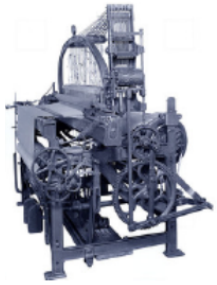
Joining 4.0

- Industry 4.0 in the context of joining -

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Prof. Jean Pierre Bergmann, TU Ilmenau

Industry 4.0



First **mechanical loom** 1784



Assembly line Ford early 20th Cent.



First **Programmable Logic Controller** (PLC) »Modicon 084« 1969



»Smart Factory«

4. Industrial revolution
Based on the Cyber-Physical Systems

3. Industrial revolution
By the use of the electronic and IT for the automation of products

2. Industrial revolution
By introduction of mass production based on the division of labor with the help of electrical energy

1. Industrial revolution
By introduction of mechanical manufacturing processes with the help of water and steam power

Degree of complexity

	End 18th Cent.	Beginning 20th Cent.	Beginning 1970s	Today
Employment	Determined		Co-determination	Voting / cooperation
Processes	Rigid		Flexible	Adapt in real time
Resources	Based on prediction		Based on demand	Order related

According to FhG IAO Stuttgart and DFKI

Industry 4.0 a global change of values

- new tech titans were born during last two decades (high power of new economies)
- European companies already lost significance in comparison to US and China
- European manufacturing and joining technologies and products are still leading in efficiency and technical capability
- imminent loss of importance if the transfer to cyber physical systems fail
- critical situation especially for the SME with strong technological orientation

➔ **Europe risks loss in economic prosperity**
➔ **serious political and social consequences**



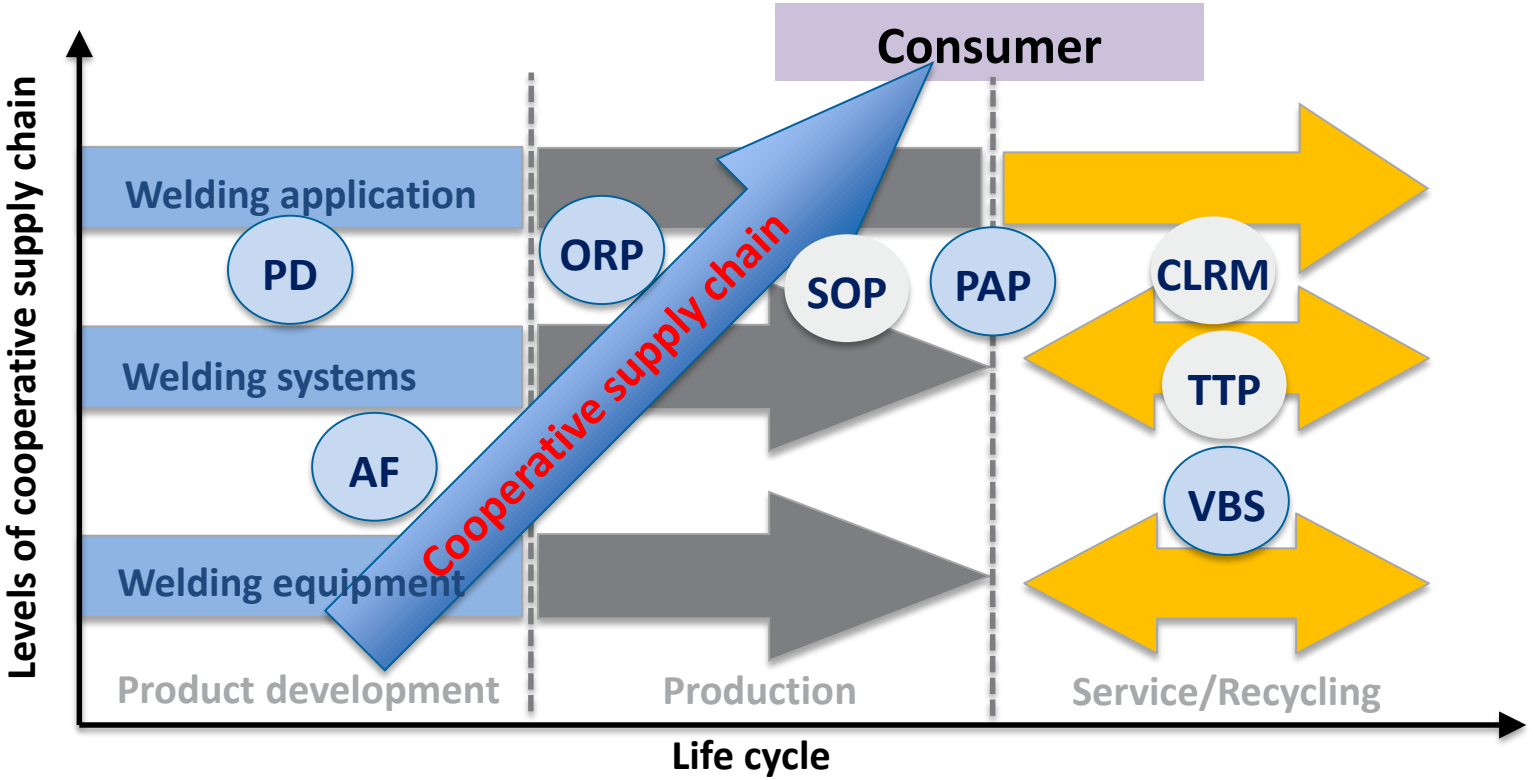


Source: PLATTFORM INDUSTRIE 4.0

What is to do? What's the issue to start with?

methodical approach and structure

(acc. Plattform Industrie 4.0)



PD: Product Development
ORP: Order related Production
PAP: Personal Assistance in Production
AF: Adaptive Fabrication
VBS: Value Based Services

SOP: Self-Organizing Logistics
CLRM: Closed Loop Recycling Management
TTDP: Transparent and Transformative Delivered Products

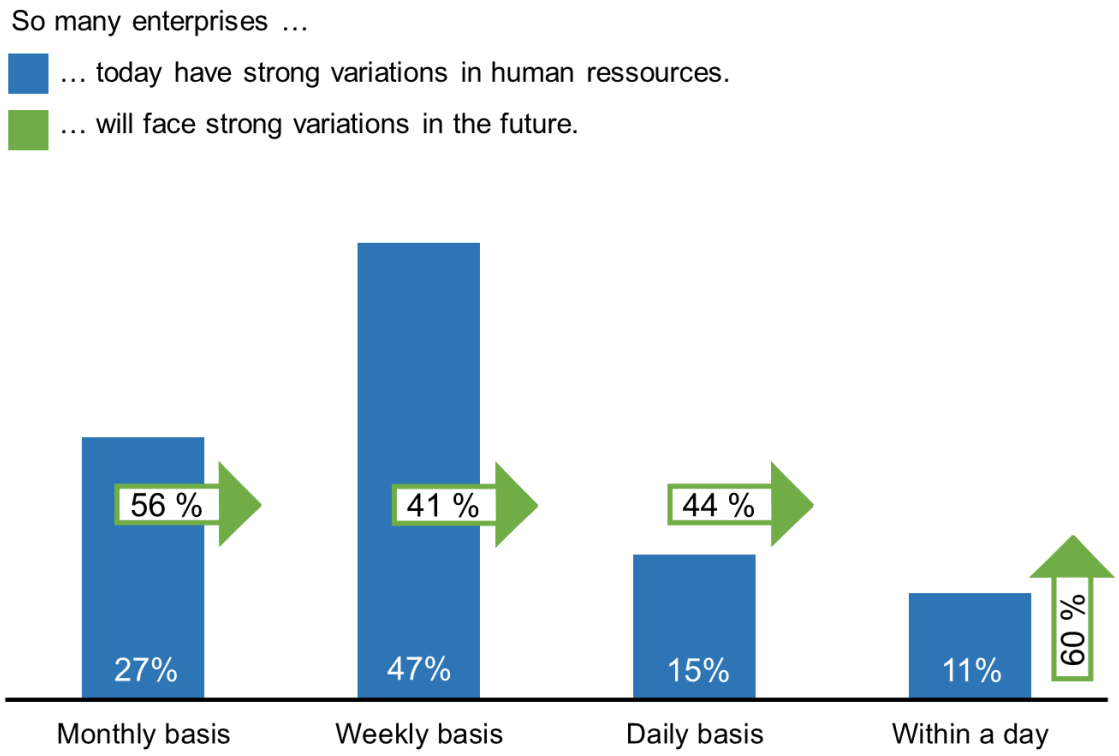
Manufacturers challenge

Dynamic of market leads to:

- **shortage in delivery time**
- **increased individualization**
- **smaller batches sizes**

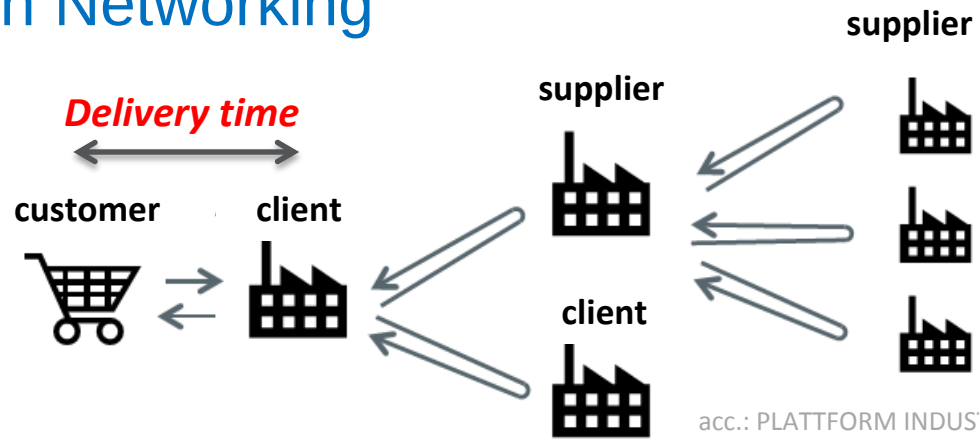
➔ **strong variation of production capacities and human resources**

➔ **enhanced importance of the variation especially daily and within a day**



According to: Spath, D et al.: Produktionsarbeit der Zukunft – Industrie 4.0. Fraunhofer Verlag, (2013)

Order related Production Networking

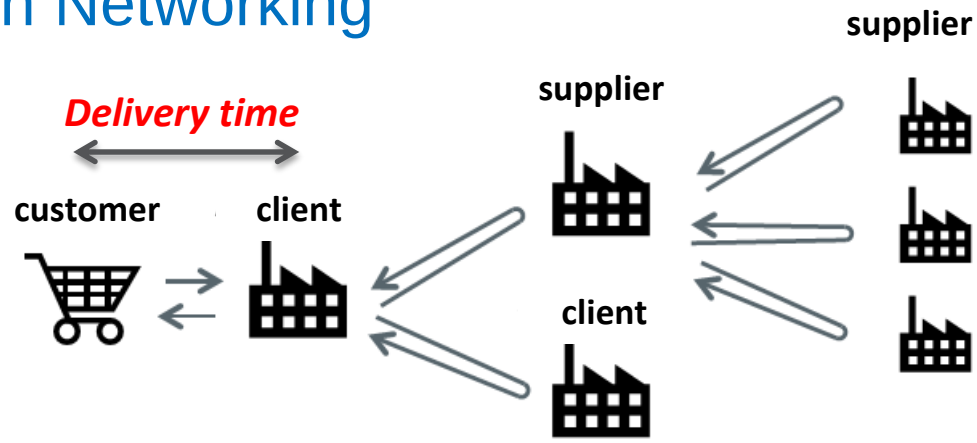


acc.: PLATTFORM INDUSTRIE 4.0

GOALS: meet customer's deadline and delivery time → reduce constraints
autonomous project and/or order related cooperative supply chain through integration of external production plants into manufacturing chain

Added Value	Needs for Realization
- ad hoc adaption of production capacities and quantity to orders - higher flexibility to customers and marked needs - increased workload and capacity utilization through the network - low binding of funds	- transition from rigid business relations to fragmented dynamic networks - enhancement of ERP system for Network Resource Planning - certification and standardization for automated networking

Order related Production Networking



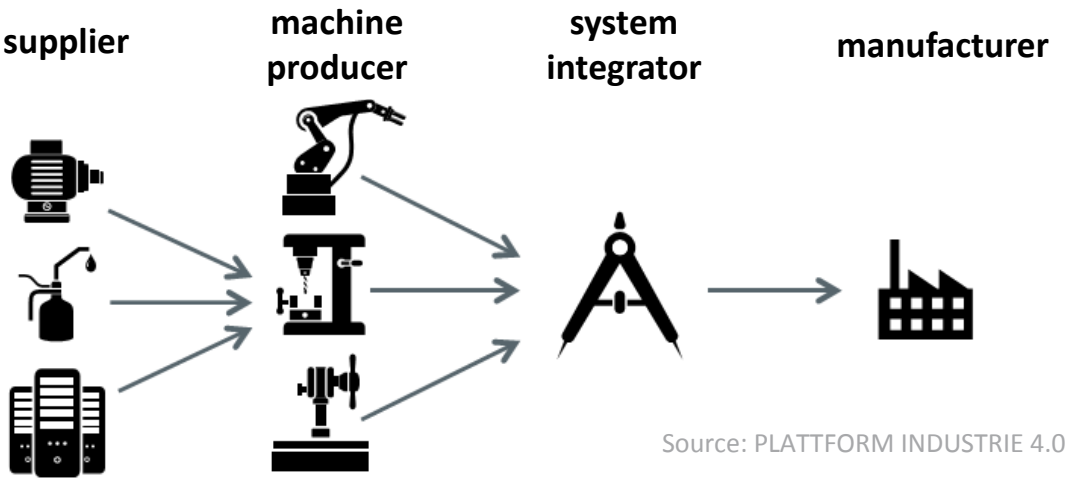
acc.: PLATTFORM INDUSTRIE 4.0

Consequences and Challenges for Joining :

- market shrinkage especially for joining machinery and production systems but
- more added value in diversified and customer related services
- (specialized) technological competences and expertise instead of (unique) products
- increased efforts in robustness and capability of processes and production, in order to be better inserted in a manufacturing chain
- function and stability of processes and technology regarding varying conditions are key factors for the success instead of marketing and sales (Like-button, I-rating)

➔ **network is hardly predictable and forces to reach adaptable fabrication systems!**

Adaptable Fabrication



Source: PLATTFORM INDUSTRIE 4.0

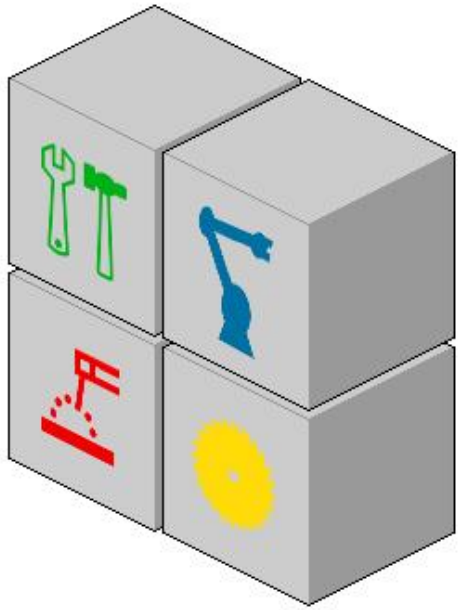
GOALS: enhance enterprise stability towards high dynamic of market
rapid and autonomous physical modification of production systems
smart and interoperable modules enables high mutability (ability to change)
(**plug & produce or plug & join**)

Added Value	Needs for Realization

- improved response capability to market changes (customer requirements and especially network behavior and uncertainties)
- reuse options for new combination of features & component of different suppliers
	- modular engineering concepts with:
	  - combinable mechatronic modules
	  - Plug & Produce capability
	  - interoperable interfaces and
	  - adaptive automation technology
	- little effort integration of new services and functions

Adaptable Fabrication

„LEGO in production sites,
a new organisation challenge“

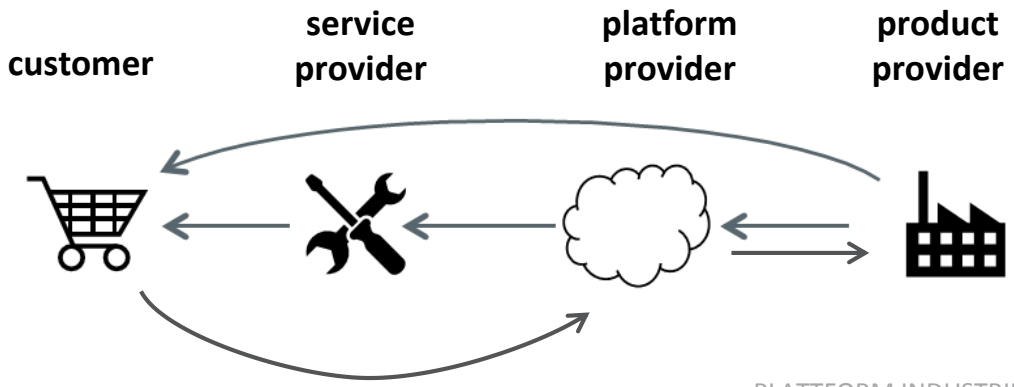


Consequences and Challenges for Joining :

- value change in systems and engineering from technological skills to flexibility, integration capability and operators support functions (new customer needs)
- flexible control concept (master/slave, (de-)central control) and standardization of mechatronic and control interfaces
- more and closer relations between joining technology supplier and manufacturer (direct cooperation substitutes system integrator !?)

➔ **massive enlargement and diversification of digital services**

Value based Services

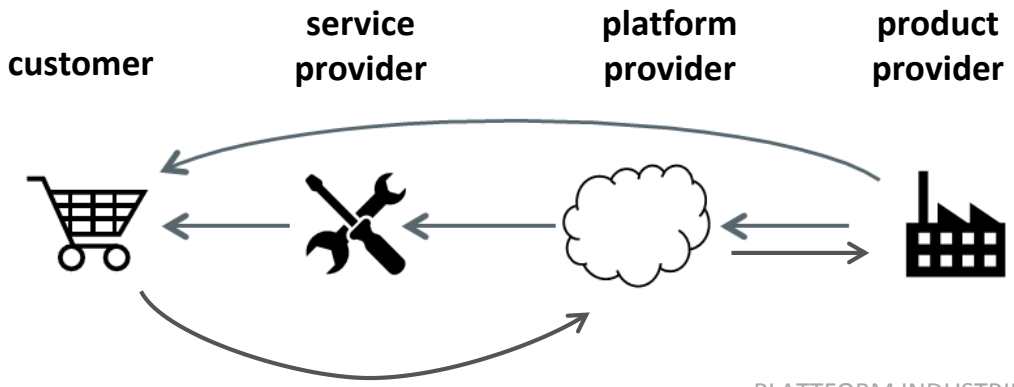


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GOALS: digitalization of customer relationship in terms of
- service on demand and new service business cases
- additional customer information and customer requirements for product development

Added Value	Needs for Realization
- enhanced understanding of customers and marked for product providers - enables data mining for undetected customers needs ➔ enhanced service products ➔ enhanced products with new functions ➔ new business models	- convince customers for opening data channels - data integrity and security - data selection and condensation - wear measurement, sensors, diagnostics

Value based Services

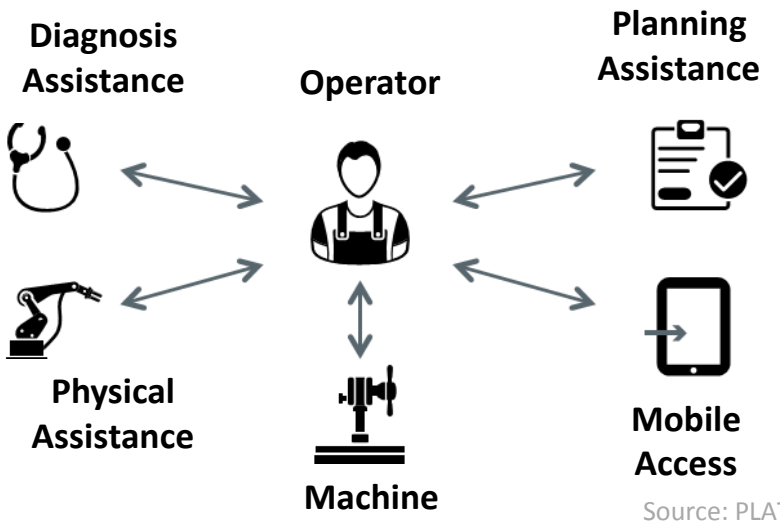


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Consequences and Challenges for Joining :

- value change in business models of product providers:
  - platform and data management as additional part of the product
  - increased relevance of service products for turn over
  - innovative service products and business models important for product differentiation and assurance of consumables business

Personal Assistance in Production

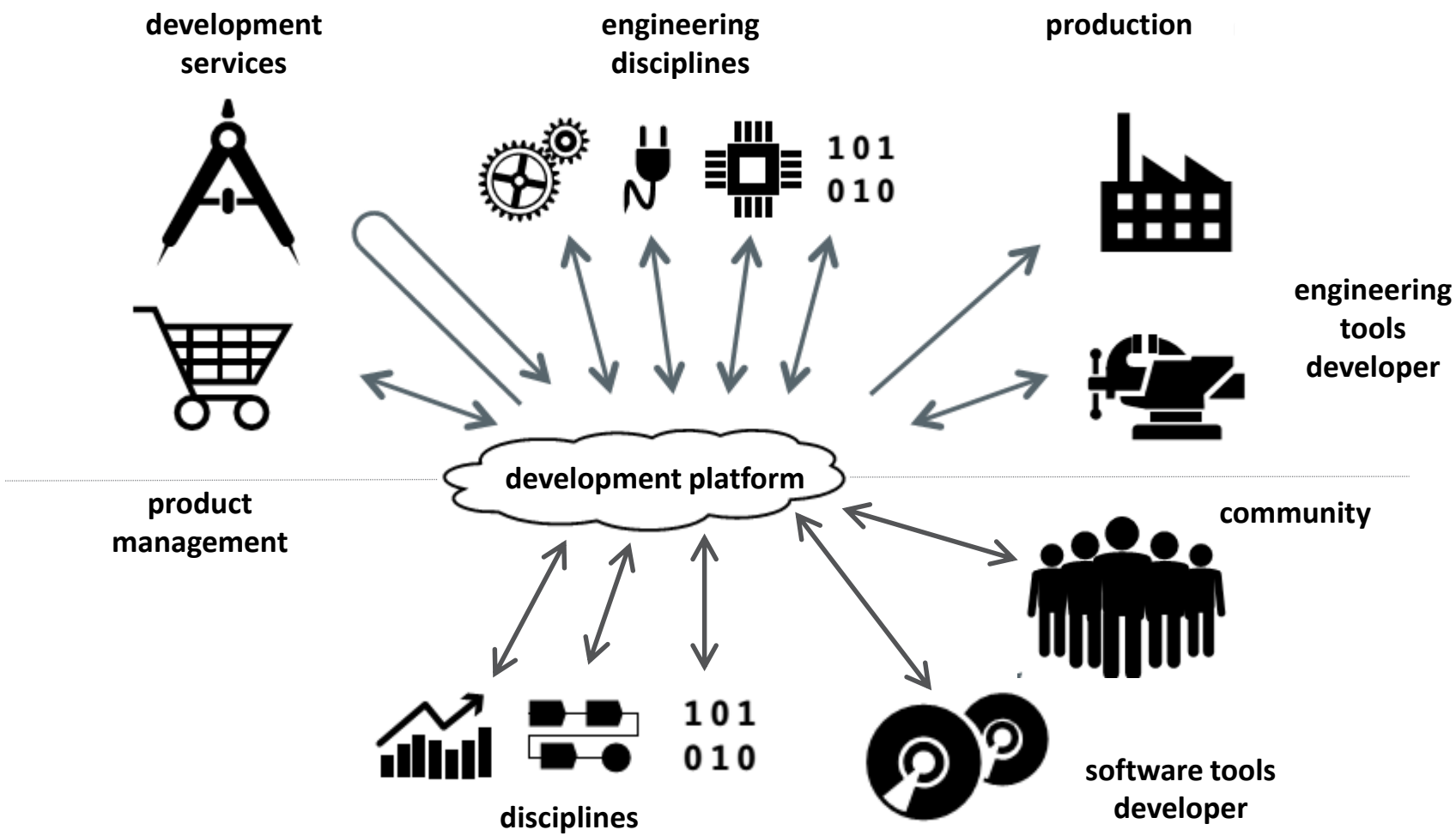


Source: PLATTFORM INDUSTRIE 4.0

GOALS: technical systems enhance the physical, mental and intellectual abilities of operators (**the "bionic worker" in a job of one's dreams**)

Added Value	Needs for Realization
- protecting operator from physical or intellectual overstressing - more varied and interesting jobs and tasks - shorter incorporation, flexible usage, less work-related diseases - Telework and worldwide operations of professionals without travel expenses	- development of assistance systems - entrainment of staff (workers) and communications of benefits - best practice studies and samples - training and education - early retirement pension for hardest disputants

Smart and innovative Product Development

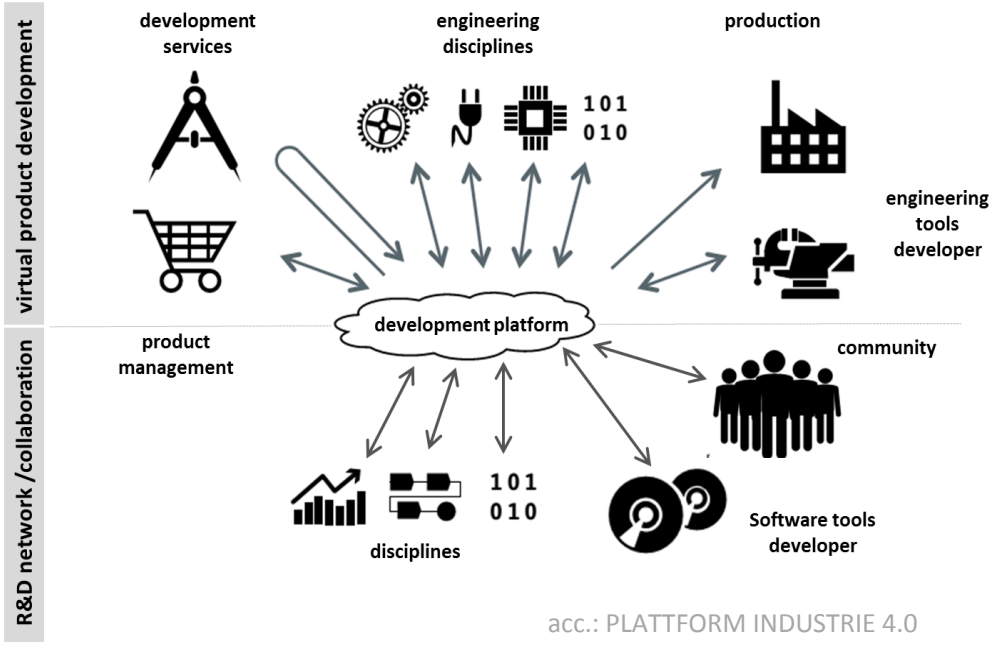


acc.: PLATTFORM INDUSTRIE 4.0

Smart and innovative Product development

GOALS:
virtual product development with enhanced engineering tools and automatic colla-borations on a virtual development platform

automatic including of all relevant development networks and collaboration forms to develop the right product



acc.: PLATTFORM INDUSTRIE 4.0

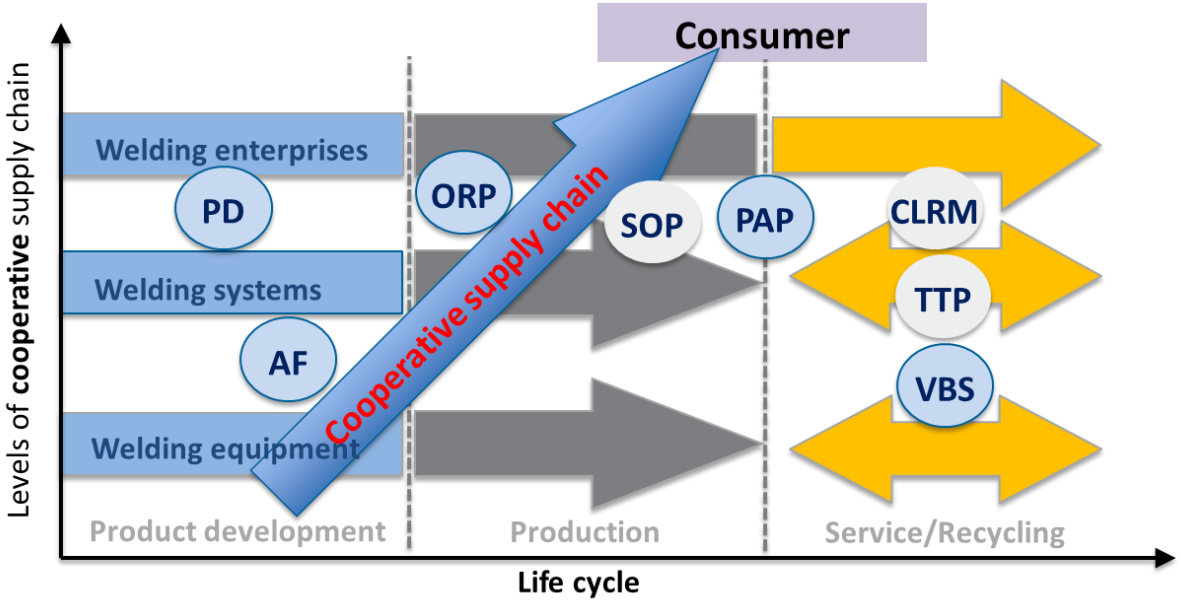
Added Value

- faster, better and customer oriented product development by parallel including partner, suppliers system integrators etc.
- new market for machine producer & enhanced solution skills
- ad hoc involvement of external R&D resources
- on demand and crowdsourcing services
- prototyping by additive manufacturing

Needs for Realization

- enhanced methods: simulation and VR
- an open development system ensuring:
  - safety of information and core competencies
  - up-building of business case for cooperating development services
  - built up of collaboration platforms (WikiJoin, WikiWeld)

Conclusions for Joining Industry 4.0



Upgrade to Joining 4.0 demands the consideration of the full supply chain!!!

Collaboration along supply chain and with enlarged R&D networks ensures development of highly innovative and really appropriate products, services and business cases.

Need for innovation and best practice projects, in order to detail road map and to demonstrate the innovation ability of European joining industry.