and
  - Represented immediately as the required standard profile with all and only the needed terms.

A New Integration Approach to Achieving Interoperability