

Prof. Dr.-Ing. Thomas Bauernhansl
Hannover Messe 2023 | Technology Academy Hanover | 19th April 2023

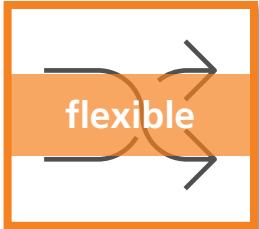
Future-proof production –
sustainable, flexible, productive and resilient

Necessary characteristics of future production systems

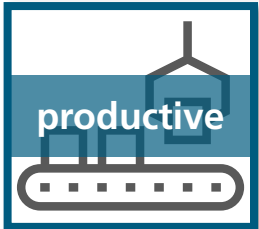
Production systems should be sustainable, flexible, productive, and resilient



- Climate neutrality by 2030 according to Scope 1-3
- Recyclable products with neutral CO₂ footprint



- Flexibility regarding fluctuations in production
- Flexible adaptation of hardware and software to changing conditions



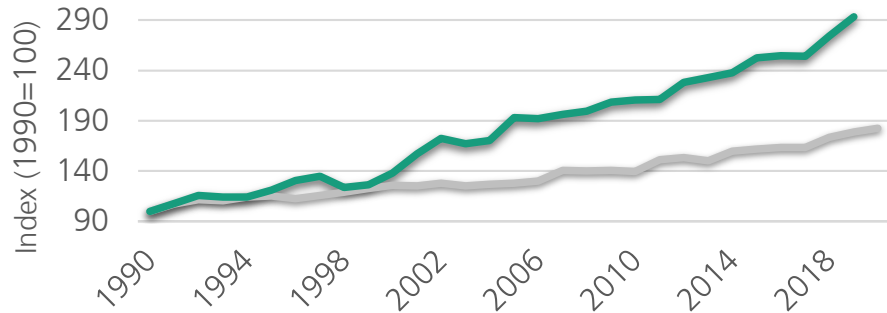
- Transparency about the performance of all business processes => Time is money
- Focus on increasing labor, machine, material and energy productivity => Asset productivity: < +5%/a



- "Performing under adverse conditions"
- Securing value creation (local for local, access to raw materials and semi-finished products, technological sovereignty)

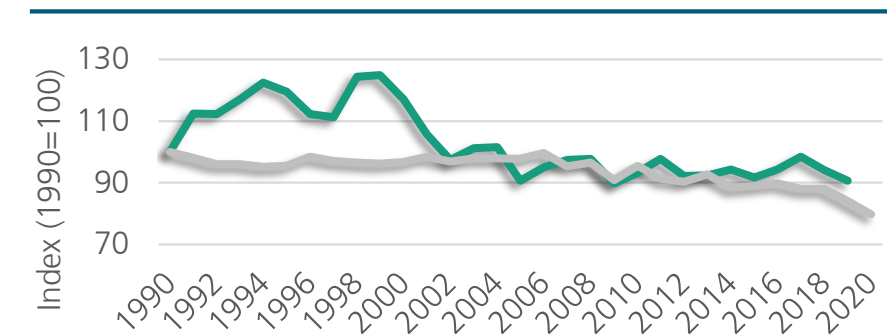
Increasing energy and resource productivity is not enough

Energy & material productivity increase at the example of Germany



Energy productivity: +82%

Material productivity*: +193%



Primary energy consumption: -10%

Raw material consumption (RMC): -9%

Despite an increase in energy and material productivity...

... resource consumption in Germany currently corresponds to **3 earths**.



... global resource consumption is currently equivalent to **1,7 earths**.

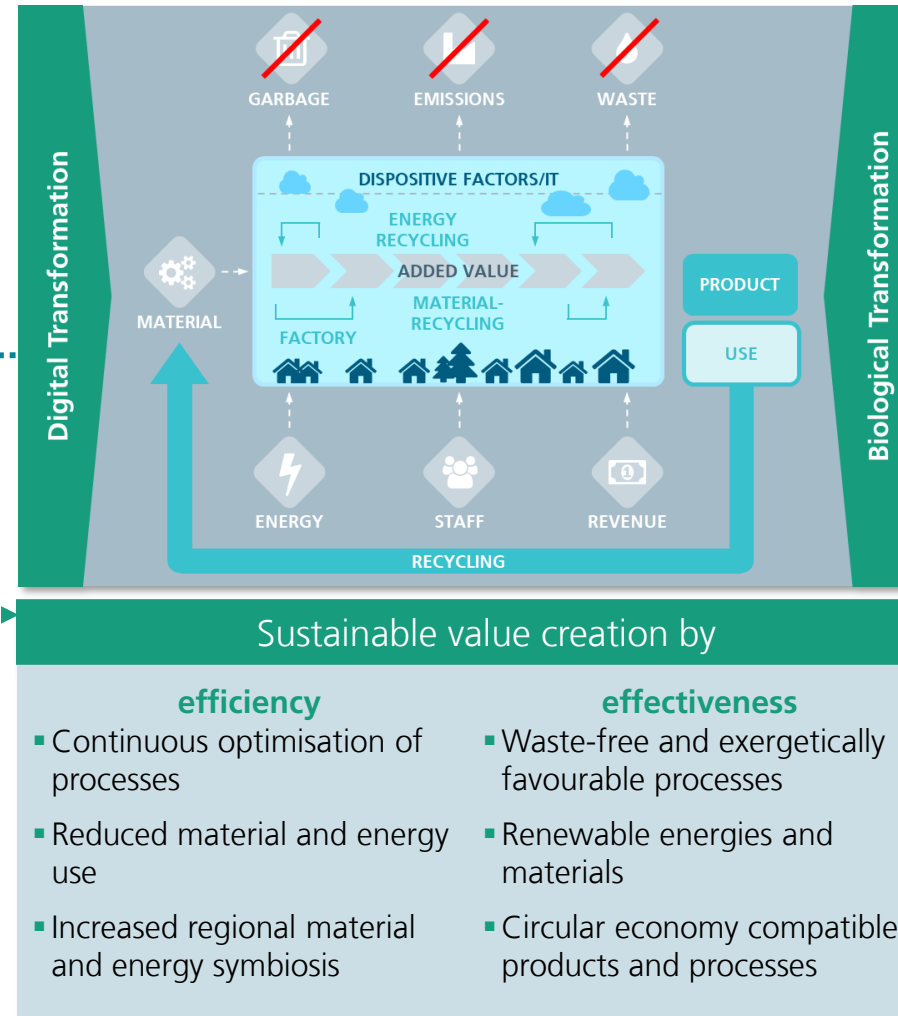
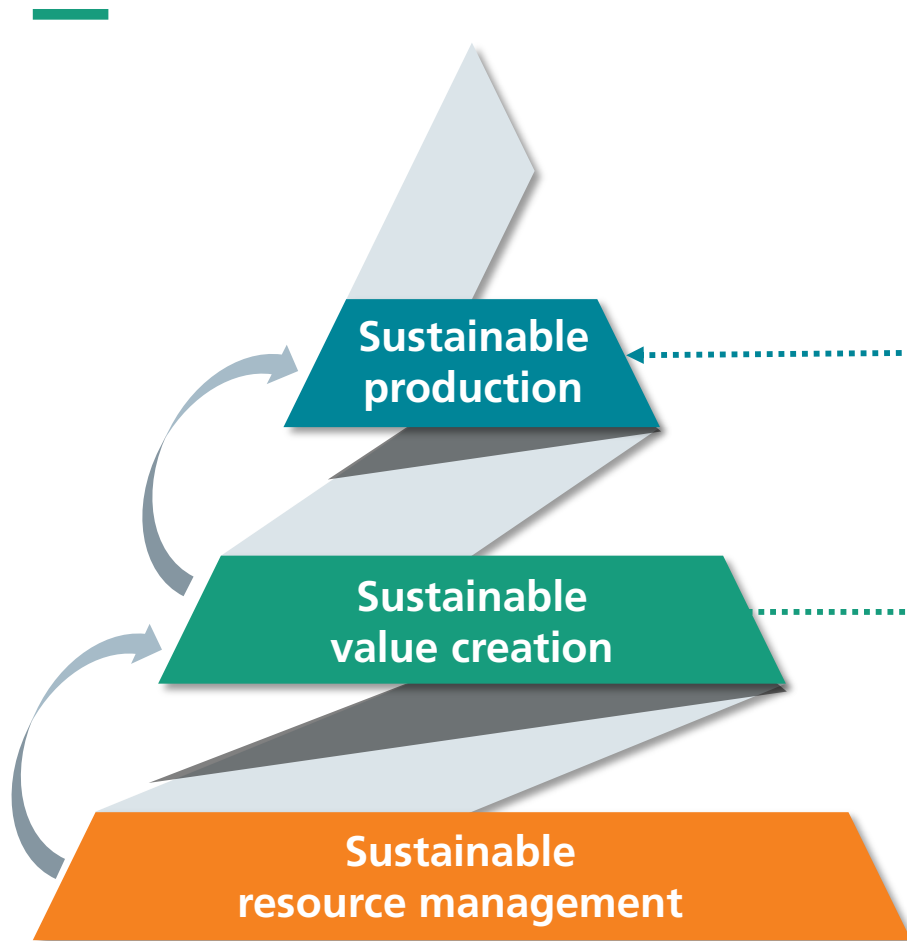


To face current environmental problems, an increase of energy and resource productivity is not sufficient. We need sustainability on an economic, ecological and social level.

Source: WU Vienna (2022): materialflows.net/visualisation-centre/country-profiles/; BMWK (2021); Global Footprint Network (2022): <http://data.footprintnetwork.org/#/>; Fraunhofer IPA

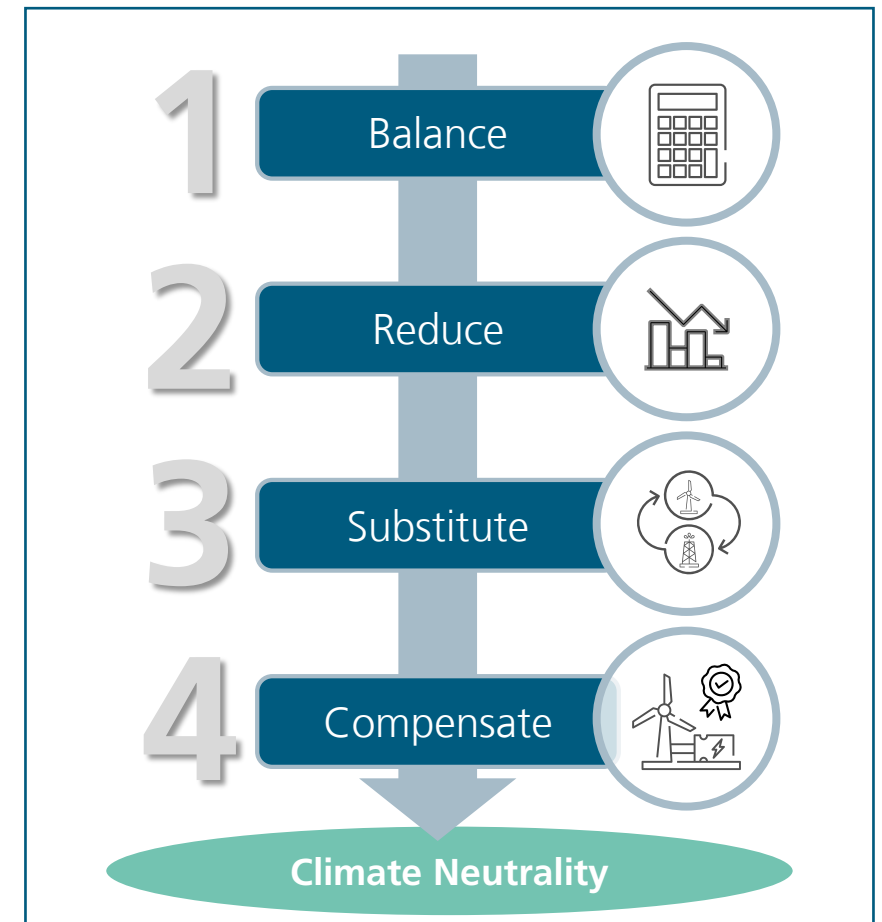
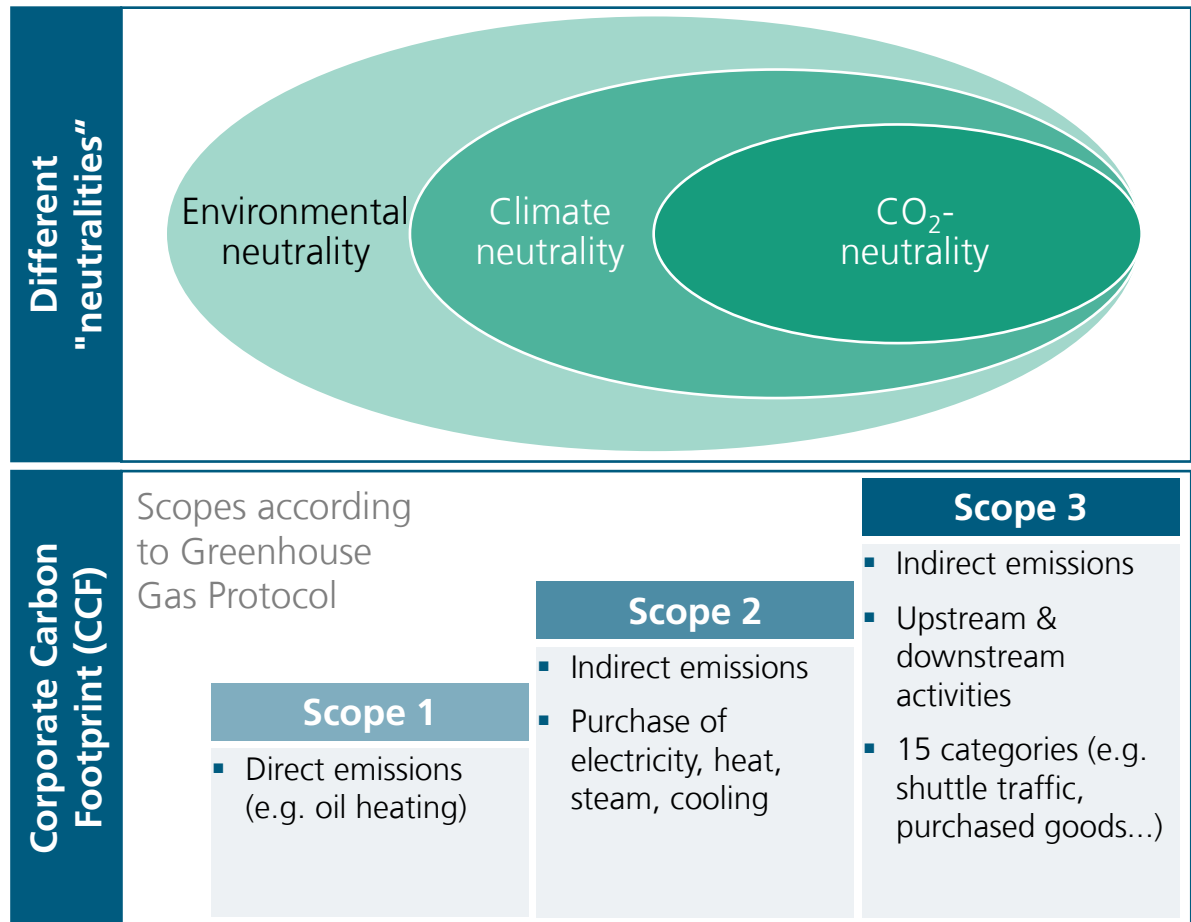
What does sustainable value creation mean?

Efficiency and effectiveness as a basis



Climate neutrality - first step towards environmental neutrality

Systematic approach and attention to scopes necessary



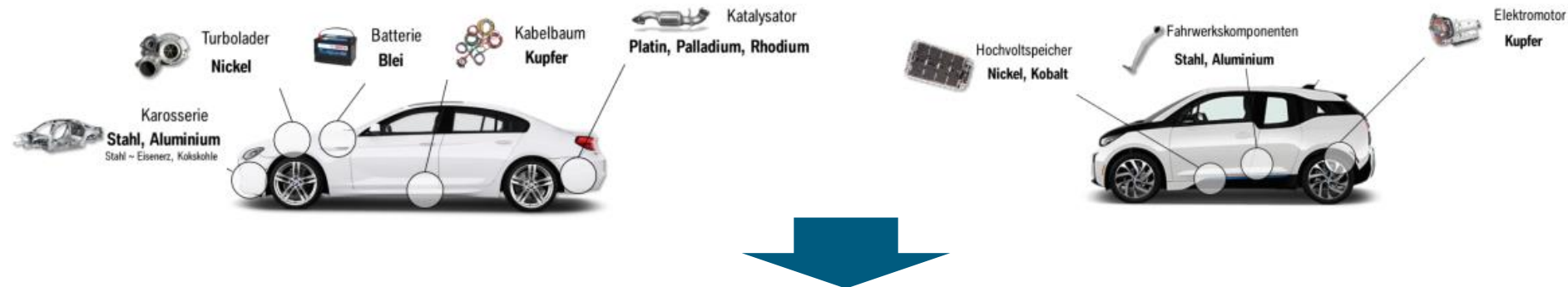
Catena-X Automotive Network

Building the First Operating System for a Data Driven Value Chain



Premise:

Without Catena-X, the targets for secondary materials and the associated CO₂ targets will not be achieved.

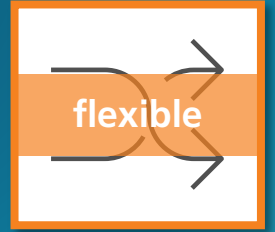


- Catena-X enables access to life-cycle data of vehicles.
- Catena-X enables the reduction of overhead costs through a data ecosystem.
- Catena-X enables the certification and transparency of material cycles for CO₂ reduction.
- Catena-X directly affects CO₂ targets and enables new sourcing models.
- Catena-X structures fragmented markets, sets standards and enables economic dismantling

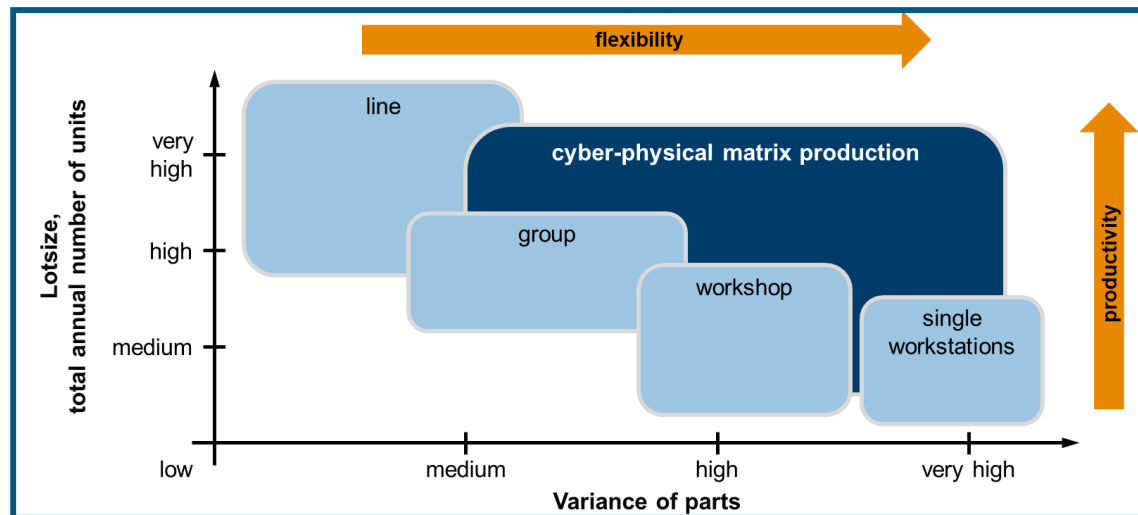
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Flexible production as a response to short-term changes

Cyber-physical matrix production systems as one flexibility possibility



- Production systems must be planned, built and managed flexibly to react quickly to changes at short notice (i.e. order fluctuations, supply chain problems, new or changed products, ...)
- Today's technologies enable high flexibility on both the hardware and software side, for example automated guided vehicles, factory operating systems or flexible automations
- Cyber-physical matrix production systems enable the production of variable lot sizes as well as variable number of parts



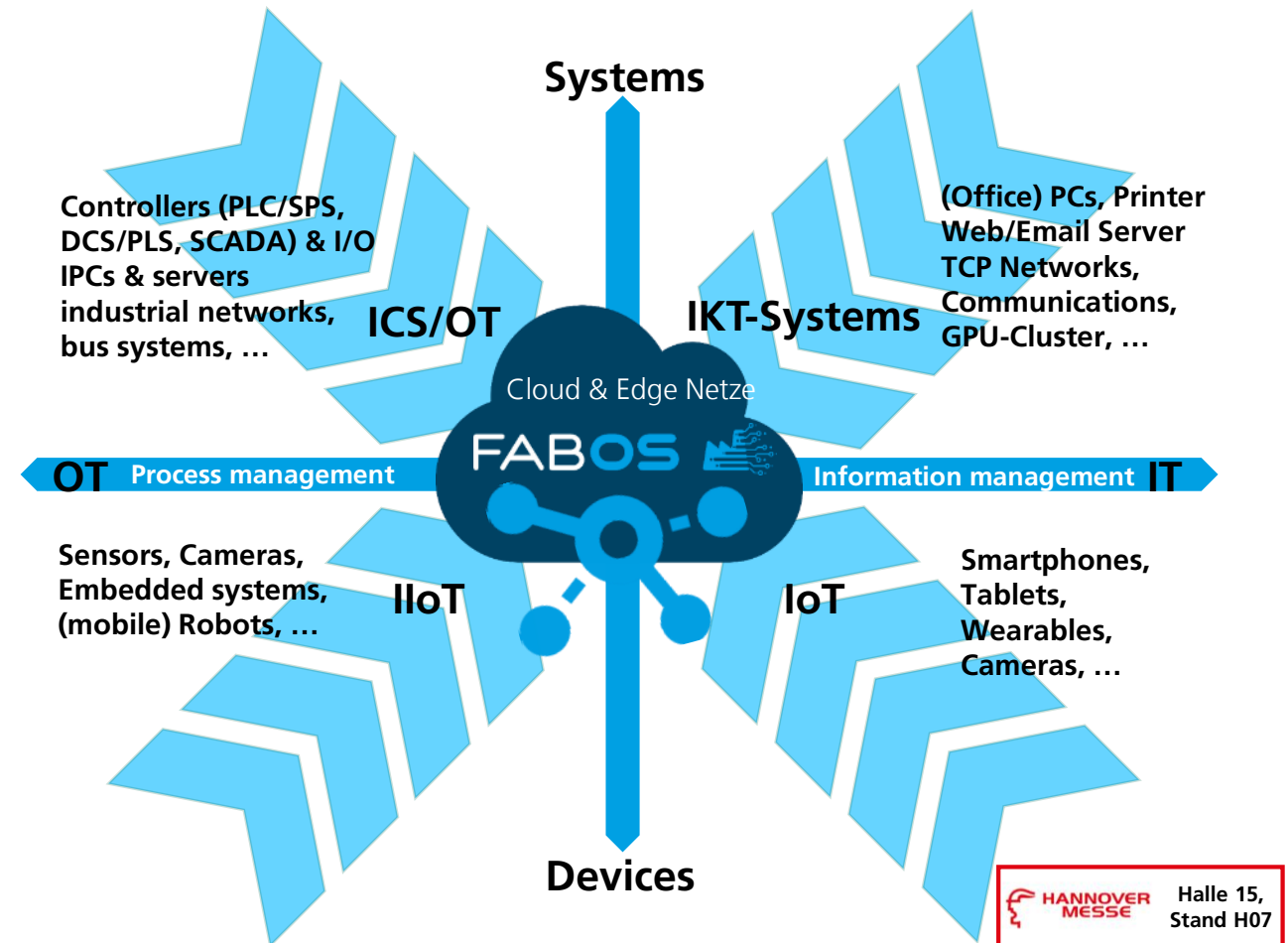
High flexibility must be one of the goals in planning and designing future-proof productions. This can become a major competitive advantage in the event of short-term fluctuations.

Source: own representation, inspired by Eversheim 1996, S. 103, 135, Wöhe/Döring 2000, S. 442, Spath et al. 2014, S. 10.10, extended by matrix production systems.

Example FabOS: Industrie 4.0 Drives the Convergence of ICT and OT

System landscape in manufacturing companies inhibits efficient use of new technological possibilities

- ICT & OT are increasingly converging, do not fit together due to different genesis (e.g. reliability vs. flexibility)
- IoT & IIoT approaches are increasingly being used
- New possibilities
 - Better communication technology, Computing power and AI tools
- New challenges
 - Efficient use of domain knowledge while maintaining technological sovereignty
 - Use of the flexibility of ICT in OT
 - Widespread use of artificial intelligence for production optimization



DCS Distributed Control System, ICS Industrial Control System, industrielle Kontrollsysteme

Example of application of matrix production systems – SEW Eurodrive Bruchsal

Achieved: High productivity independent of variance and short lead time of 5 days

Starting point:

- Offer of customizable products leads to high variance

Goal:

- Produce high variance efficiently and with short delivery times

Solution:

- Continuous matrix production system across all production stages
- Production in one-piece flow

Result:

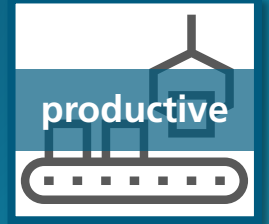
- Number of employees: lower
- Number of operating resources: lower
- Lead time: lower
- Stocks: lower
- Degree of automation: higher
- Space requirement: slightly higher



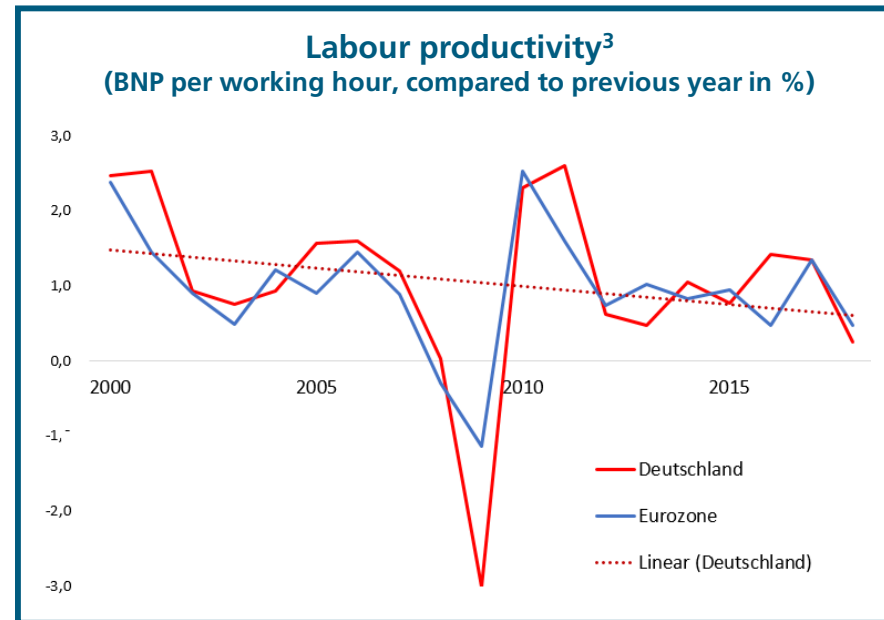
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Productivity paradox exacerbates skills shortage

Skilled labour shortage and demographic change require higher productivity



- Demographic change and the shortage of skilled workers are leading to a sharp rise in the number of job vacancies in Germany despite the risk of recession.
- Despite Industry 4.0 and technologies such as artificial intelligence, there is a negative trend in labour productivity in Germany and the EU¹



Companies in global competition need a big leap in productivity due to demographic change and the shortage of skilled workers.

Source: ¹Produktivitätsparadoxon im Maschinenbau, IMPULS-Stiftung 2018; Deutscher Gewerkschaftsbund; Shollo et al. 2022, Shifting ML value creation mechanisms: A process model of ML value creation in Journal of Strategic Information Systems;

²Bundesagentur für Arbeit, Darstellung KfW; ³OECD 2019, Deutscher Gewerkschaftsbund

Example for assist systems

Increasing productivity with assist systems



Visual worker assistance for error-free assembly

Photo: Rainer Bez, Fraunhofer IPA

Photo: Rainer Bez, Fraunhofer IPA



Human-robot collaboration for the optimal linking of man and machine



VR-/AR-Applications, e.g. for error recognition

Photo: Valentina Klepikova, Fraunhofer IAO

Example: Intelligently automated assembly planning

Assistance of human workers



Montageplanung, Intelligent
Automatisiert.

- Editor for assembly planning that uses CAD models generated in advance
- Intuitive assembly plan generation using artificial intelligence
- Video and assembly instructions are automatically generated with the graphic planning tool Assembly Composer
- KIM: Automatic and intelligent generation of assembly assists from existing CAD models



up to
73%
less
preparational
effort



up to
92%
faster
assembly
planning

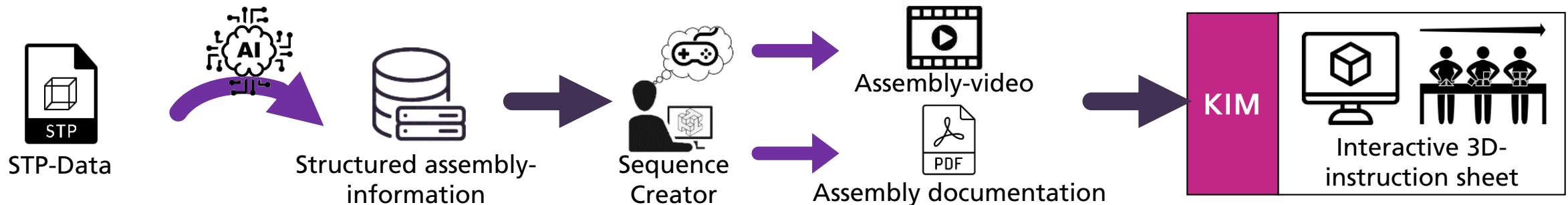


up to
55%
less
planning errors

Server und Web-Application

3D-Analyse AI

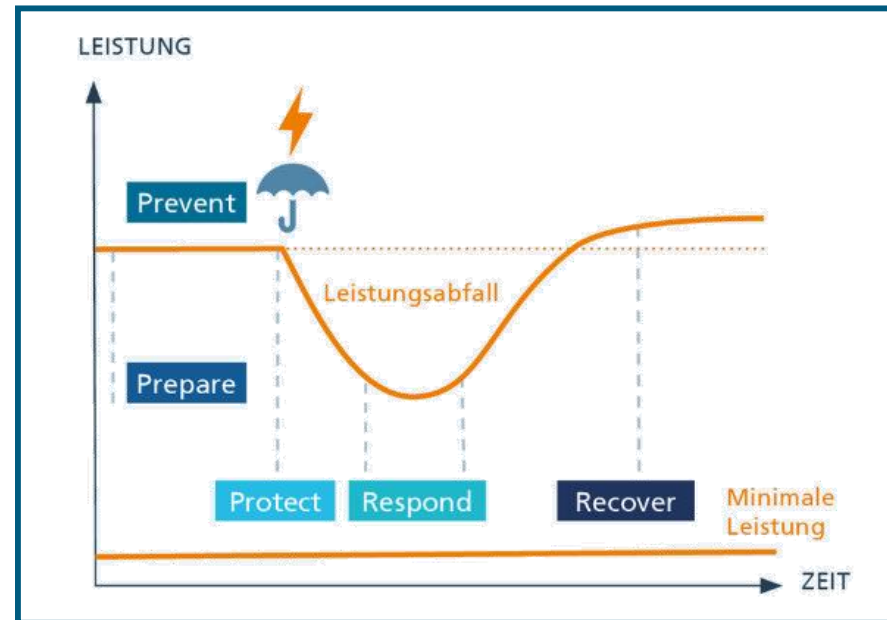
Assembly Composer



Resilience in production

5 steps for resilient systems

- Current crises increase the need for resilient systems
- "Prepare", "Prevent", "Protect", "Respond" and "Recover" can help dampen a drop in performance after a shock occurs
- Focus on raw materials and commodities and local for local (e.g. Inflation Reduction Act)

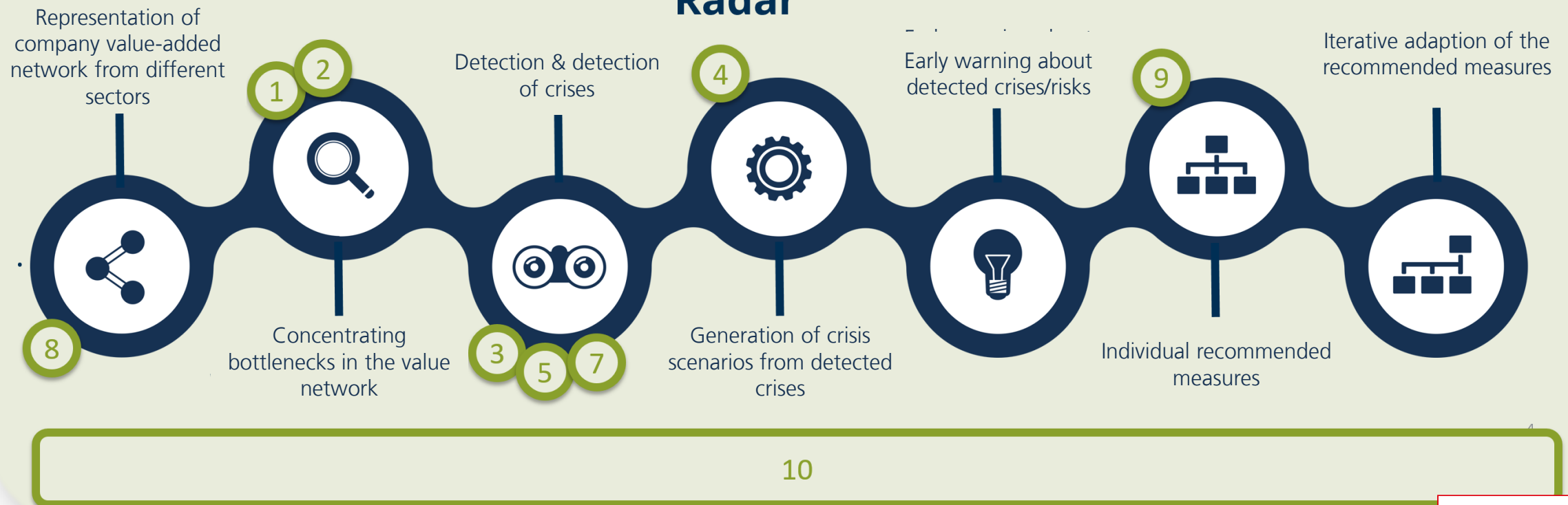


It needs a clear strategy to be resilient to unpredictable shocks and to minimise their impact.

Project PAIRS (Privacy-Aware, Intelligent and Resilient Crisis Management)

Development of a risk & crisis management platform for decision-makers based on AI-tools

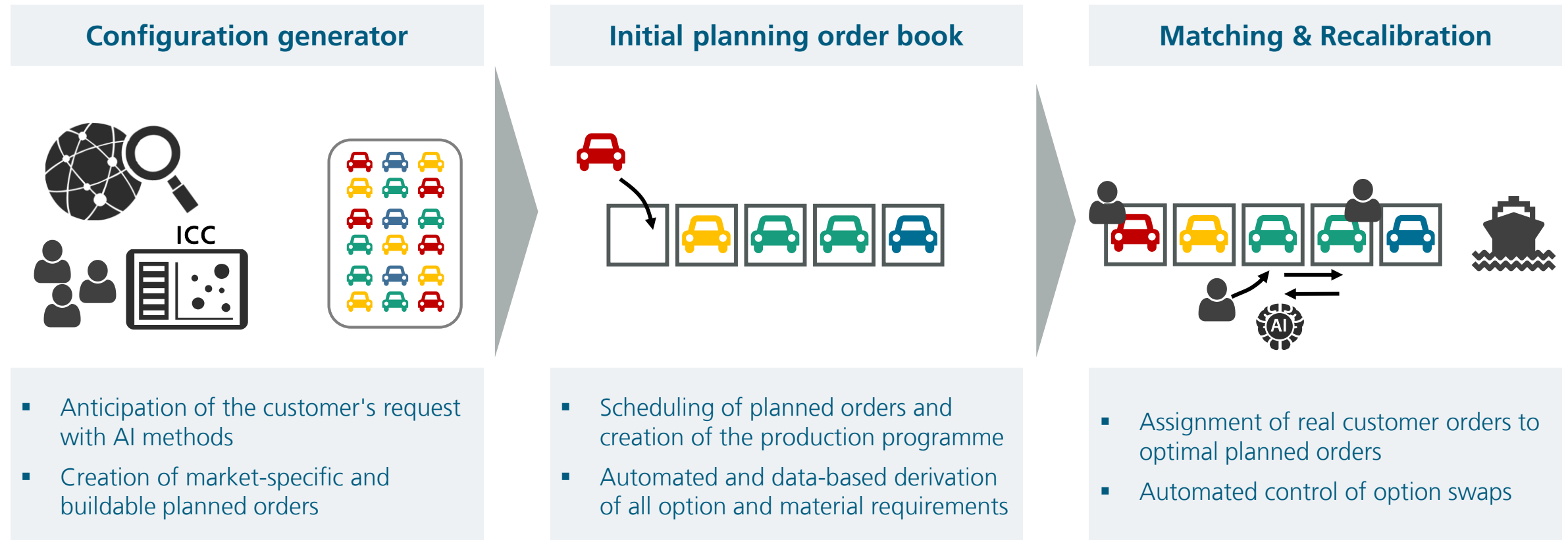
Supply Chain Radar



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Example for resilient production via AI

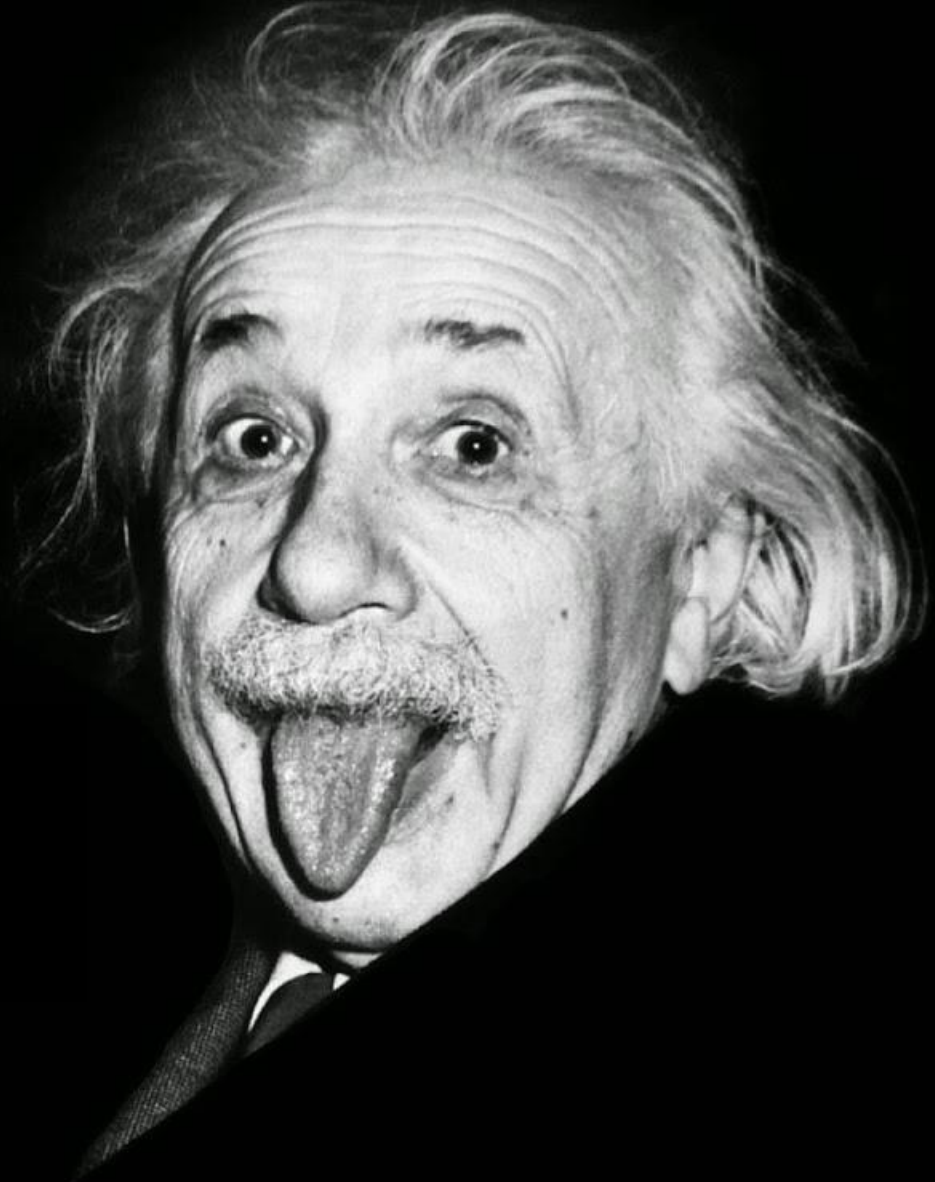
Order planning for car manufacturers



ICC: Internet Car Configurator

The definition of insanity is
doing the same thing over and over again
and expecting different results.

Albert Einstein

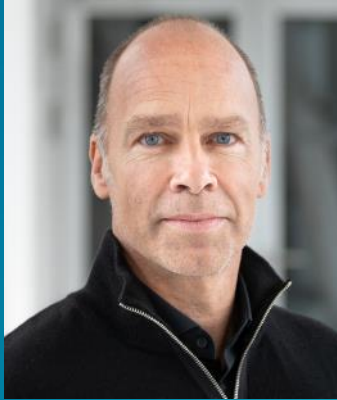


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