Production control applications in the automotive industry

- Examples from Fraunhofer IITB projects -

Fraunhofer Institut Informations- und Datenverarbeitung

Shenyang, November 23, 2007

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   - **integration of MES with digital factory**

1. Some general remarks on automation

1. Definitions (Quelle: Eversheim, W; Schuh, G.: Betriebshütte)

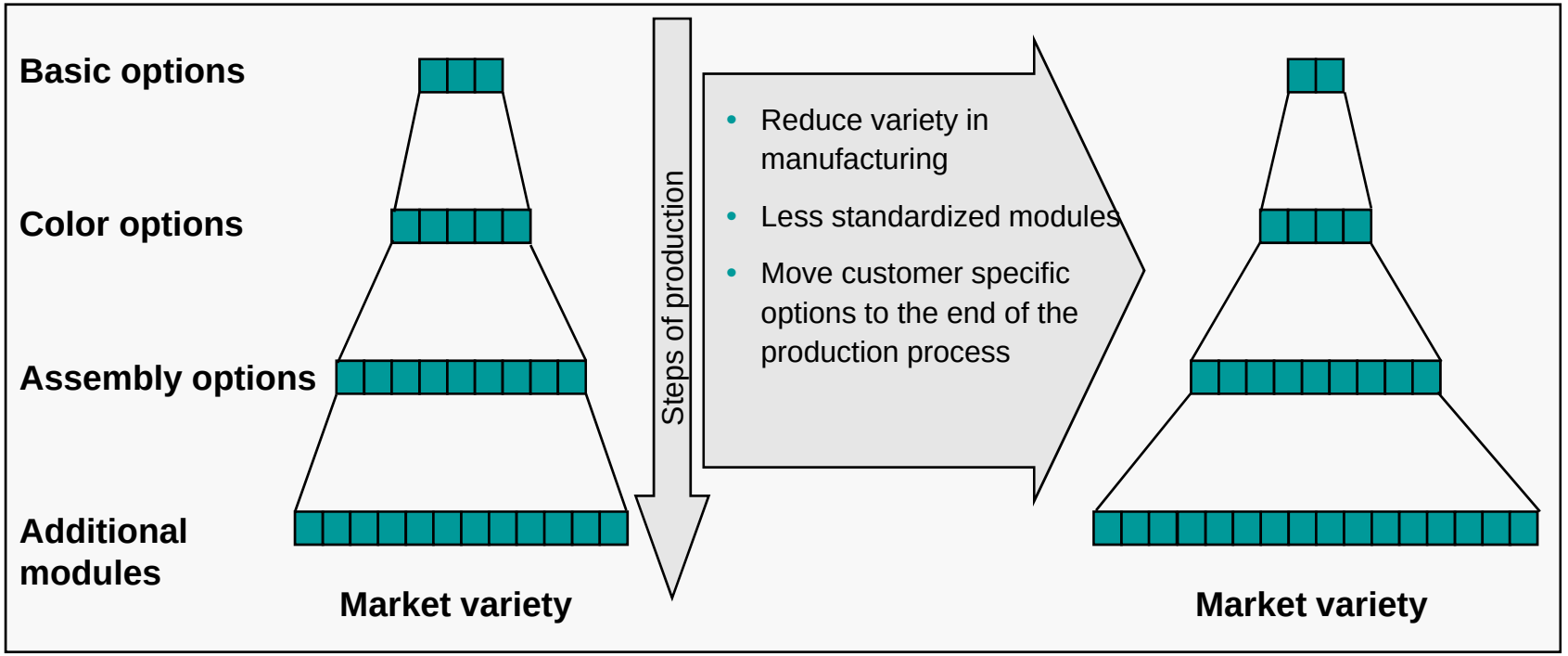
Mechanization:= **substitution of human activities by mechanical activities with the help of technical equipment.**

Automation:= **to establish a process by technical means in a way that a human must nor constantly neither in a fixed cycle be acting for the function of the process.**

Talking about automation deals with the degree of exchanging human work with technical means. In the following we discuss this by adding the aspect of substitution of production factors.

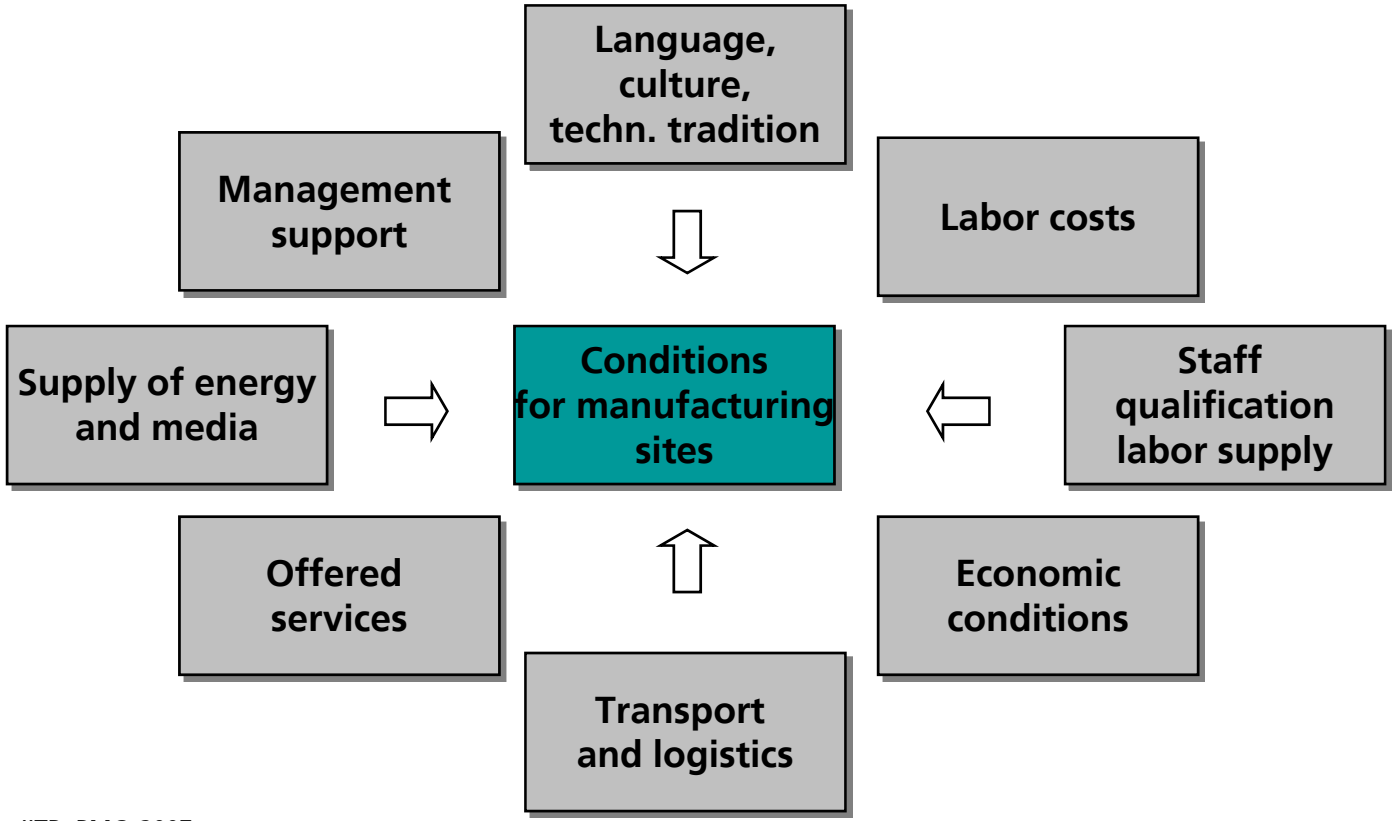
1. Objective conditions in industrial manufacturing

- **Customer individual products, high variety in product options and packaging**
- **Lot sizes are decreasing**



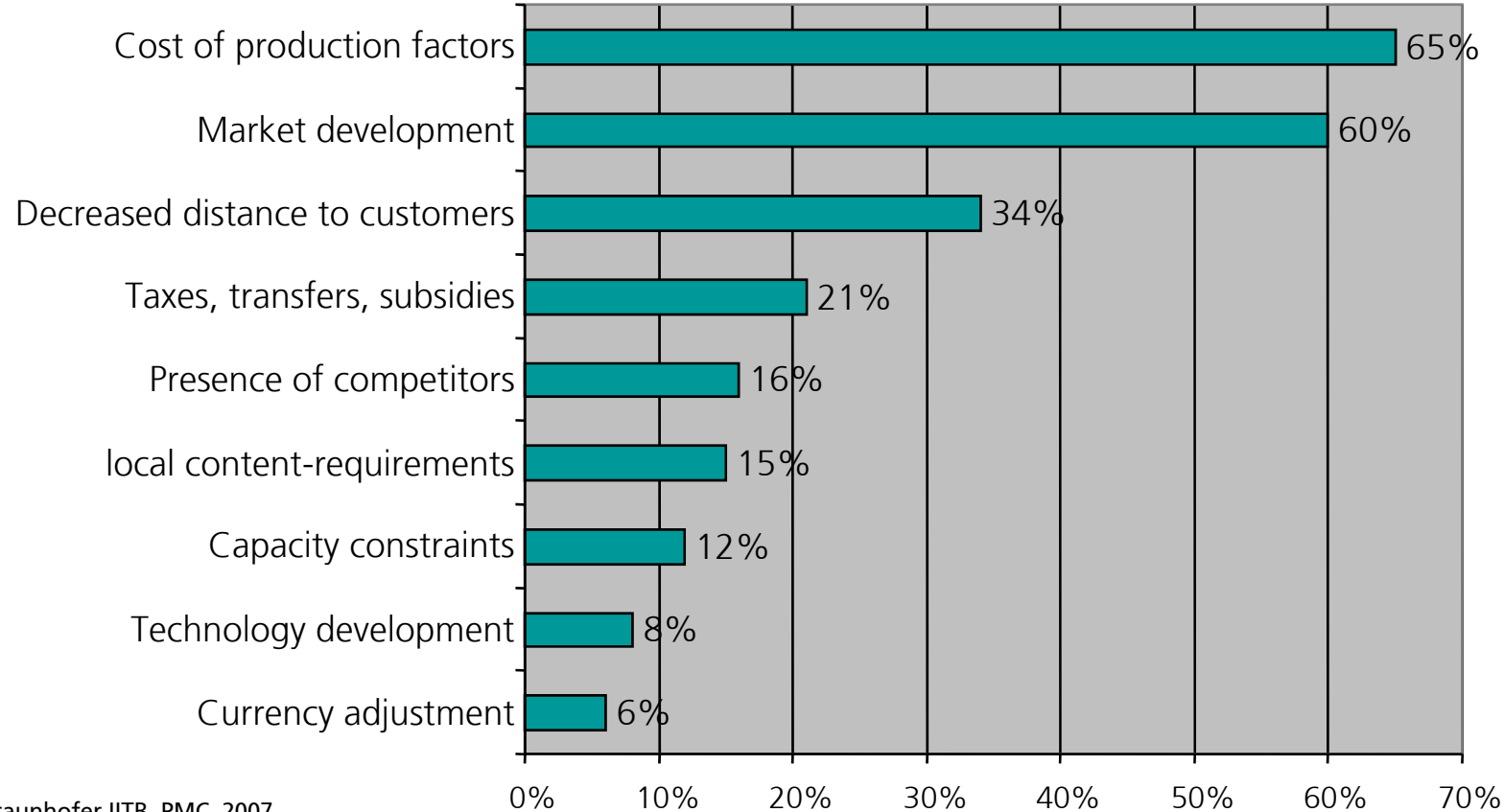
1. Objective conditions in industrial manufacturing (2)

- **Globalization: companies act world wide according to different conditions of manufacturing sites**



1. Objective conditions in industrial manufacturing (3)

- **Companies act world wide according to different conditions of manufacturing sites: why companies establish production sites abroad**



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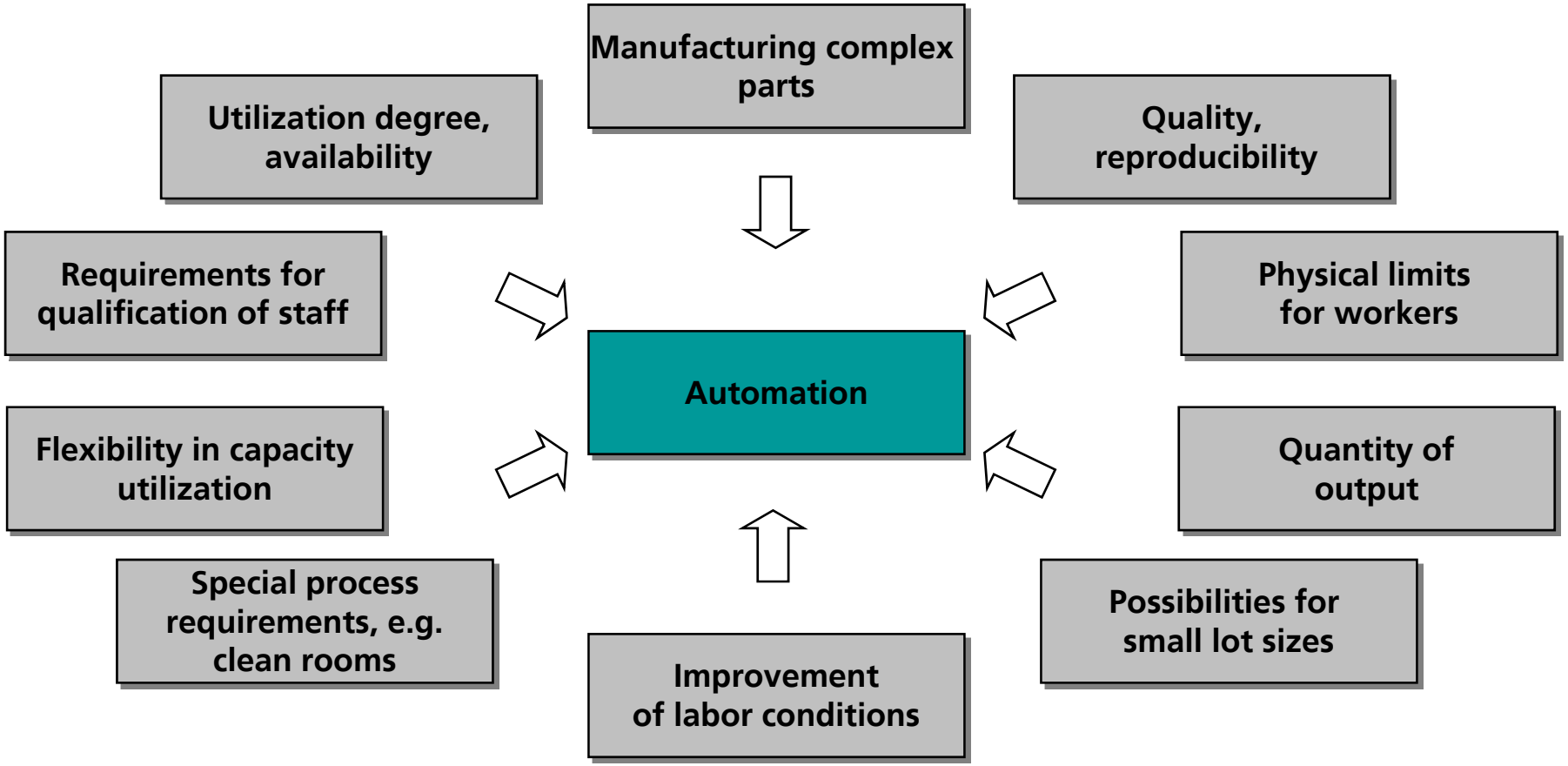
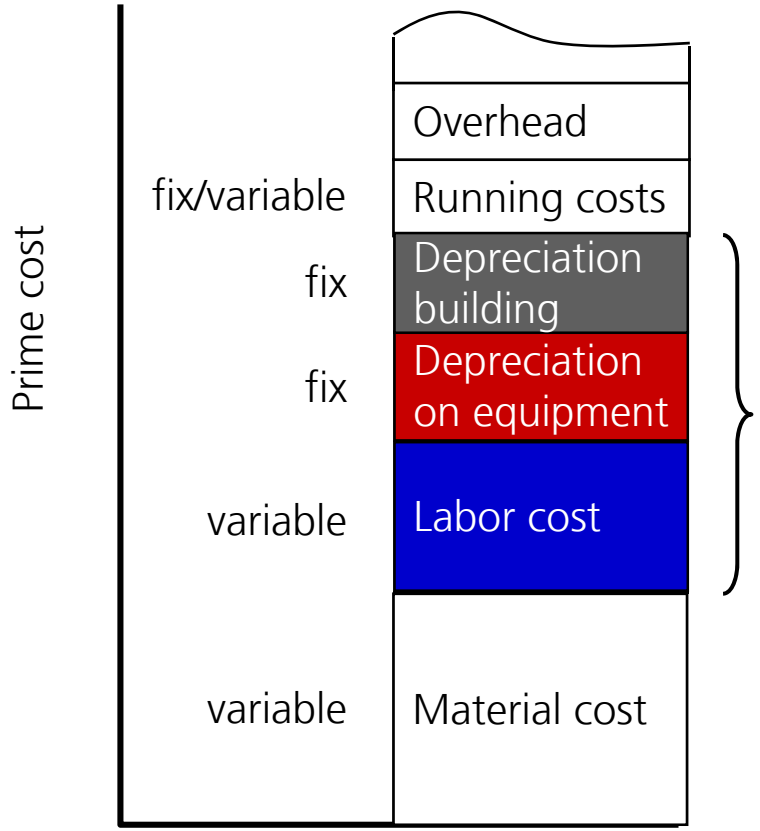
1. Functional aspects for automation



1. Cost aspects for automation (1)

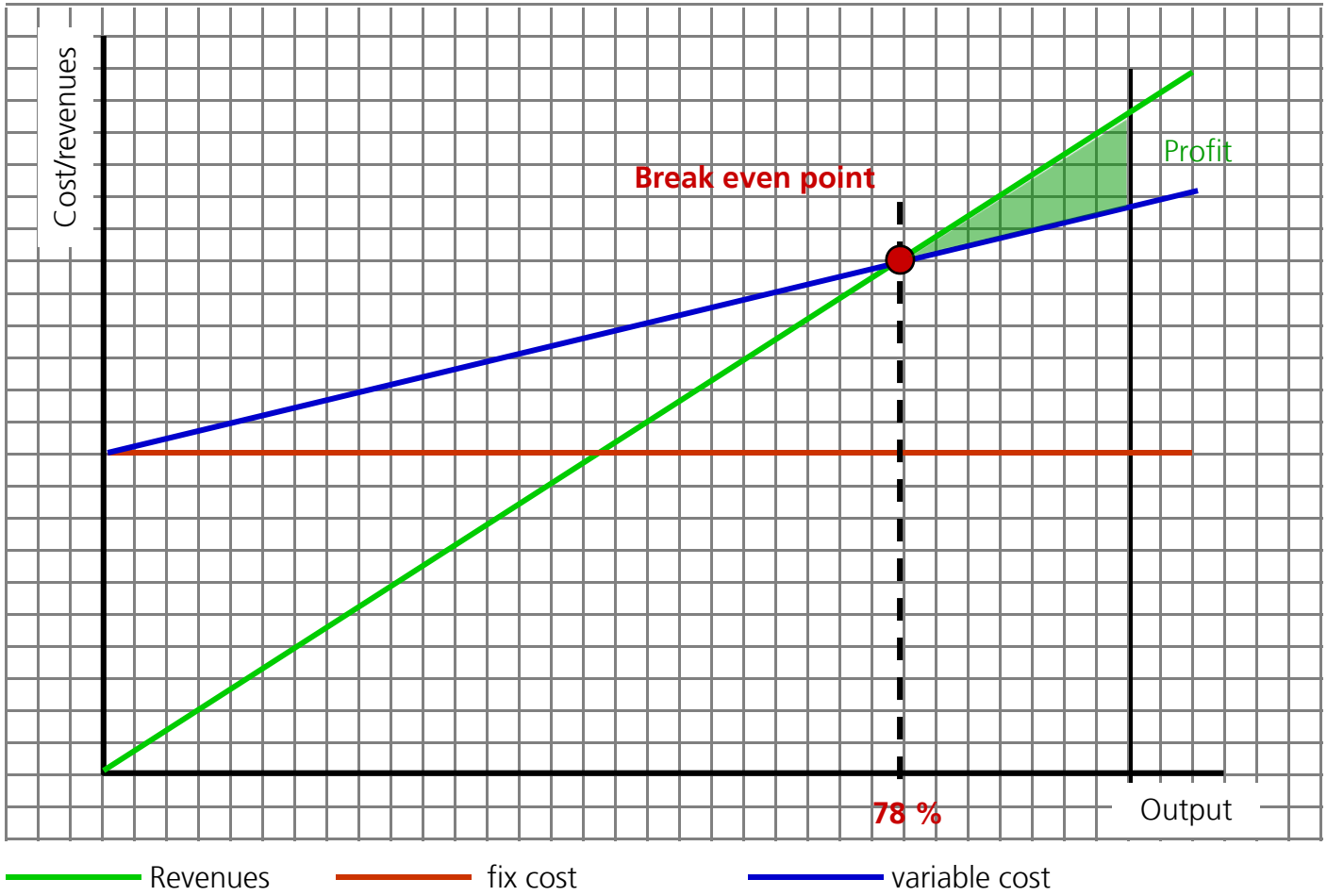
Simplified structure of prime cost



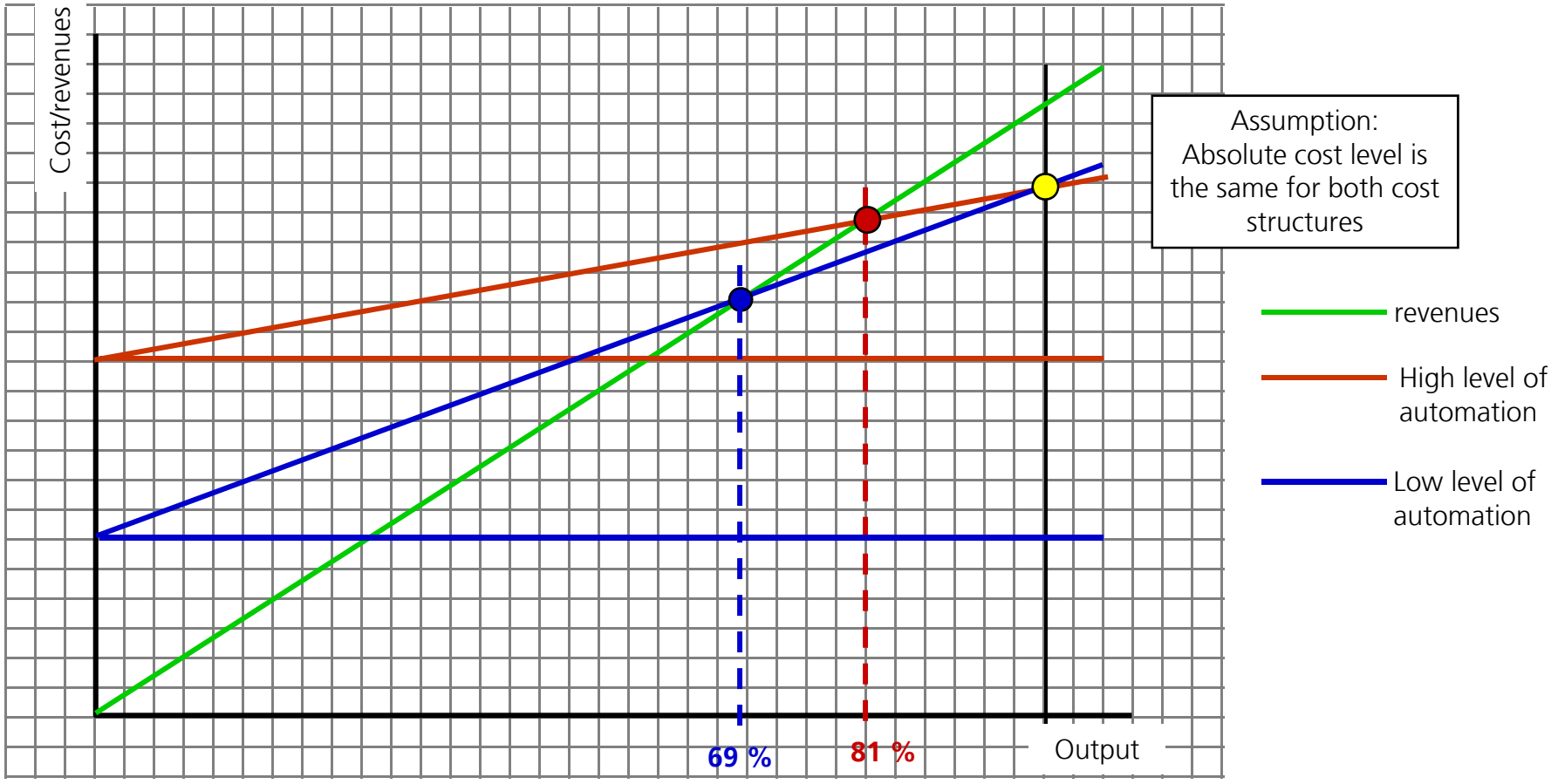
Main impact of the technological level, e.g. automation, on
- head count,
- type of equipment,
- type of building and utilities

The technological level impacts structure and number of prime cost!

1. Cost aspects for automation (2)



1. Cost aspects for automation (3): break-even curve for two different levels of automation



1. Cost aspects for automation (4): break-even curve for two different levels of automation

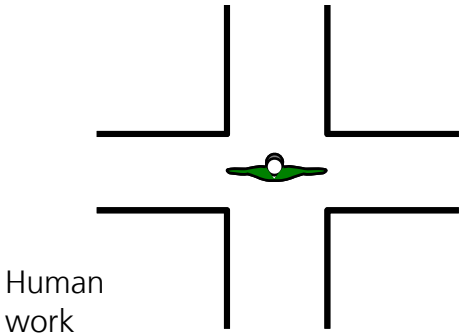
Production systems with a high level of automation lead to cost structures with a high level of fixed costs.

A high level of manual work leads to cost structures with a high degree of variable cost.

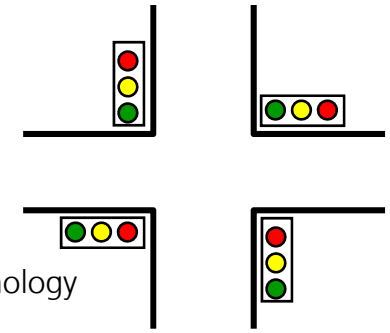
A production system with a high level of fixed costs reacts much more sensible to variations in capacity utilization than a production system with lower degree of fixed costs.

In the profit zone (on the 'right hand side' of the break-even point) profit increases faster in case of increasing capacity utilization if automation level is higher (higher fixed costs).

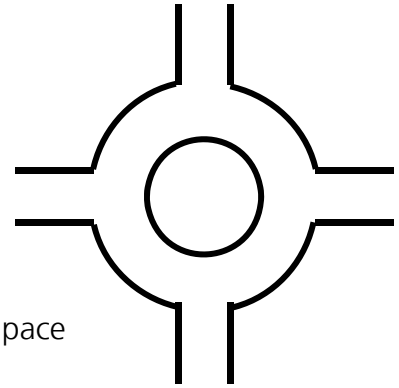
1. Cost aspects for automation (5): how can cost factors be substituted



Human work

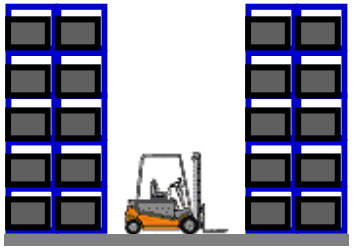


Technology

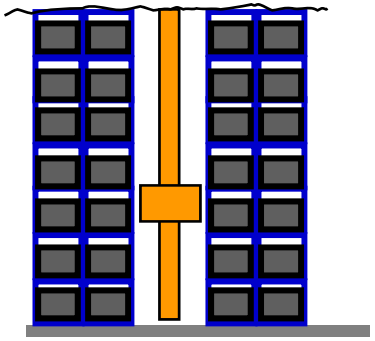


Space

ground storage, fork lift



palet storage, fork lift

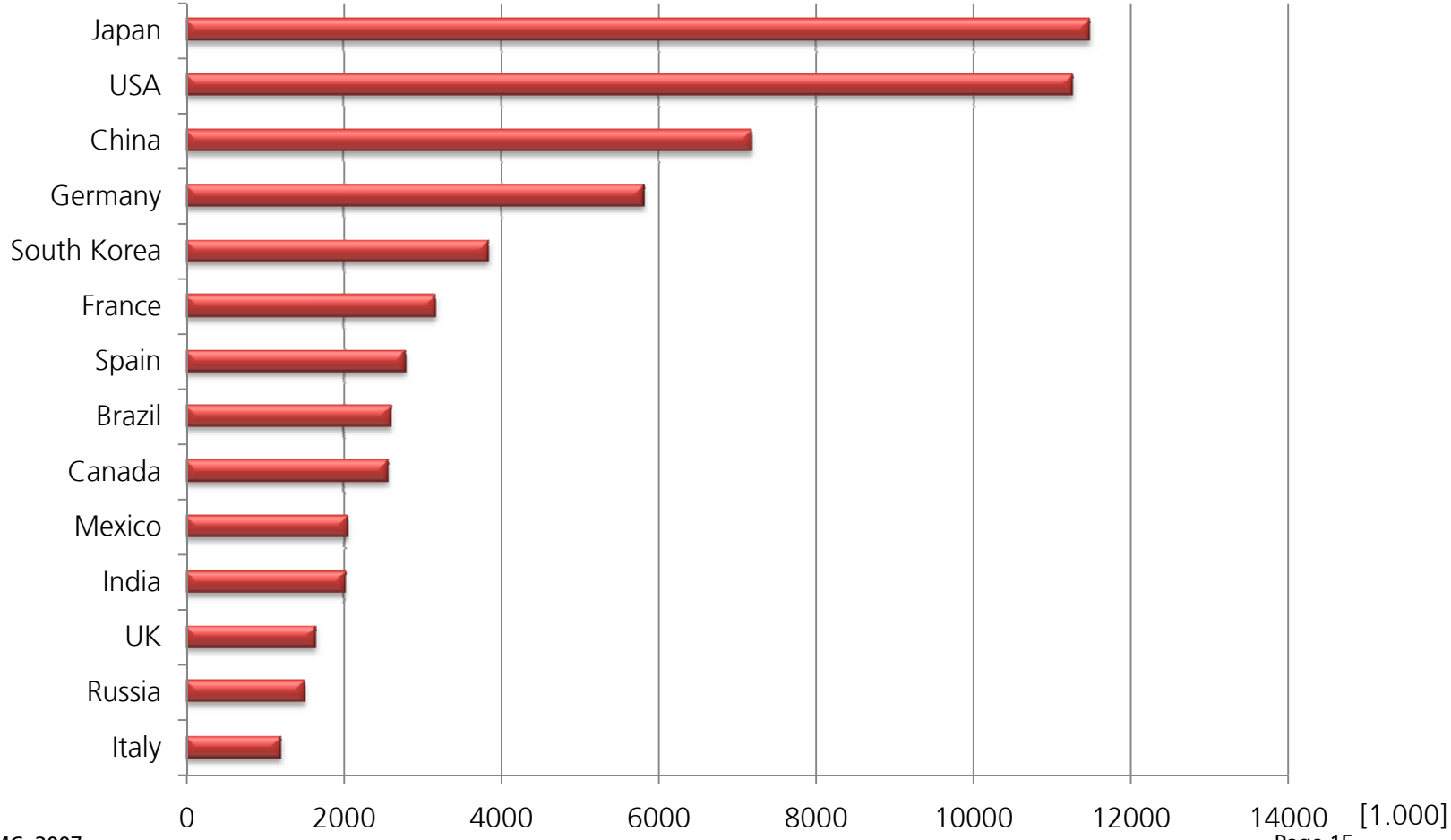


High rack warehouse, automatic rack feeder

Produktionsfactors human work, equipment, space can substitute eachother to a certain degree.

2. Automotive manufacturing

2. World Automotive Production 2006 (Source: Globus/VDA/dpa; Produktion13092006)



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2. Status in the automotive industry (Quelle: Nueno, P.; IESE Business School, Barcelona)

Overcapacity

Overcomplexity
- models
- countries
- alliances

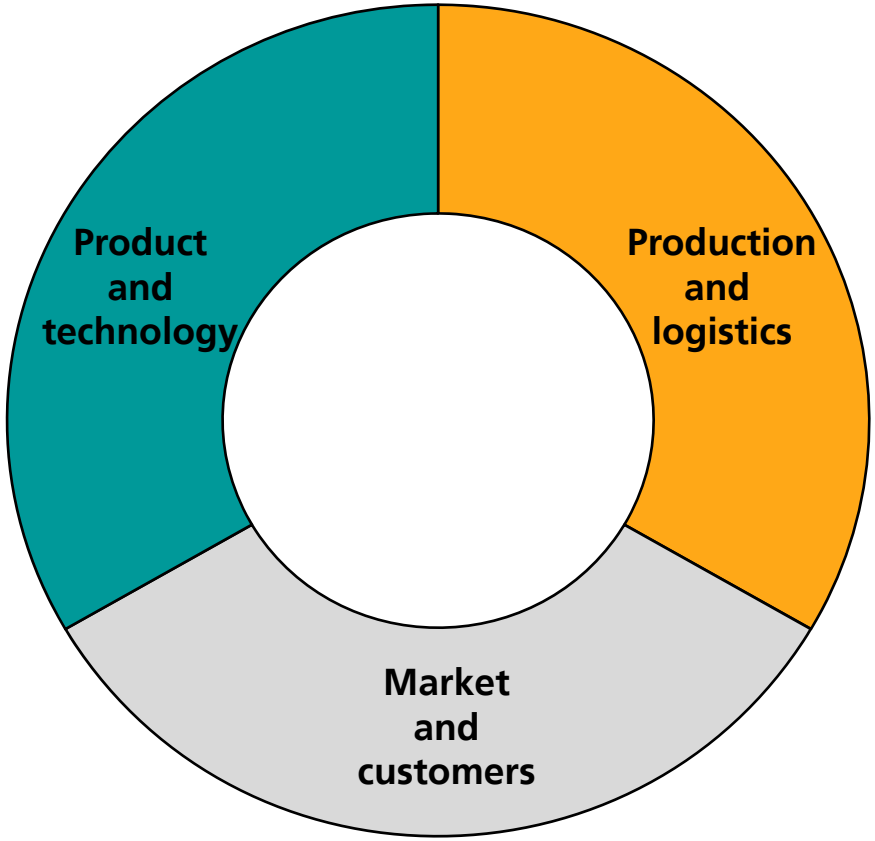
Overcompetition
- weak financials through the value chain

Pressure from the capital markets
- globalization
- facilitating concentration
- volatile, short term behavior
- changes in management

Unfriendly government
- block exemption (GVO)
- emissions
- taxation
- crowded infrastructure

2. Core factors for successful automotive companies

(source: Bischoff, J.; et.al.: Automobilbau mit Zukunft)



2. Core factors for successful automotive companies

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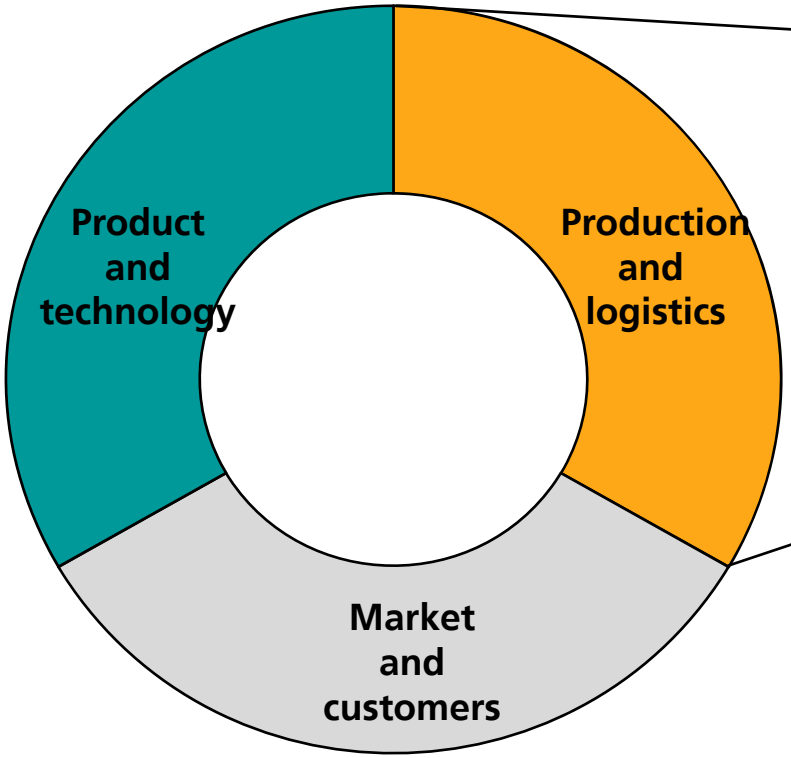

Three key success factors for future automotive production:

1. **Adaptivity**
2. **Realtime ability**
3. **Production in networks**

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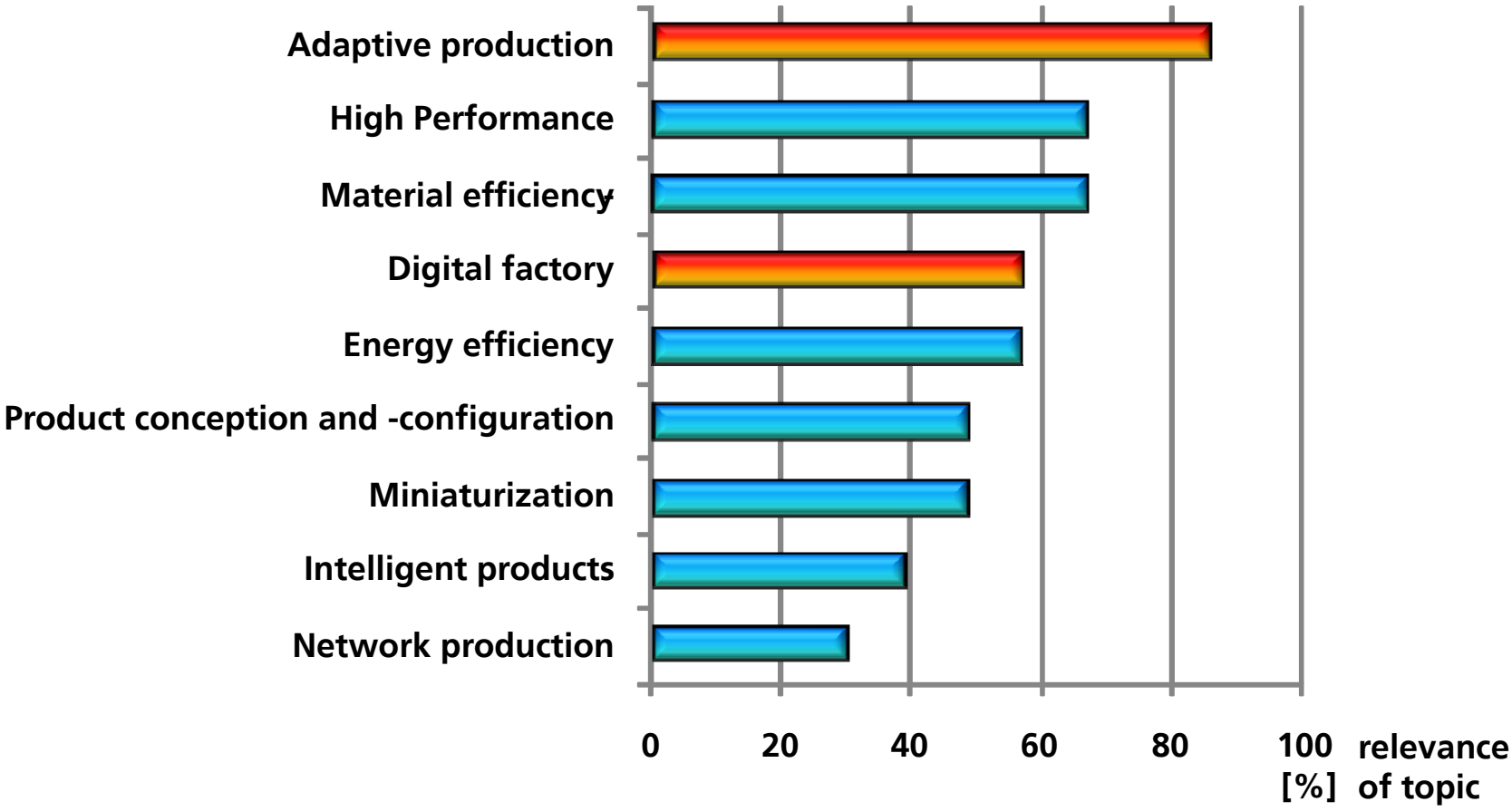
2. Key success factors for future automotive production

(source: Bischoff, J.; et.al.: Automobilbau mit Zukunft)

1. Adaptivity

- **concerning plants and buildings**
- **regarding facilities, machines, lines and tools**
- **of processes and methodologies**

2. Adaptivity and flexibility is TOP priority for European automotive companies (source: MANU*FUTURE* Germany, September 2007)



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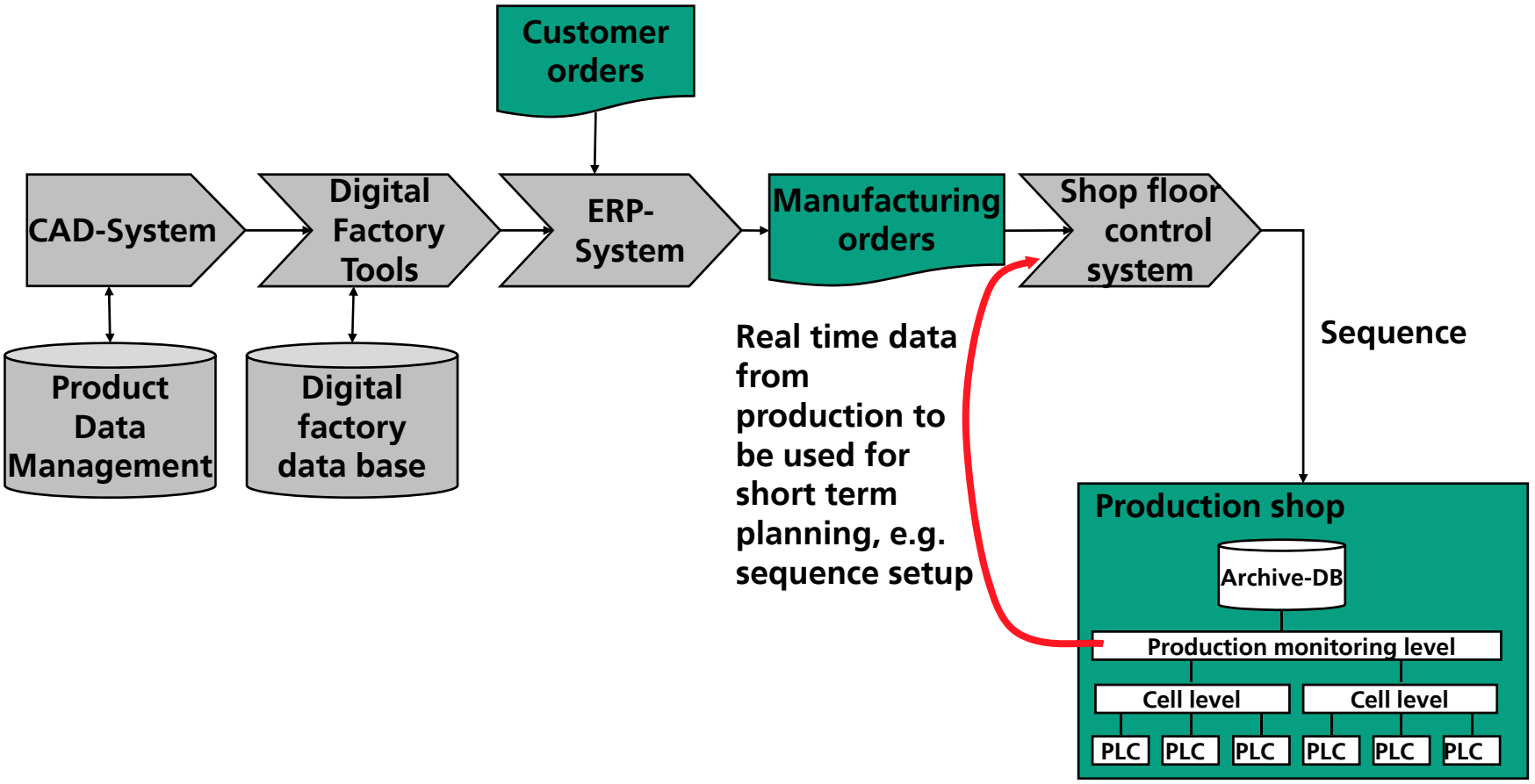
2. Key success factors for future automotive production (2)

(source: Bischoff, J.; et.al.: Automobilbau mit Zukunft)

2. Real time ability

- integration of information technology from planning to operations
- intelligent management of information and decisions without gaps
- implementation of monitoring systems to permanently access key performance indicators

2. Real time ability, e.g. by closed loop between production monitoring and sequence setup



2. Key success factors for future automotive production (3)

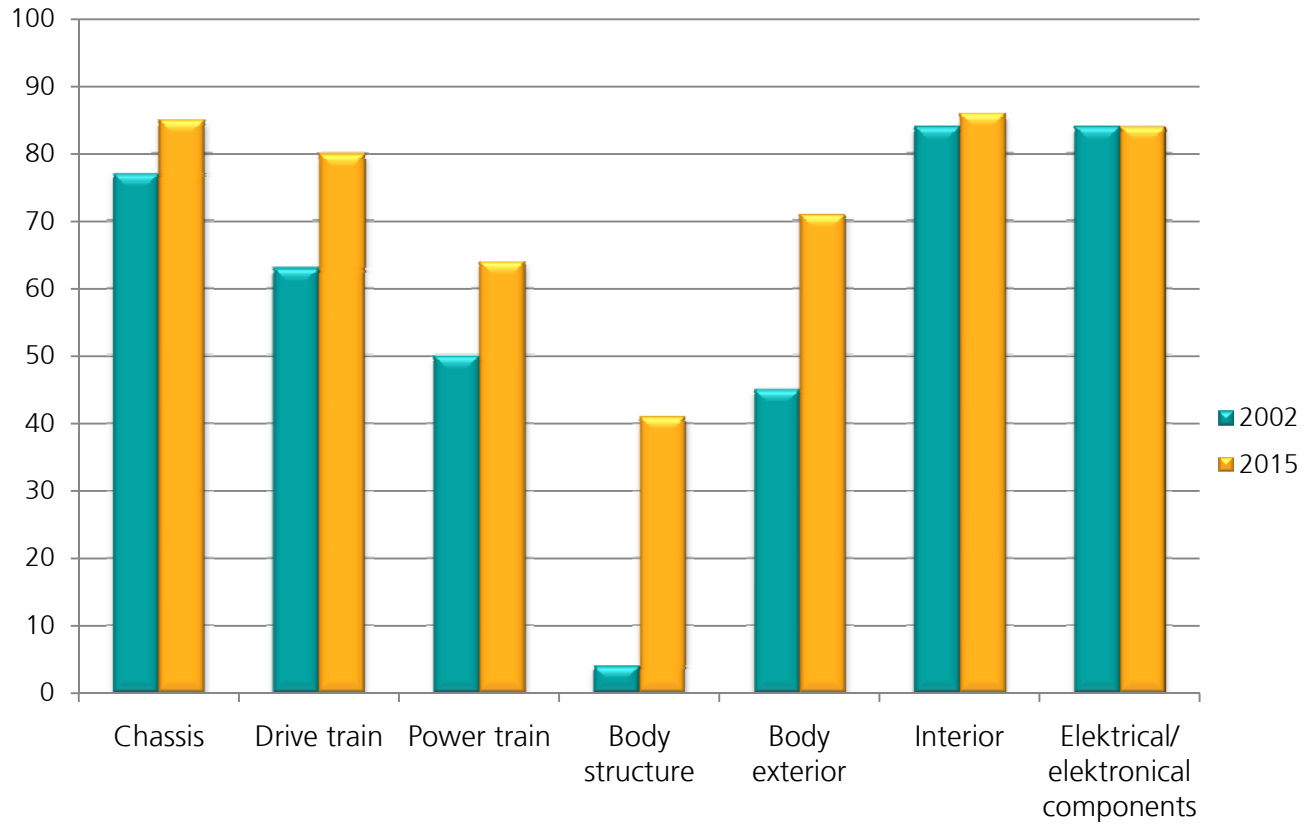
(source: Bischoff, J.; et.al.: Automobilbau mit Zukunft)

3. Production in networks

- management of suppliers
- effective optimization of networks
- supplier parks

Development of added value of suppliers

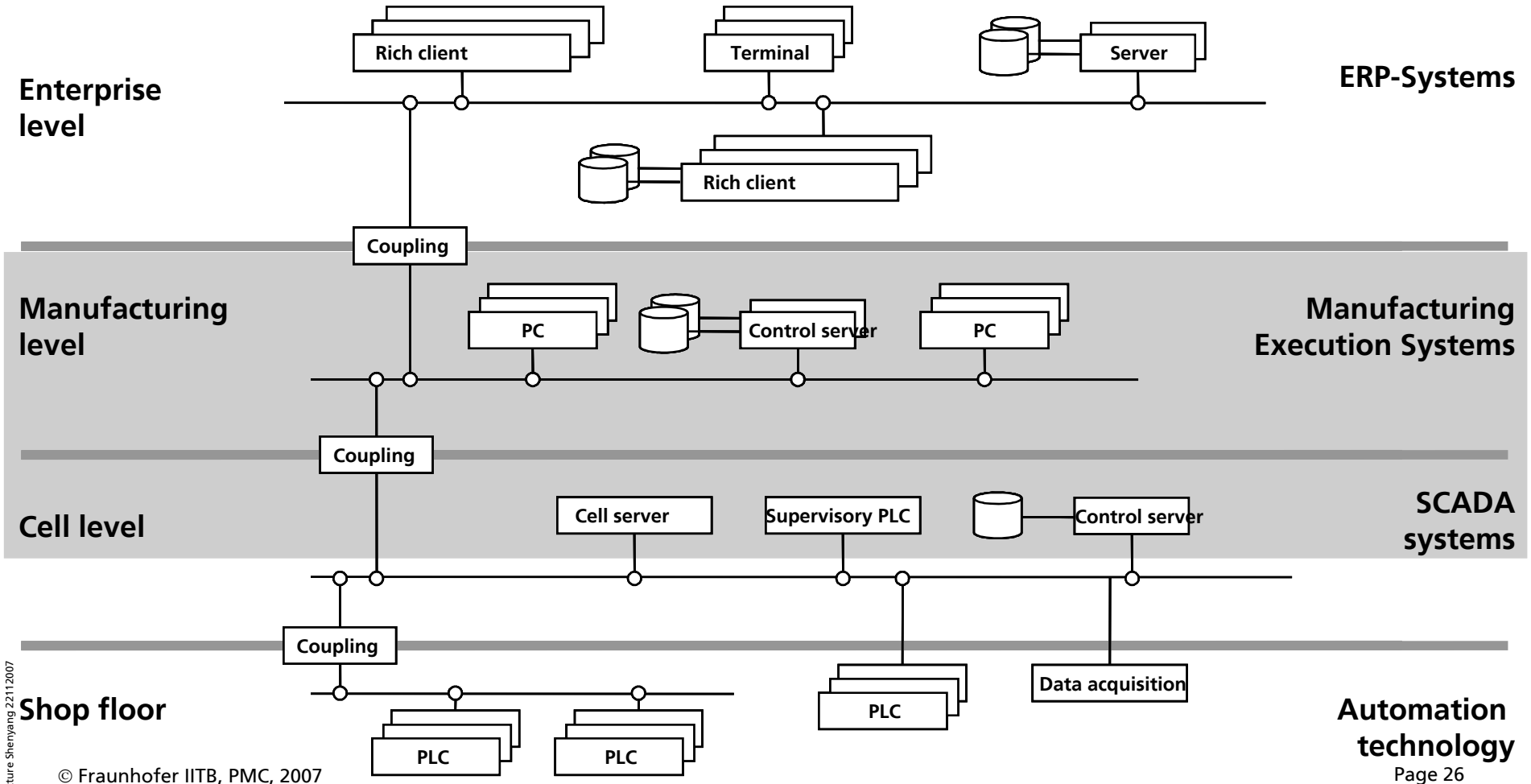
(source: FAST study)



3. Manufacturing Execution Systems for automotive production

- example for a successful production monitoring systems

3. Manufacturing Execution Systems in a factory's IT hierarchy (Source: Betriebshütte, VDI 5600)



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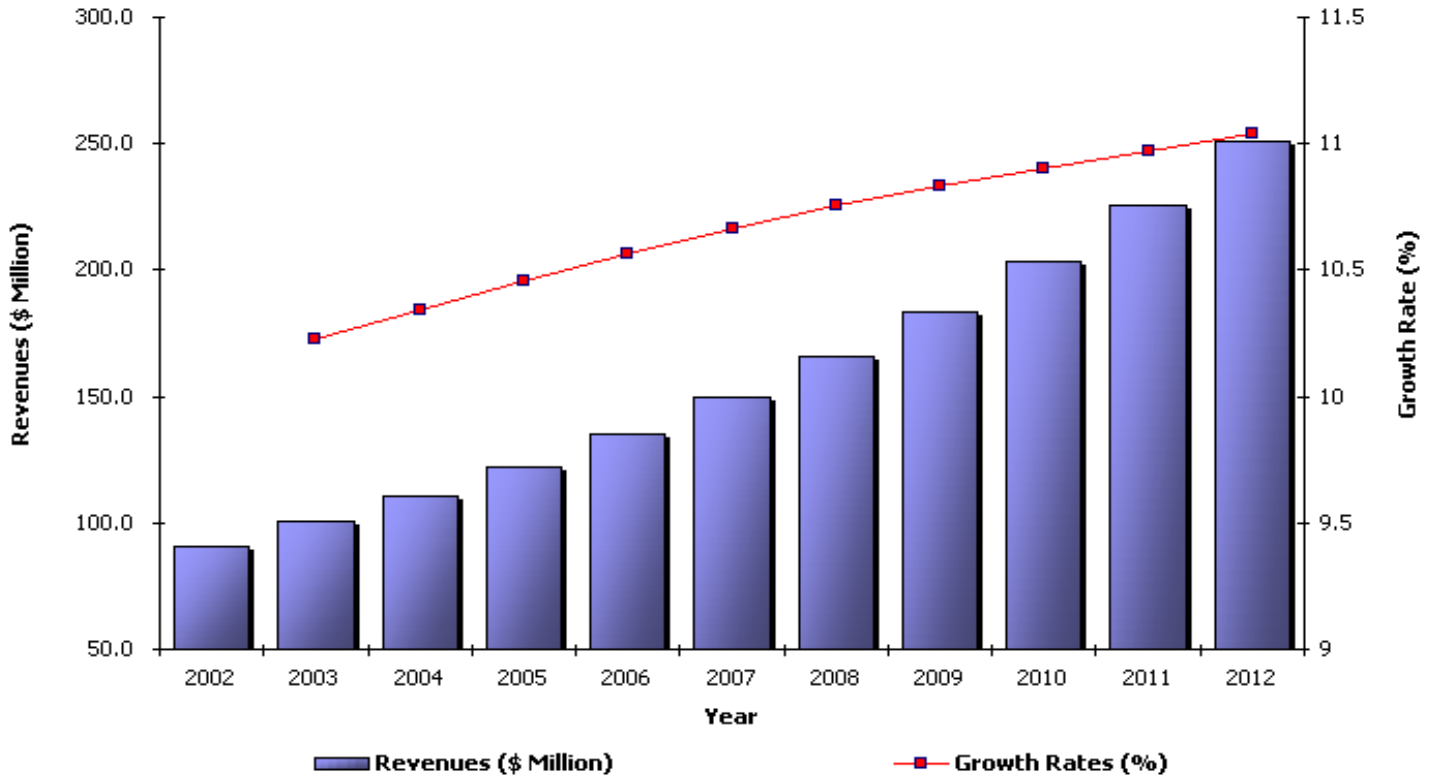
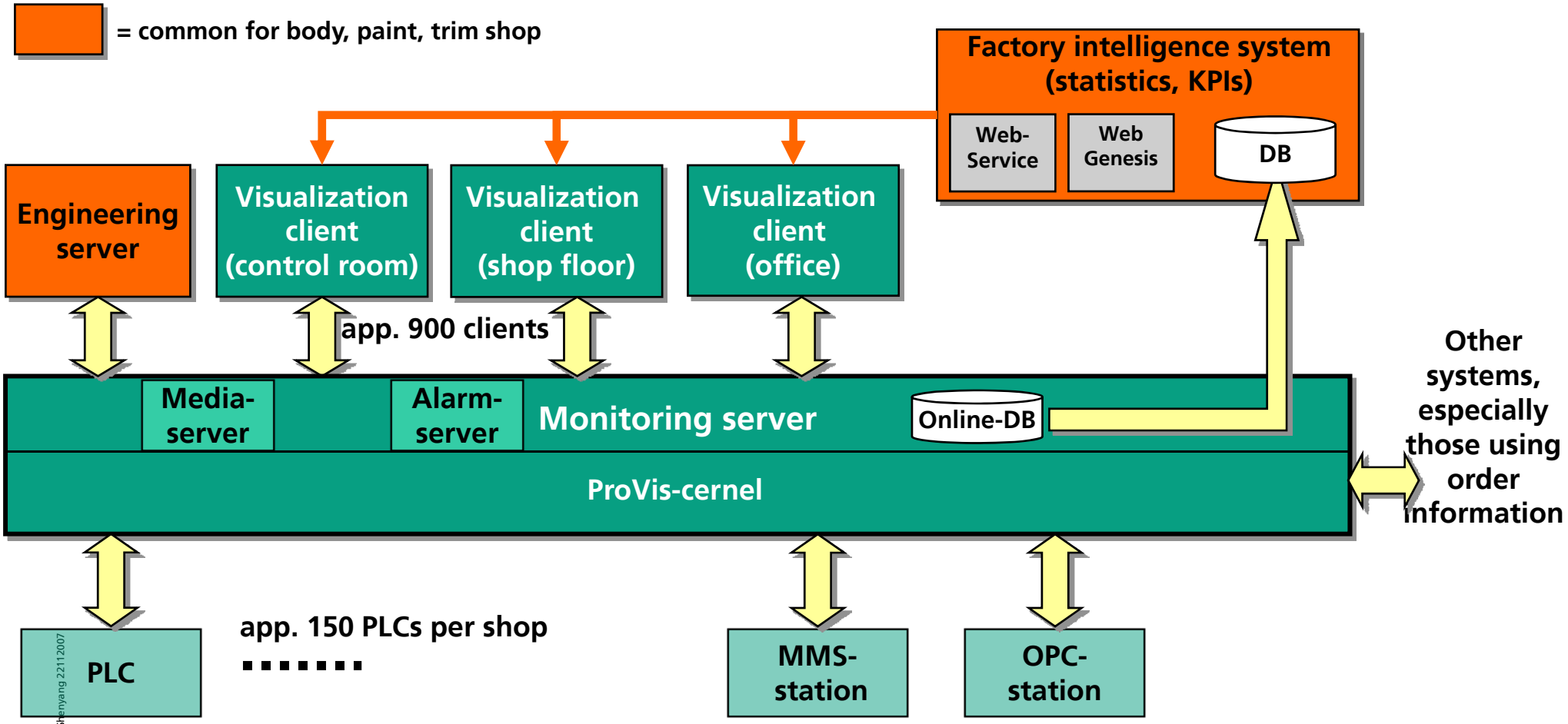
3. Worldwide market volume for Manufacturing Execution Systems in the automotive industry



Source: Frost & Sullivan Study F 699: Automation and Software Solutions in World Automotive Markets, May 5, 2006)

3. Production monitoring architecture applying software agent technology

ProVis.Agent



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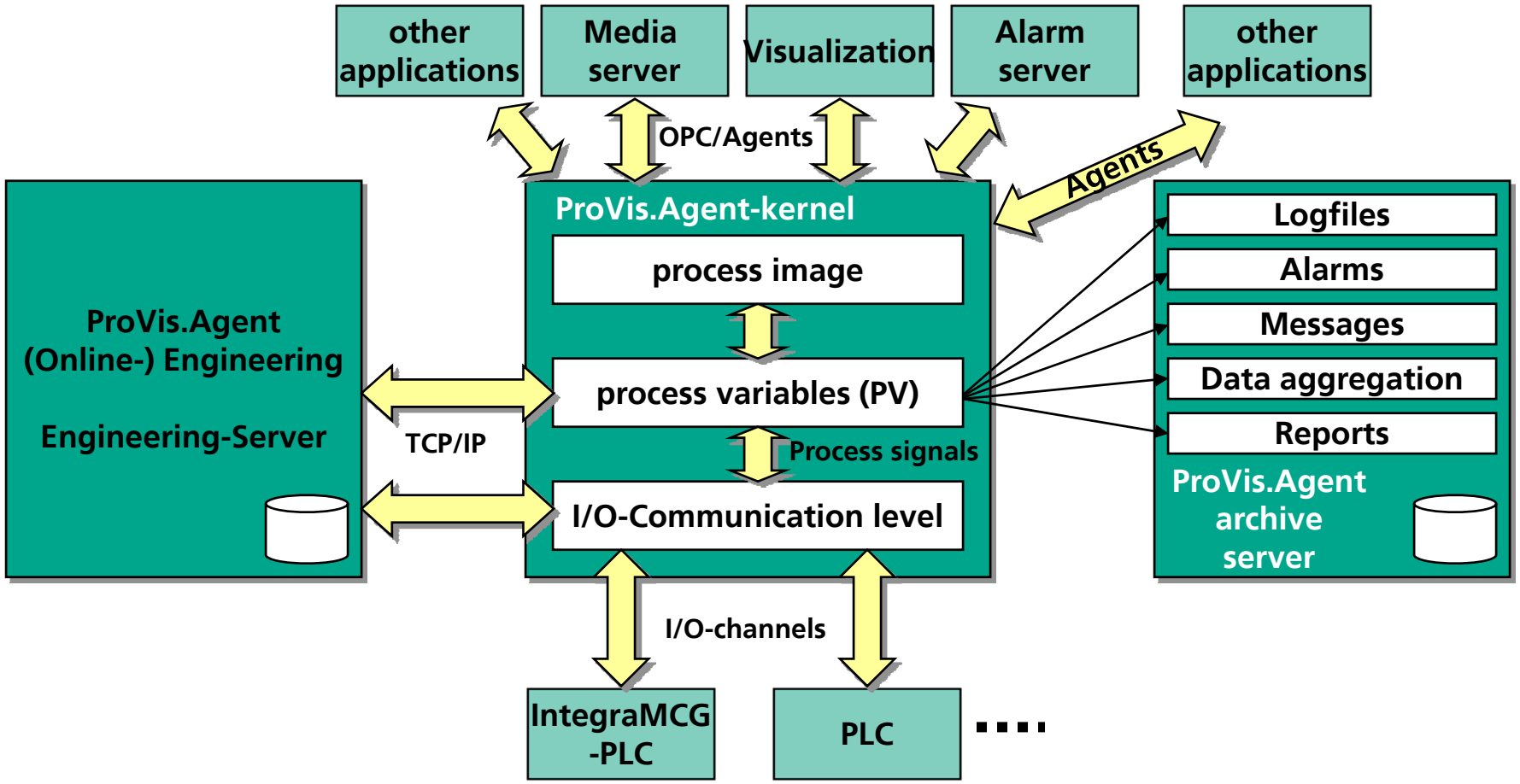
3. Production monitoring architecture applying software agent technology (2)

ProVis.Agent



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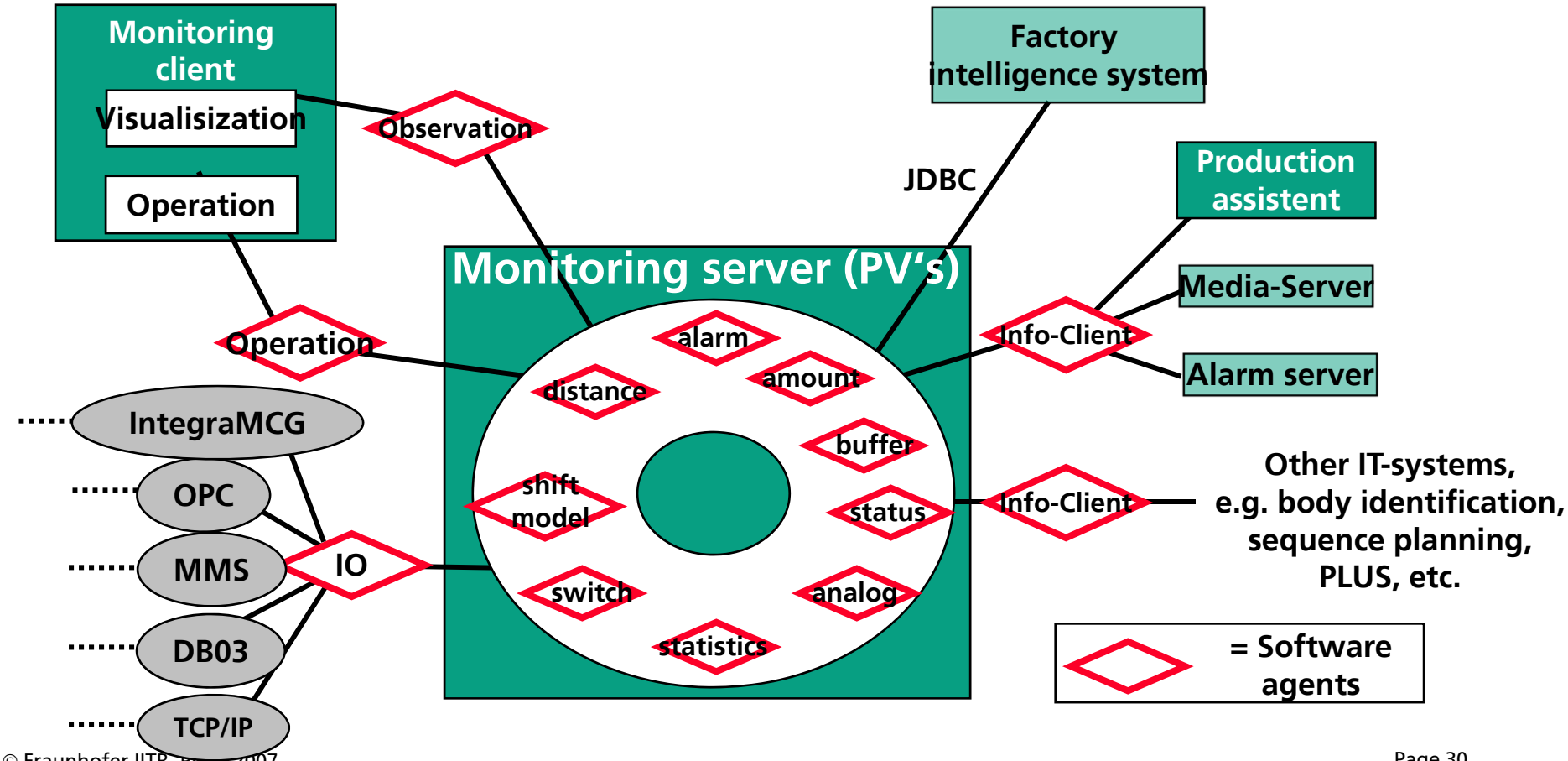
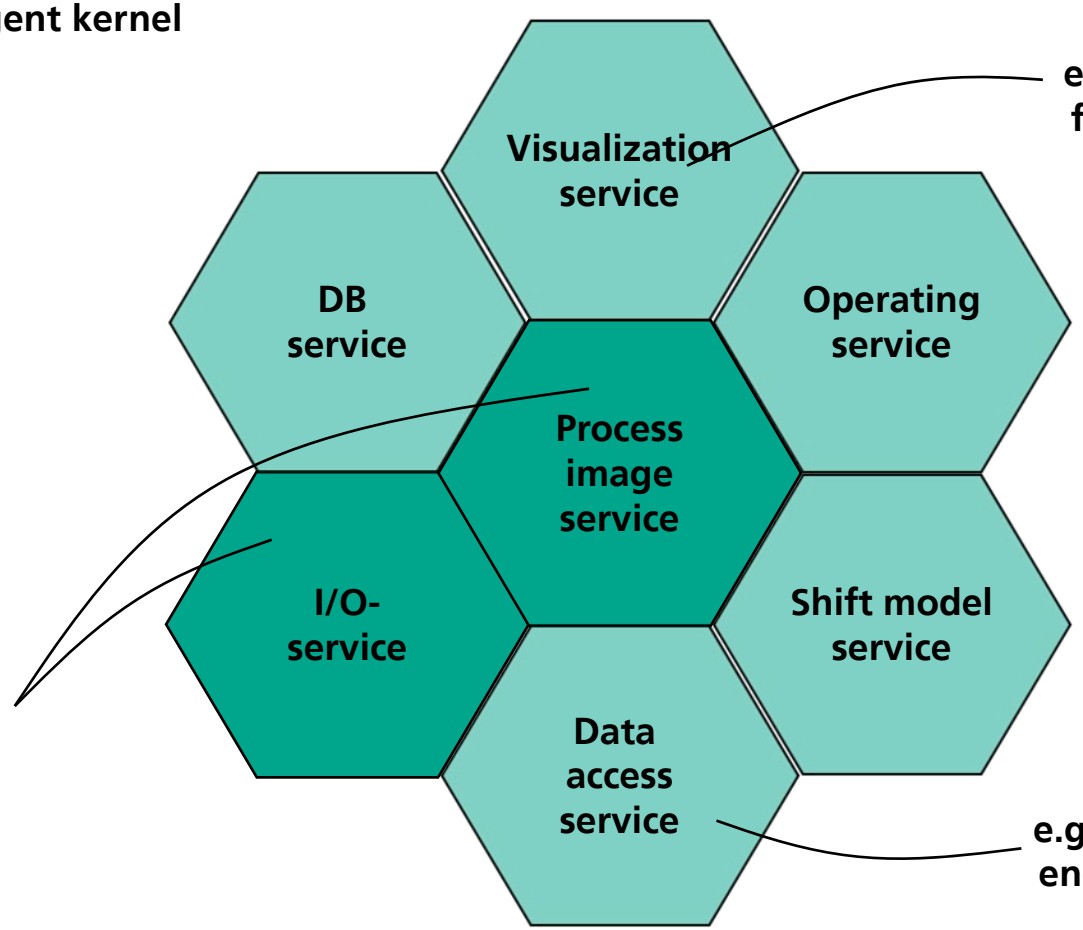
3. System architecture as working in Daimler Bremen and Woerth plants



3. Introduction to the ProVis.Agent kernel

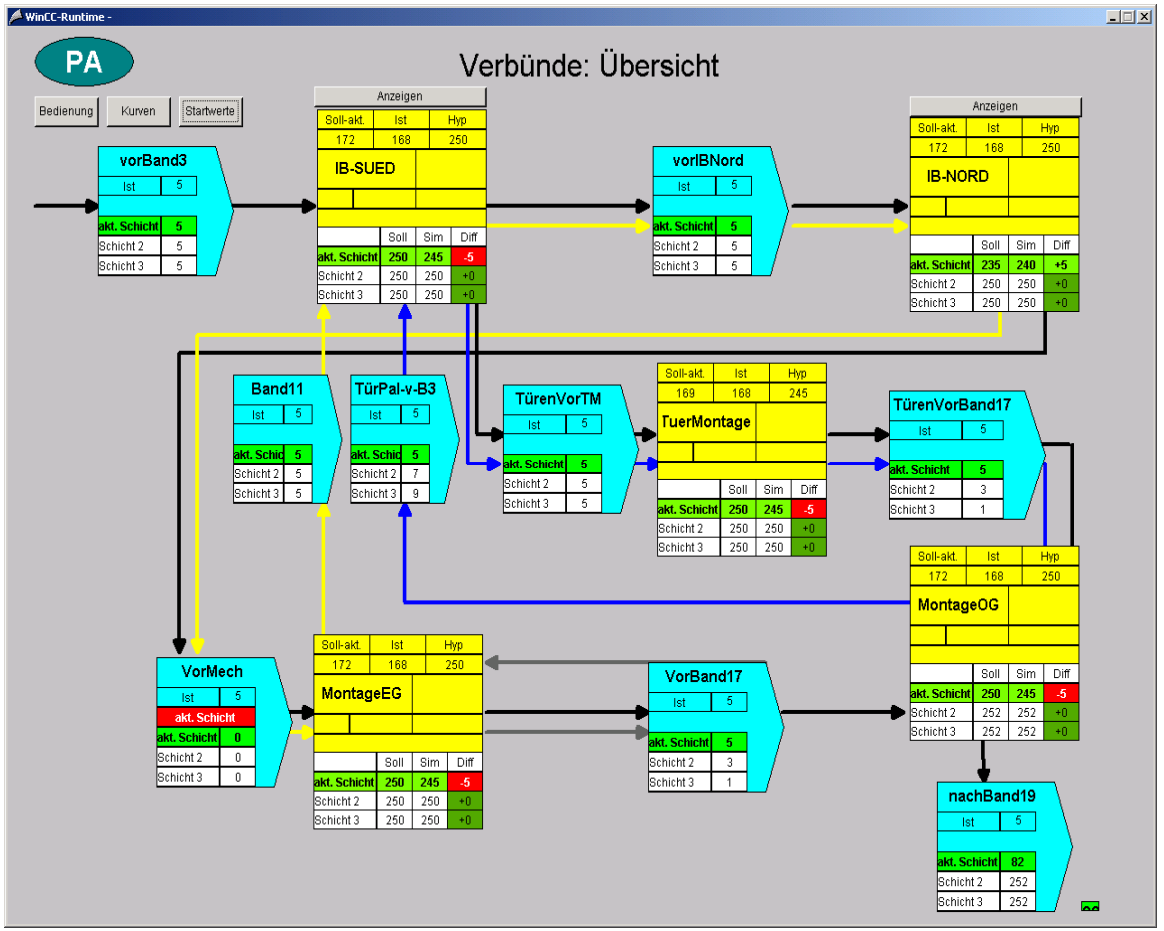
Services in the ProVis.Agent kernel



3. Highlight of production monitoring: online simulation

Online simulation...

- ...is add on function within ProVis.Agent®
- …simulates output and buffer contents for the coming shifts
- ...is already linked to the PMC-systems by agents



3. Central monitoring and control room

Control room C-class trim shop
Daimler AG, Bremen plant

Picture: Daimler

Control room trim shop Golf V
VW AG, Wolfsburg plant

Picture: VW

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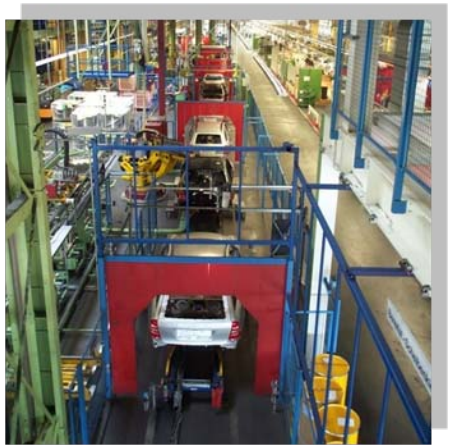
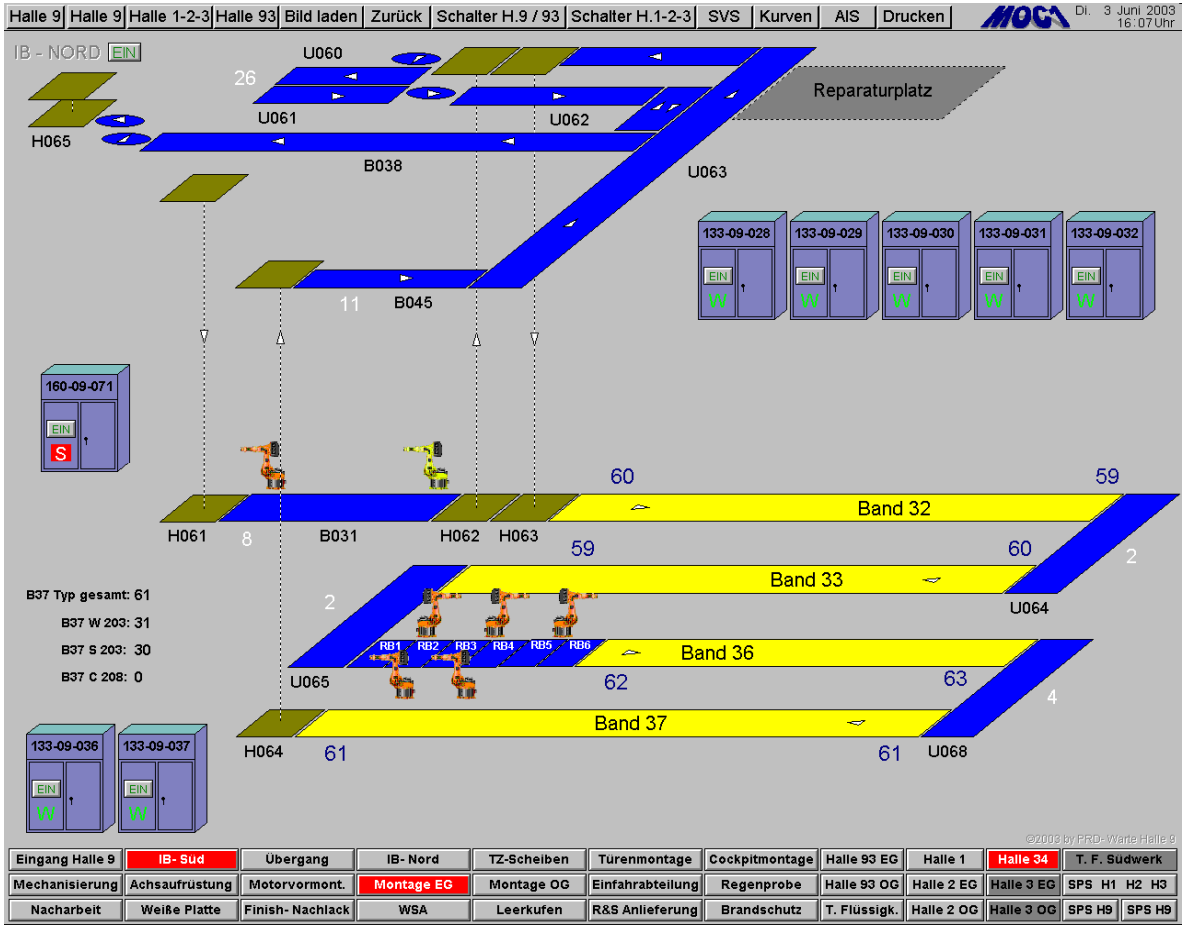
3. Example for monitoring a part of the assembly line in the Bremen plant





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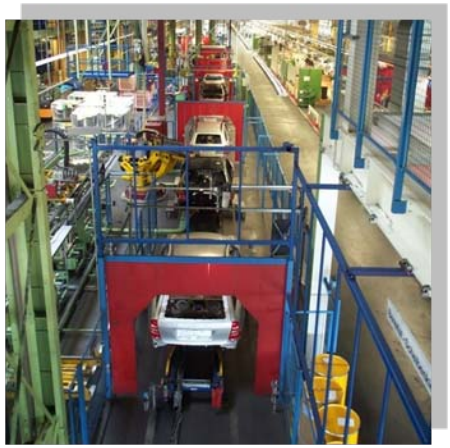
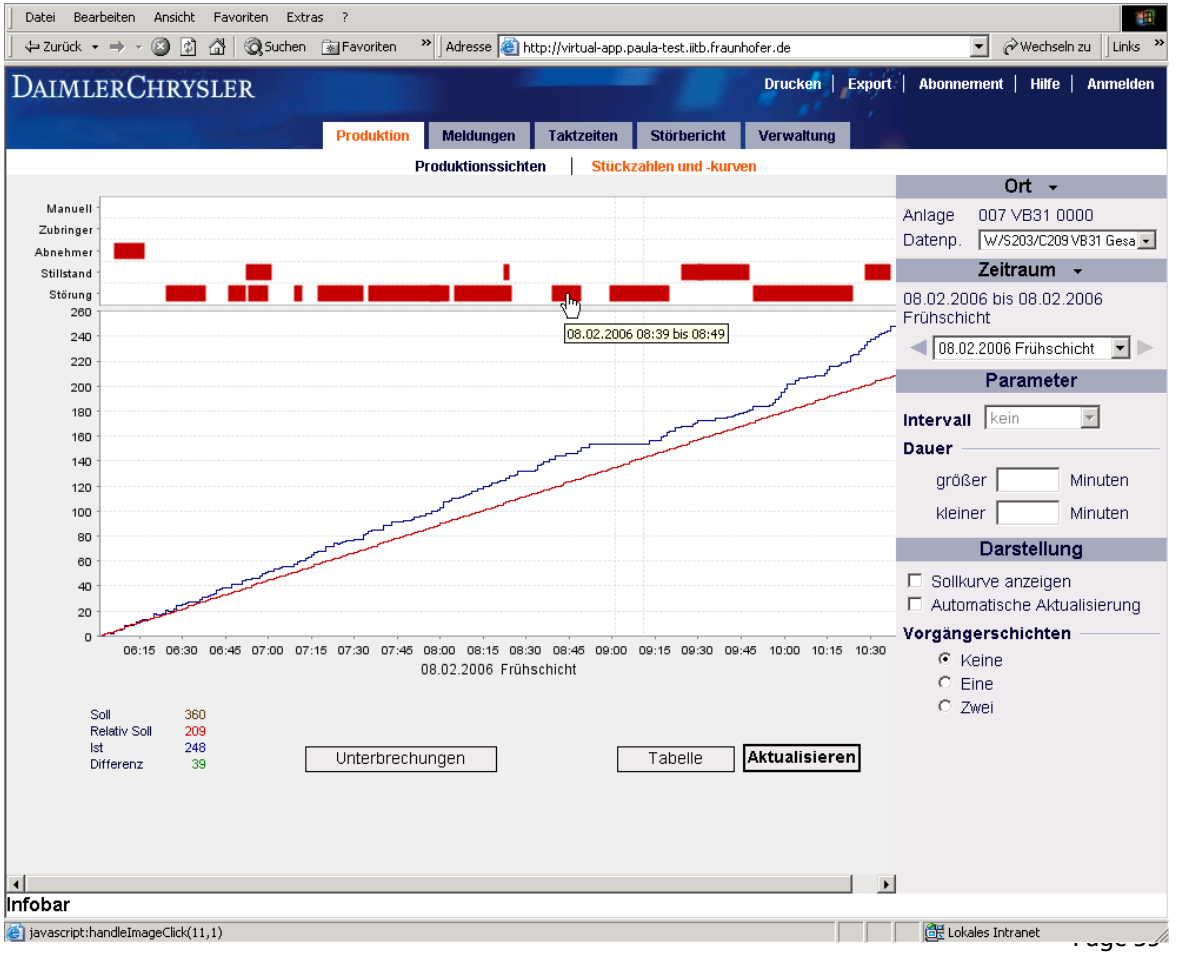
3. Example for web-based factory intelligence system





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3. Major benefits for IITBs customers

- **Most innovative software tools and technologies to be used in manufacturing plants.**
- **Direct view from each client in the plant to actual situation on the shop floor; unlimited number of clients to be used (up to 1.000).**
- **High transparency of the situation on the shop floor in real time.**
- **Assignment of work orders to machines according to best production plans concerning e.g. lead time, work in process, setup times, capacity load, etc.**
- **Less investment costs for software licences compared to commercial competitors.**
- **Strong local partners who can provide excellent service and 1st/2nd level support.**

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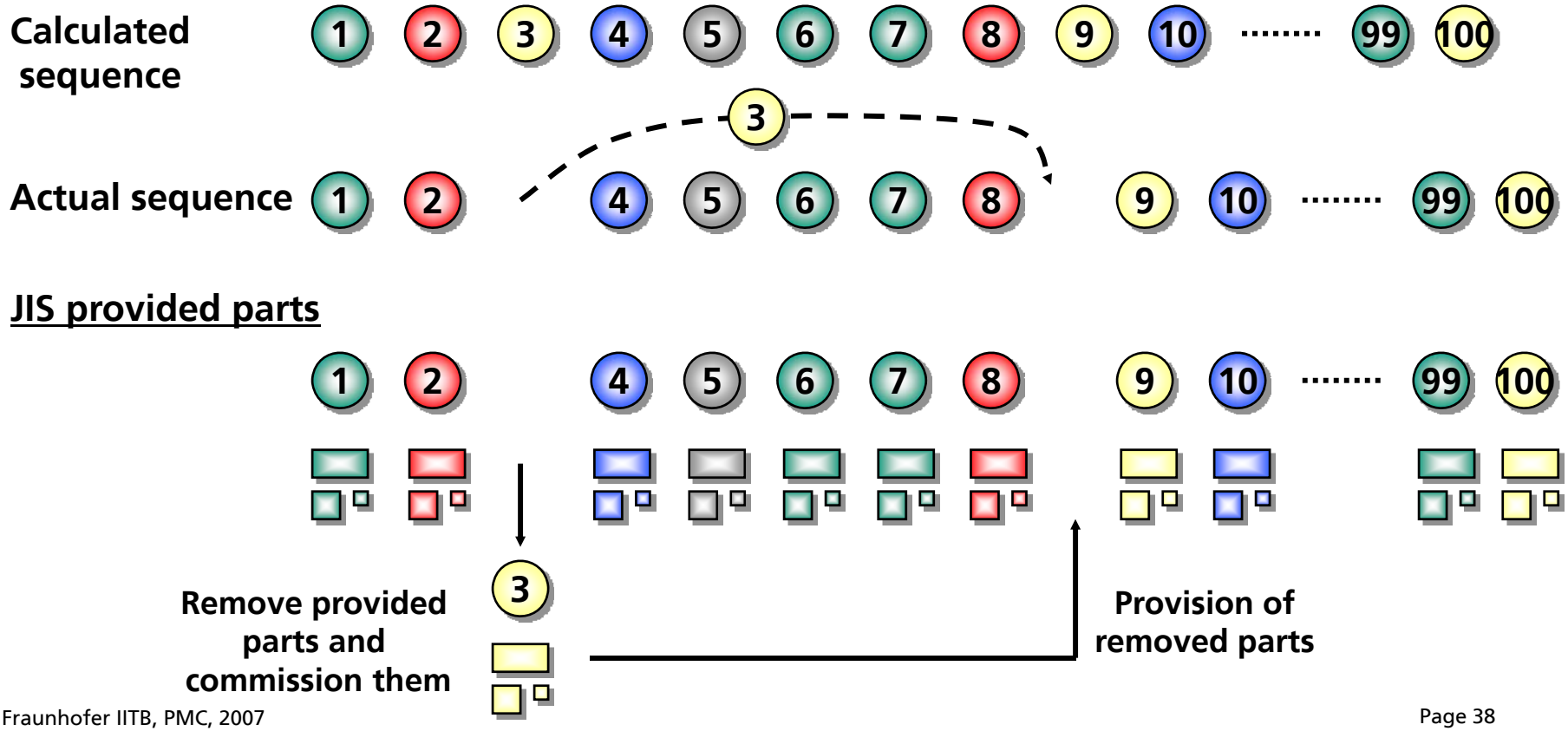
3. Manufacturing Execution Systems for automotive production

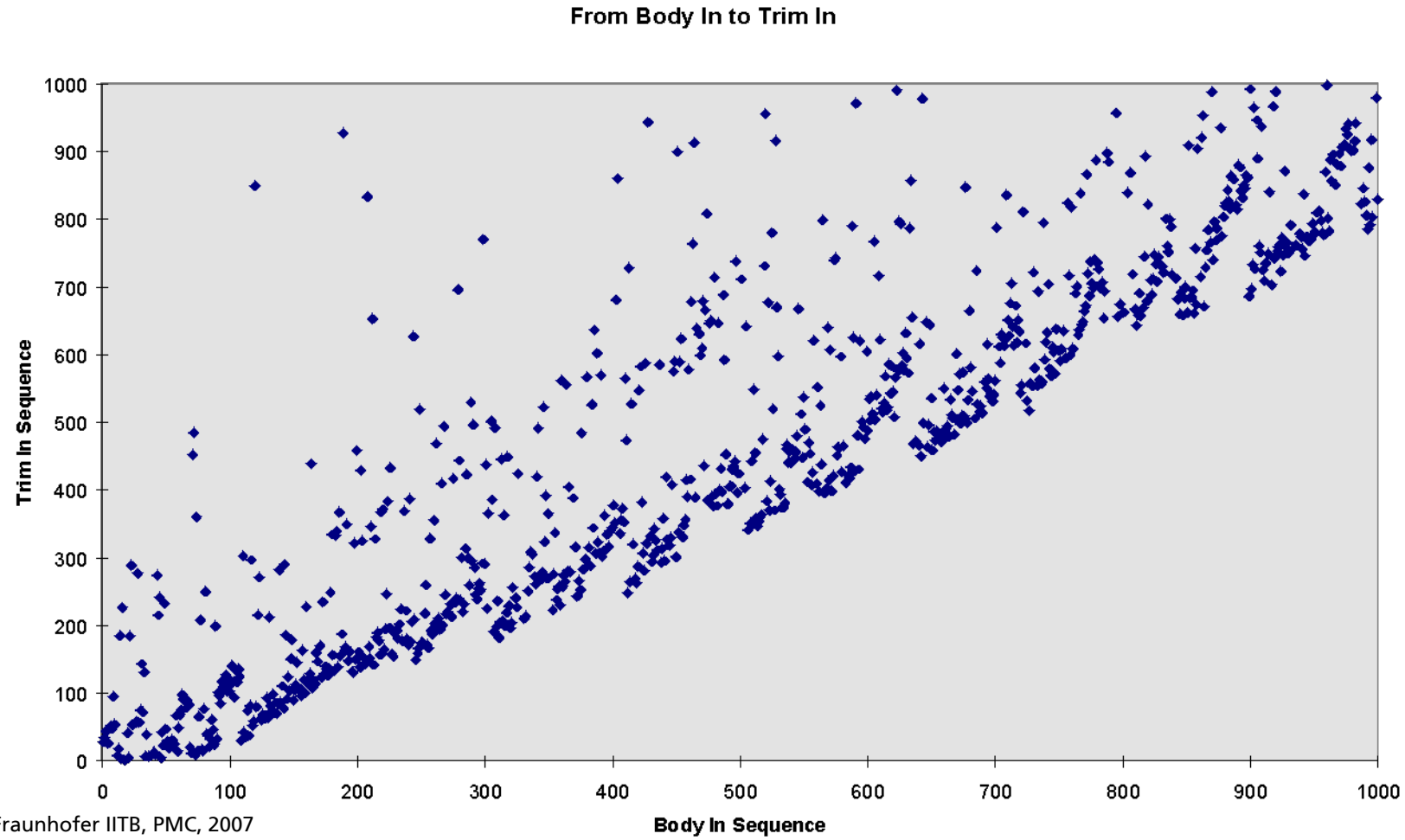
- general aspects of sequencing

3. Effects of disturbed sequence due to unexpected facility breakdown

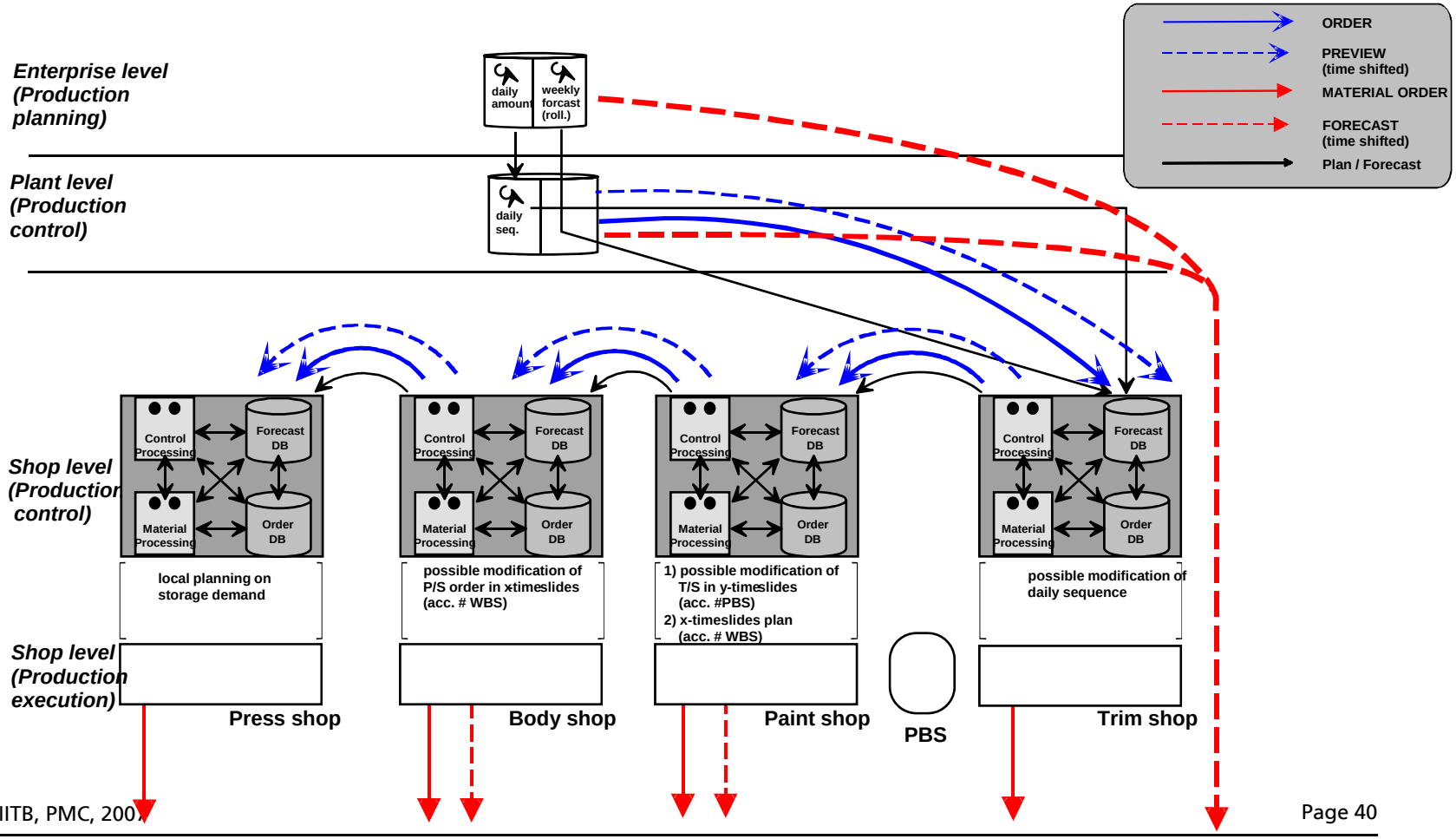
Car body final assembly



3. Project example from Hyundai Motor Company: simulation of keeping sequence (source: FhG-IPK/HMC)

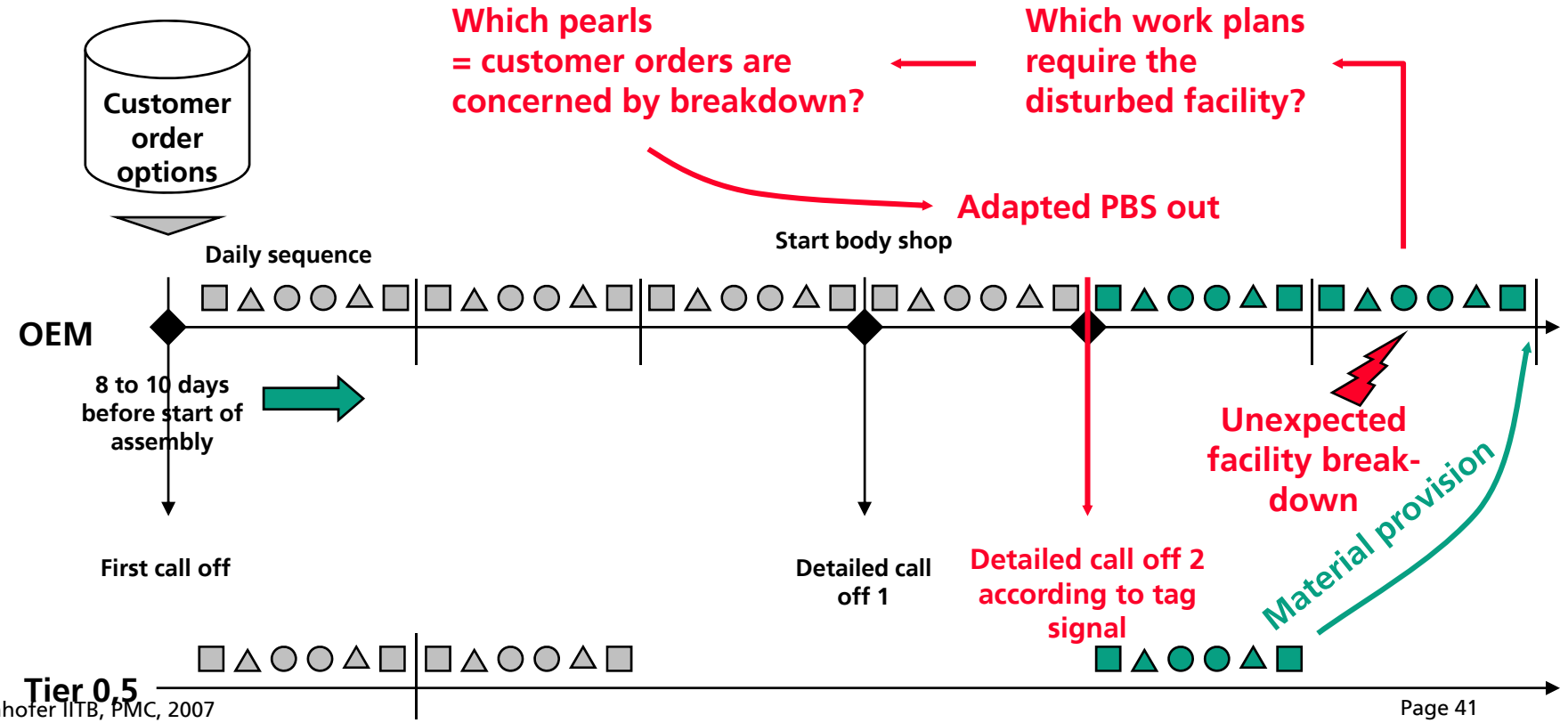


3. Project example Hyundai Motor Company: conceptional approach for control and order management (source: FhG-IPK/HMC)



3. Establishing closed loops between production monitoring and order management

Use of link between production monitoring and sequence planning



3. Manufacturing Execution Systems for automotive production

- integration of MES components

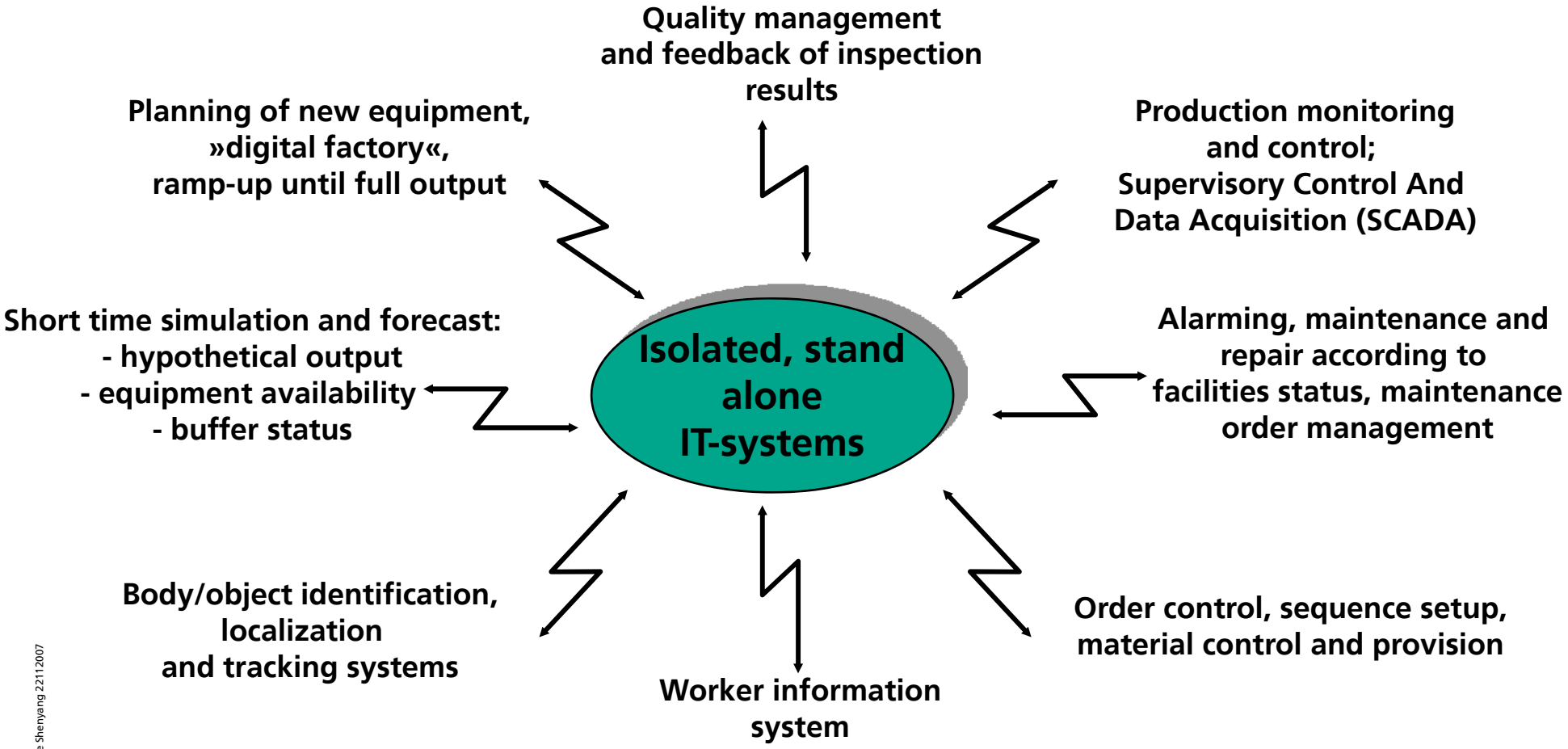
3. Current status in automotive factories (1)

- **Today's automotive plants use a large number of different software systems on the manufacturing execution level. These software systems are not yet integrated and support separate tasks such as production order control (sequence setup), production monitoring, vehicle identification, worker information and others.**

- **Shop floor people use production monitoring tools that are based on production quantities. In the case of a facility breakdown or quality inspection results they only know that a certain number of vehicles is affected. They can neither identify the customer orders related to these vehicles nor their options.**

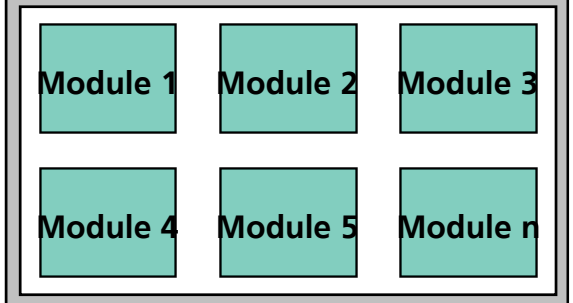
- **The vehicle identification and tracking itself has weakpoints, such as fixed read/write points, missing feedback from the manufacturing process, and is thus completed by redundant systems for body tracking calculation, PLC signals, scanning of paper information, etc.**

3. Current status in automotive factories: examples for IT-systems on the manufacturing execution level (2)



3. How IT-systems can be integrated

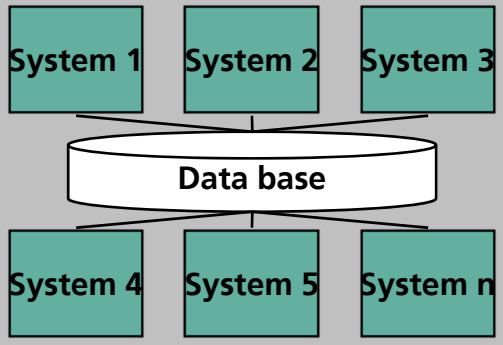
Option 1:
an integrated and modular system from a single source



Pros:
+ integrated solution from one supplier
+ real time computing possible

Cons:
- high complexity
- high invest and adaptation costs

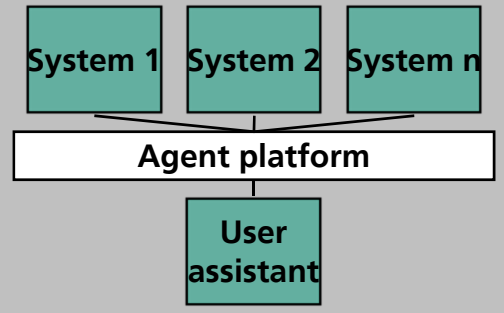
Option 2:
several systems with a common data base



Pros:
+ use of commonly accepted technologies

Cons:
- common database not available for stand alone systems
- common data model required (CIM)

Option 3:
new and existing systems cooperate via an agent platform

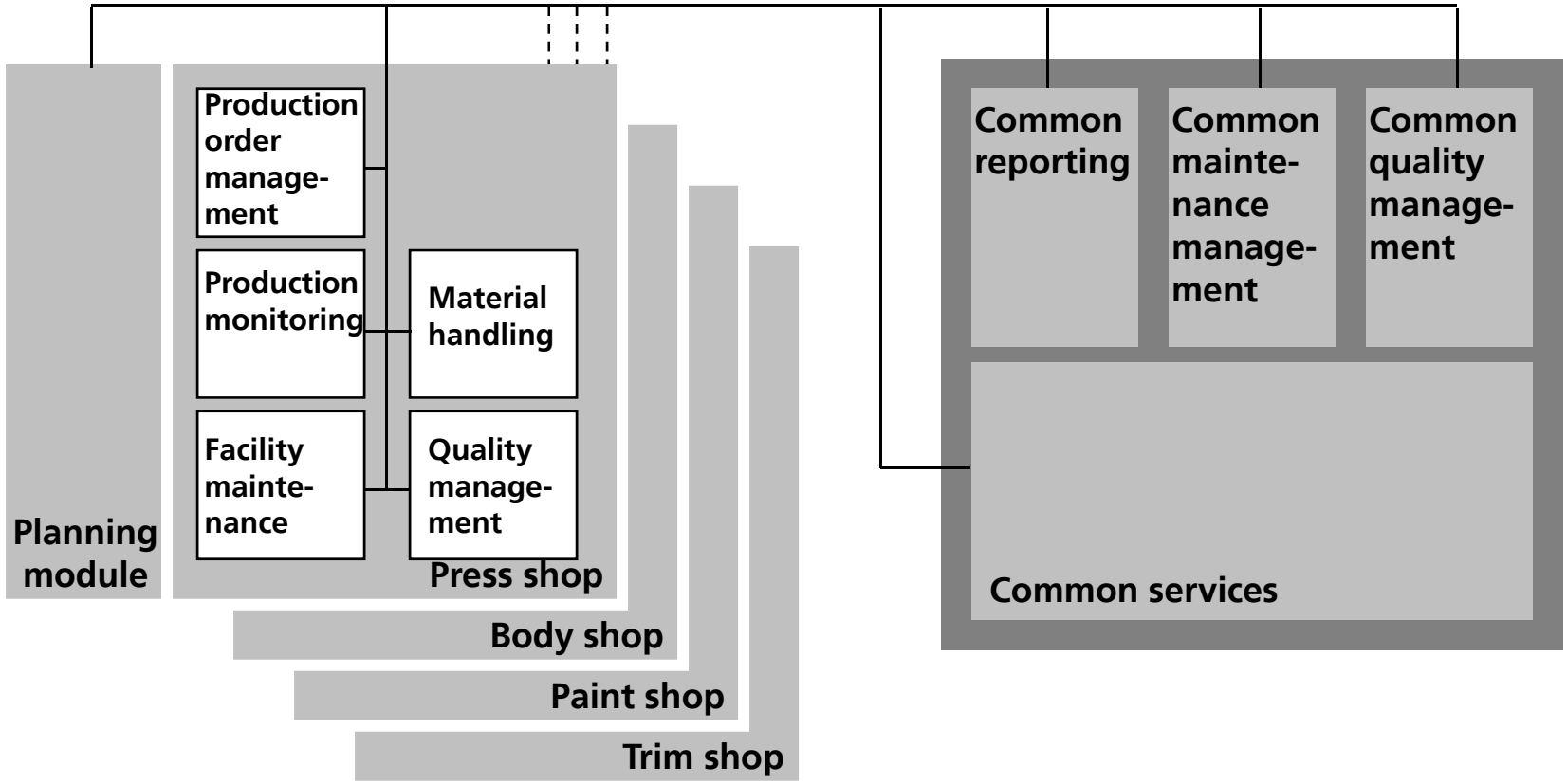


Pros:
+ existing systems can be integrated
+ information can be used borderless

Cons:
- Technology not yet proven in production

3. Components of prodction related IT for Hyundai Motor Company

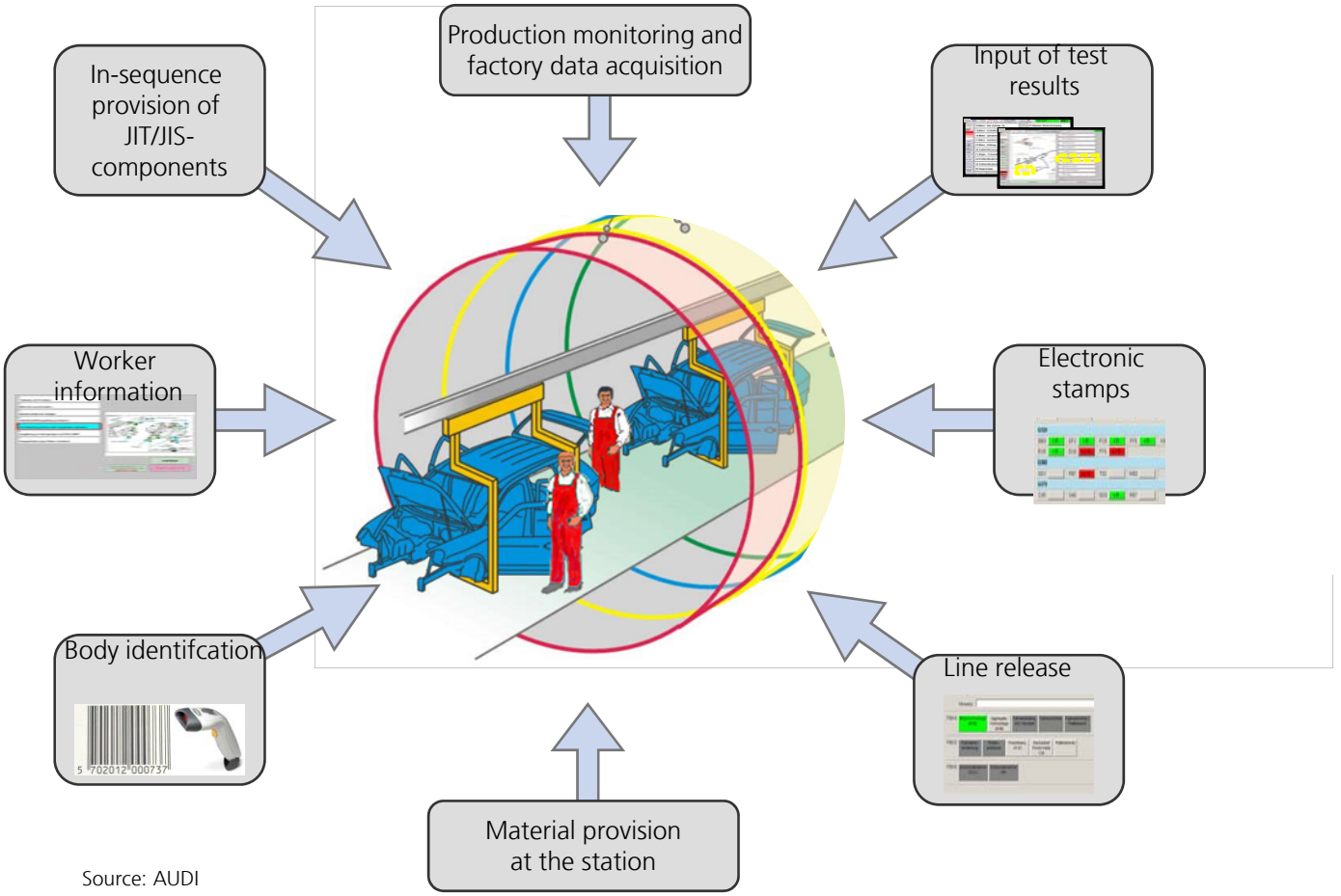
[Source: FhG-IPK – Hyundai Motor Company, Ulsan]



3. Future manufacturing execution systems: horizontally integrated

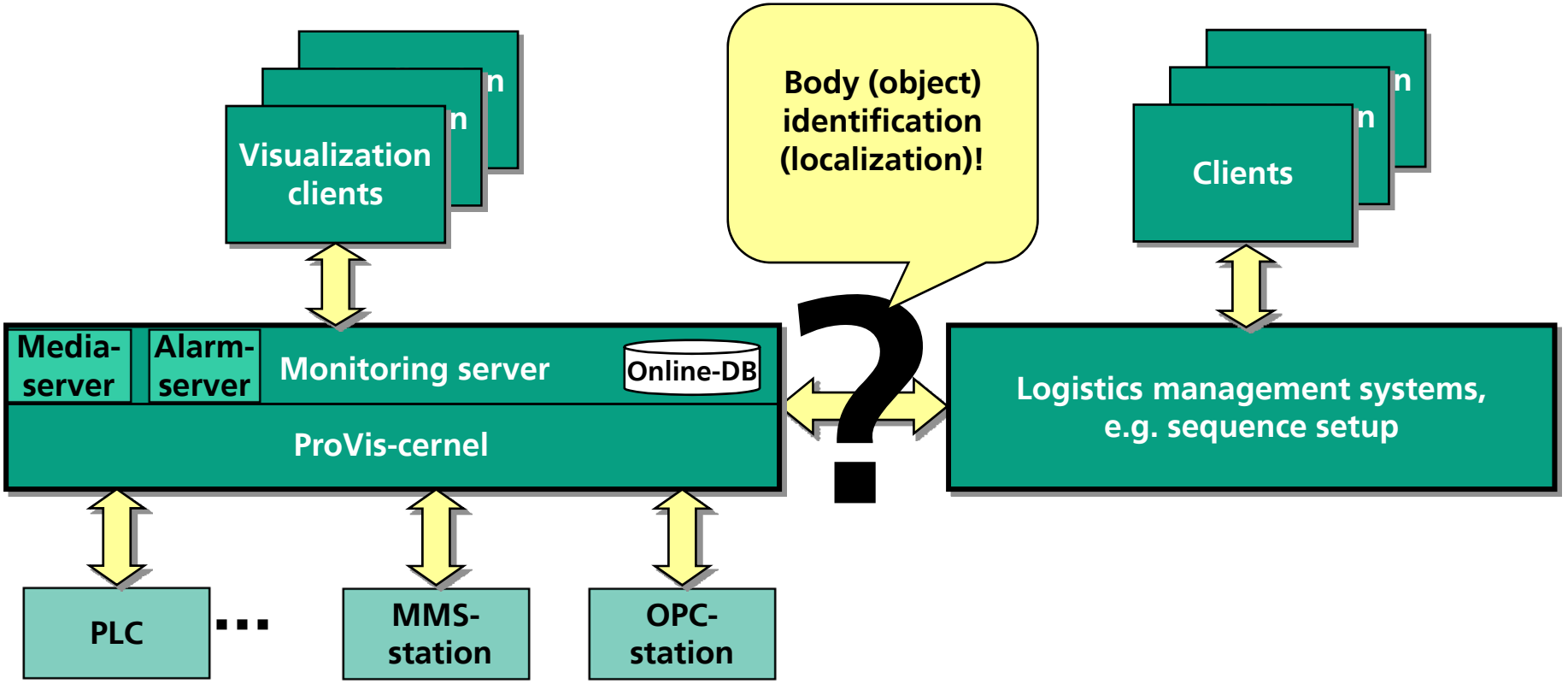
Requirement:

links between those production related applications, which data is required at a certain work station



Source: AUDI

3. Missing link between production monitoring (»automation world«) and sequence setup (»logistics world«)



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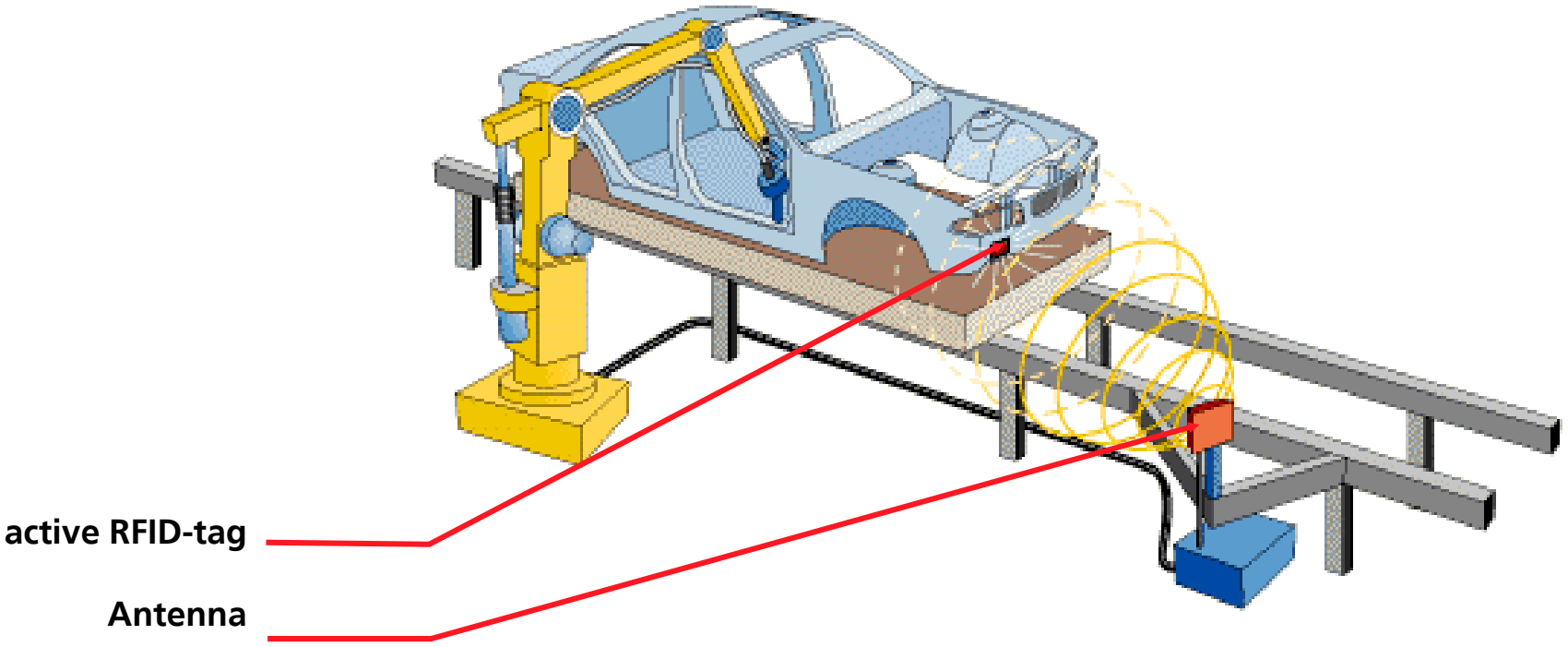
3. Today's body identification by RFID-Tags on the car body

(source: http://transpondernews.com/info/confiden.html)



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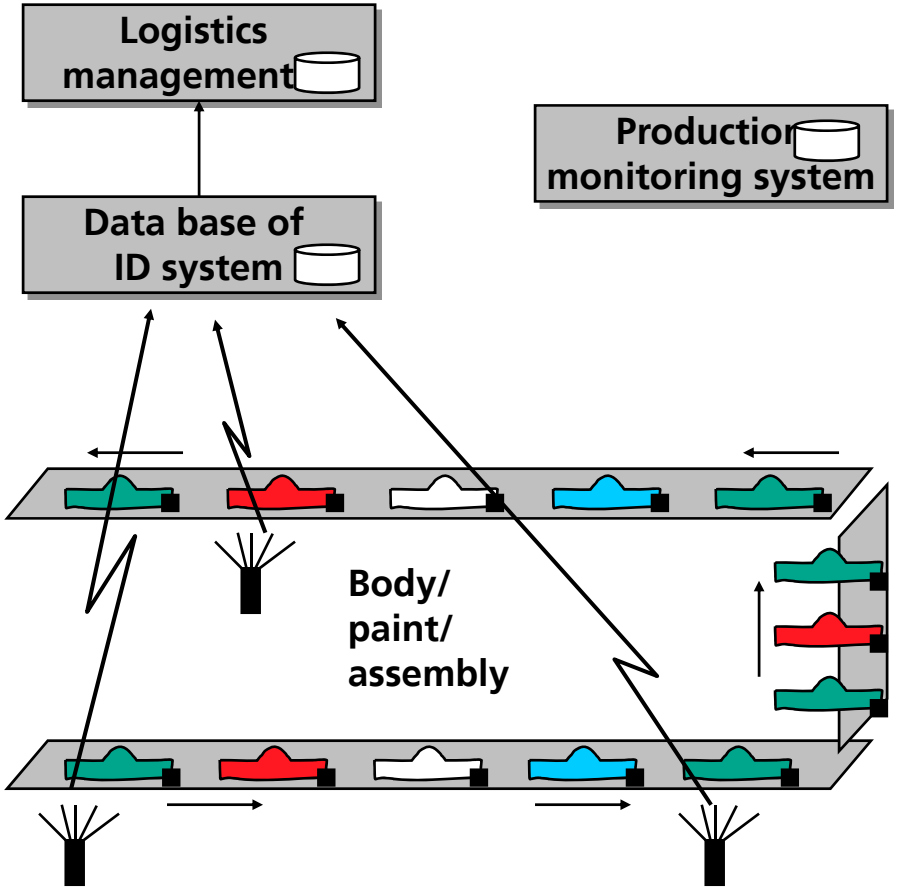
3. Today's body identification and communication of ID-data to related applications



Legend

Antenna

Mobile tags on the car bodies

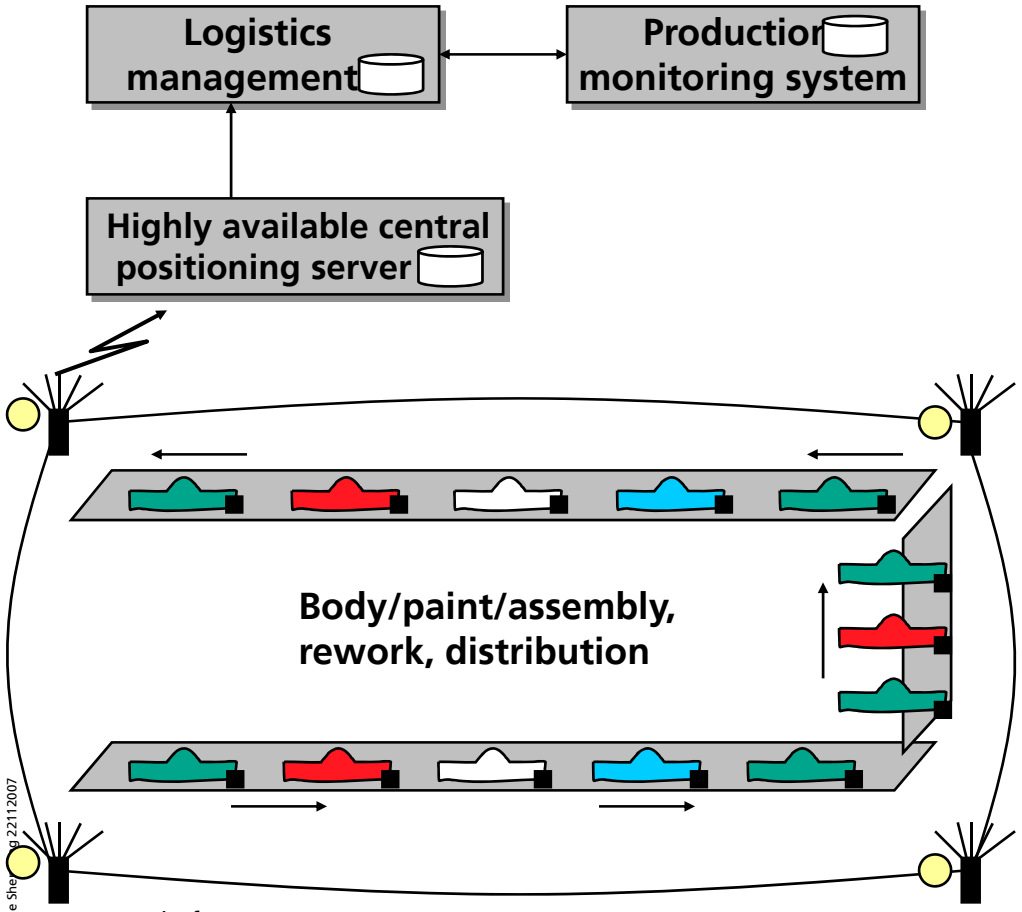
Characteristics

- Number of read-/write-points is limited by number of antennas on the shop floor
- Ident data is computed by logistics management IT
- Connection between logistic and production monitoring system is missing

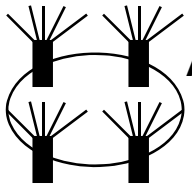
3. Objectives for connection of production monitoring and object identification/localization

- **Real time information concerning all car bodies in body, paint, trim shop, rework and distribution**
- **Reading id/positioning patterns and matching them with product options and/or manufacturing orders**
- **Distribute id/positioning data to concerned IT-components on the different levels, e.g. PLC, planning systems, etc.**
- **Hand over manufacturing orders from planning system to the PLC and its buffer**
- **Reduction and simplification of today's systems, e.g. mobile tags, body tracking calculation, bar codes/data matrix, etc.)**
- **Provision of linked information concerning production status, facility status, id/position of car bodies and status of customer orders, if possible in real time**

3. Approach: localization of car bodies and connection to production monitoring



Legend



Antenna network

Tag/sender

reference sender

Characteristics

- Each body is tracked permanently
- Data of ID-system is analyzed separately, logistics management system is relieved
- Connection of logistics management and production monitoring system (see next chart)

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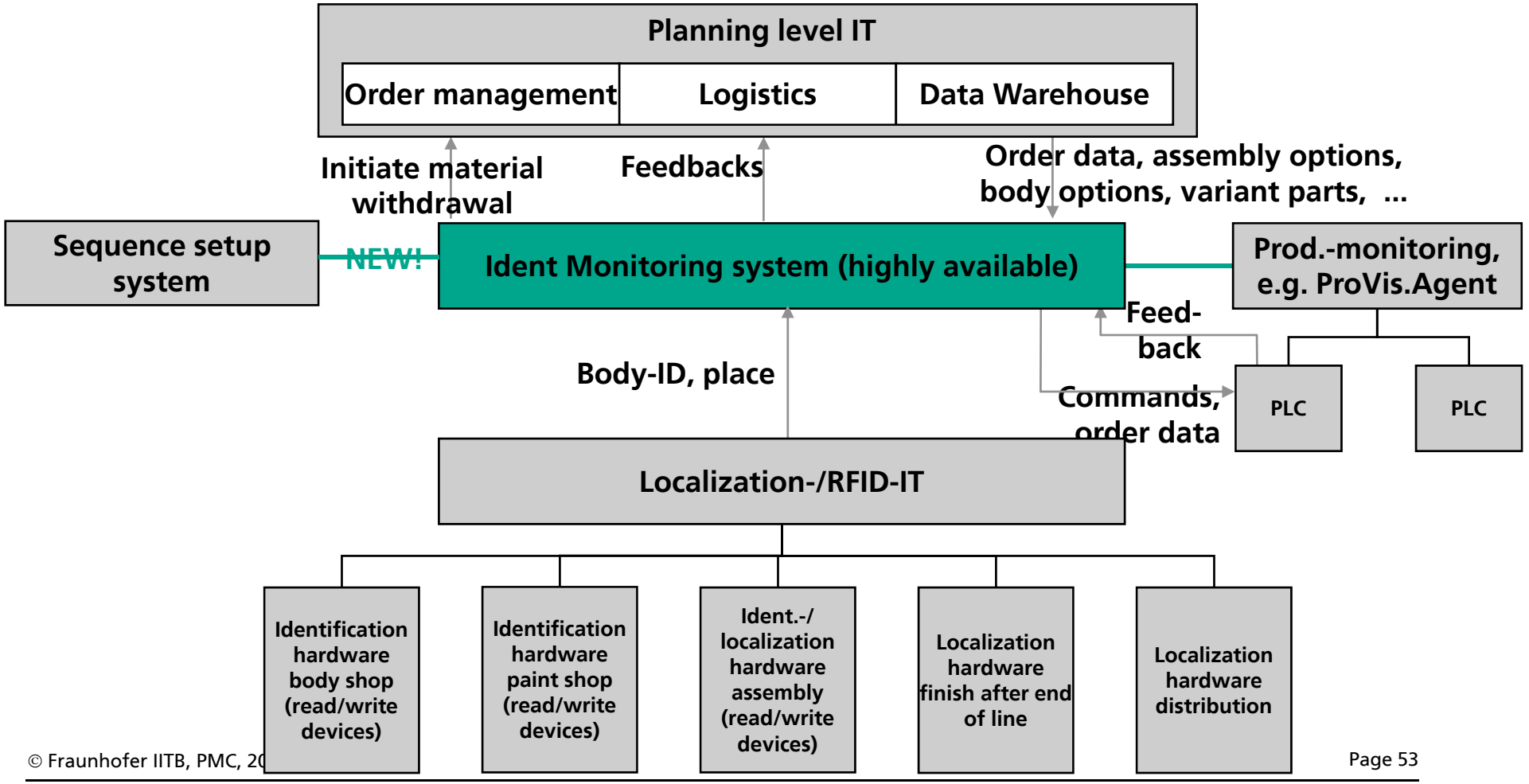
3. Horizontal ‘integration’ of production monitoring, body identification and sequence setup on the manufacturing exec. level



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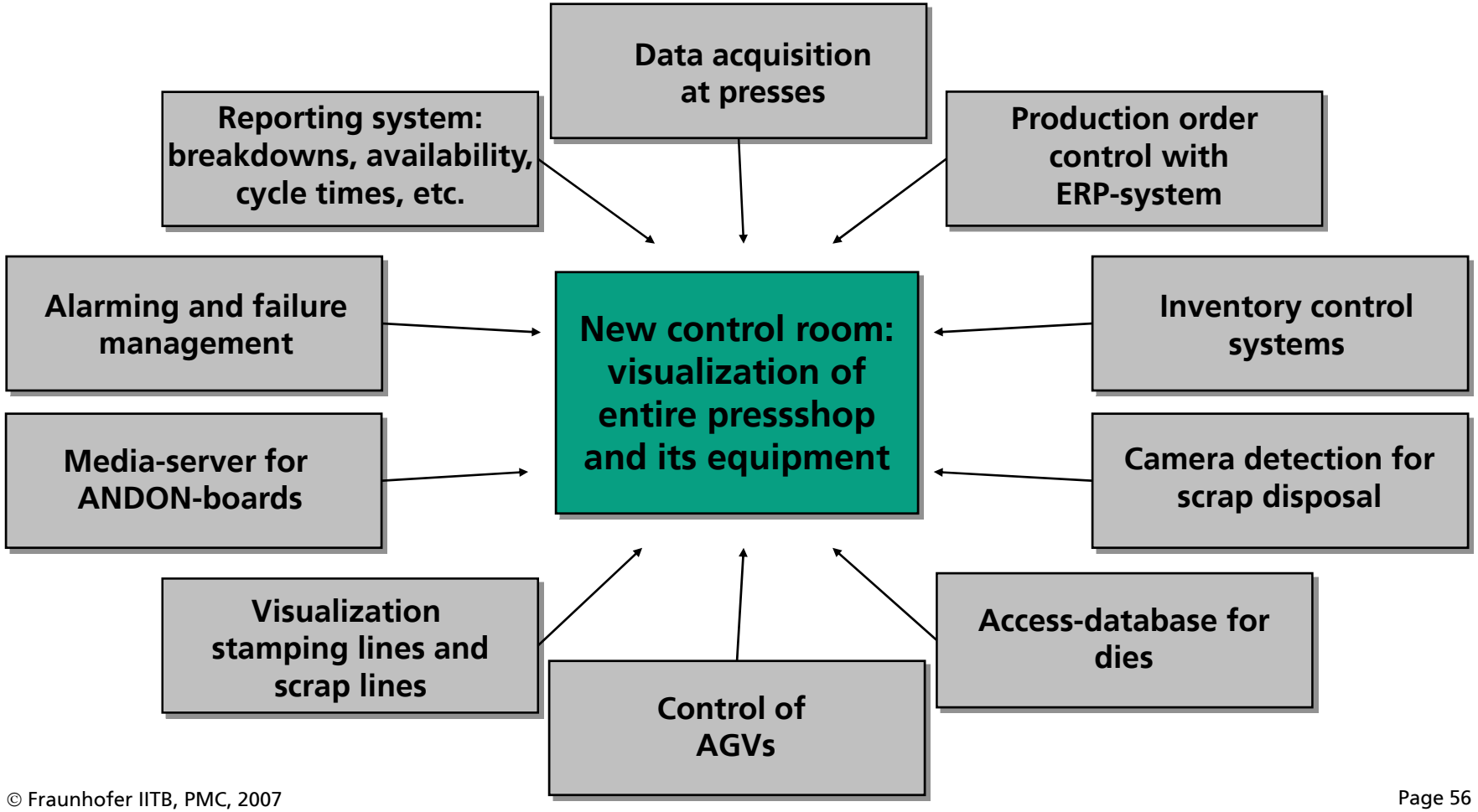
3. Benefits for customer from automotive industry

- Reduction of non-productive time by help system, e.g. for work orders, parts to be picked and assembled, car body type, etc.
- Higher quality of information, e.g. concerning reports that use both data from logistics and facility monitoring
- Car body related information is presented by the PMC's visualization system => only one user interface
- Possibilities to build up closed loops between production monitoring and sequence planning, e.g. for unexpected downtimes
- By integrating identification and logistics difficulties in the supply chain become visible
- Redundant data storage can be reduced by integration of production related IT-systems
- Localization and identification of finished cars after the end of the assembyl line can be done with one technology

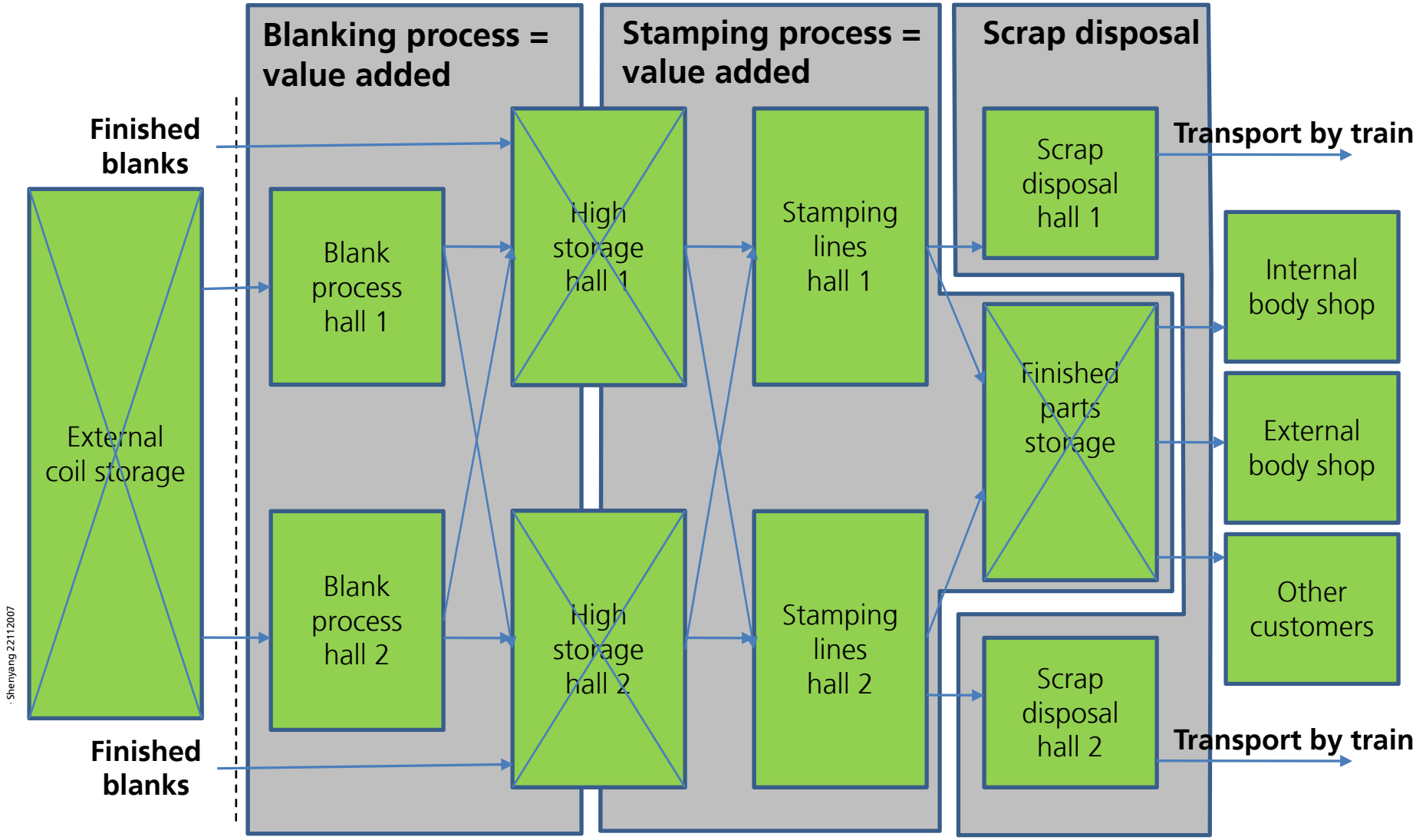
3. Manufacturing Execution Systems for automotive production

- central visualization and control room concept

3. Current IT-infrastructure within a press shop



3. Current process flow



3. How to design a central control room

Source: ABB

- **Monitoring system must enable entire process overview from the very beginning to the finished parts**
- **People in the control room must be able to see relevant information on a glance**
- **User must be able to see entire process and detailed pictures of a facility he can navigate**
- **Possibility for interaction between user and system as well as between large displays and work station, dynamic figures instead of static displays**

3. Design options for the central control room

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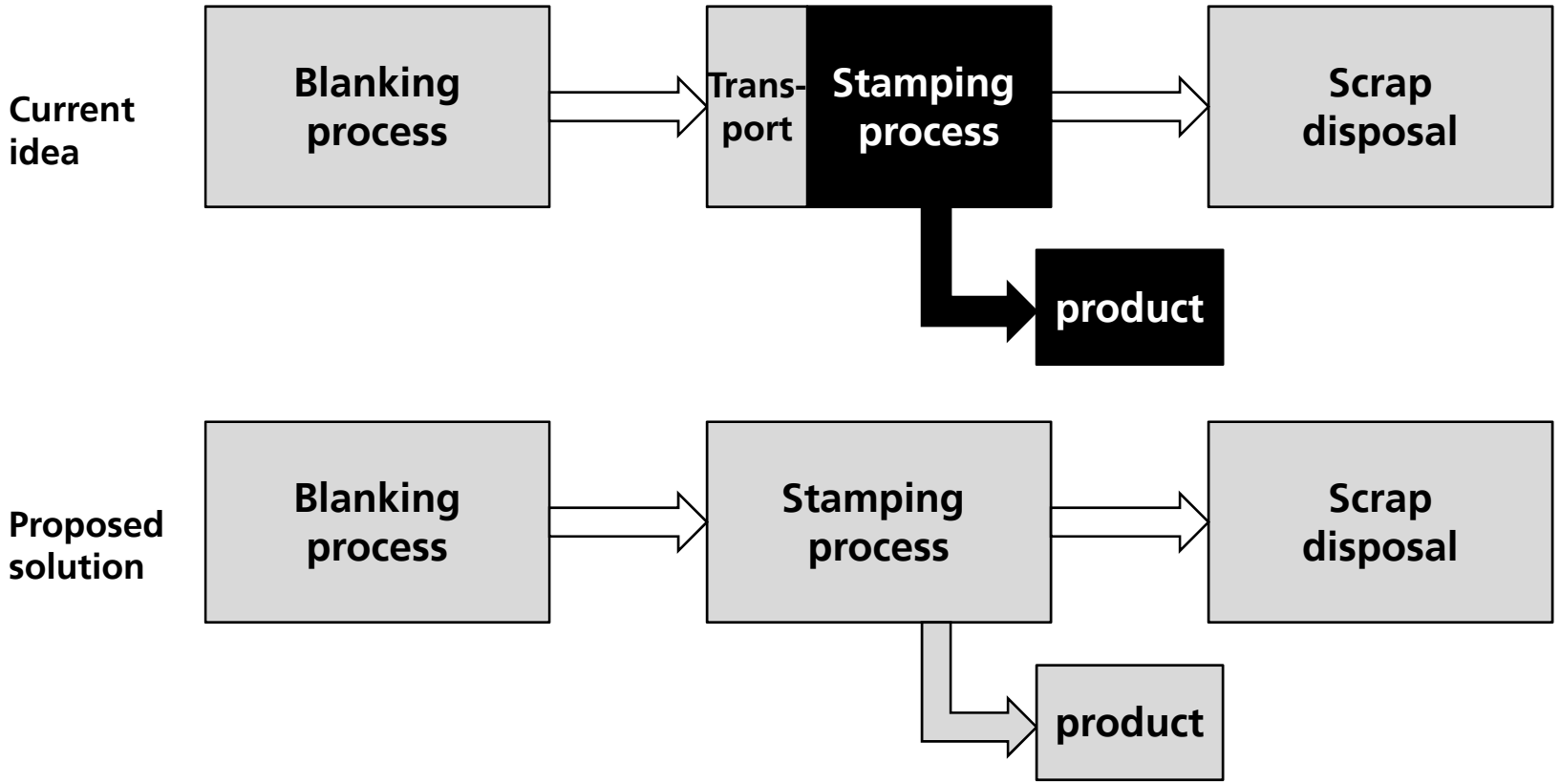
people in the new control room must be able to watch the entire process chain!

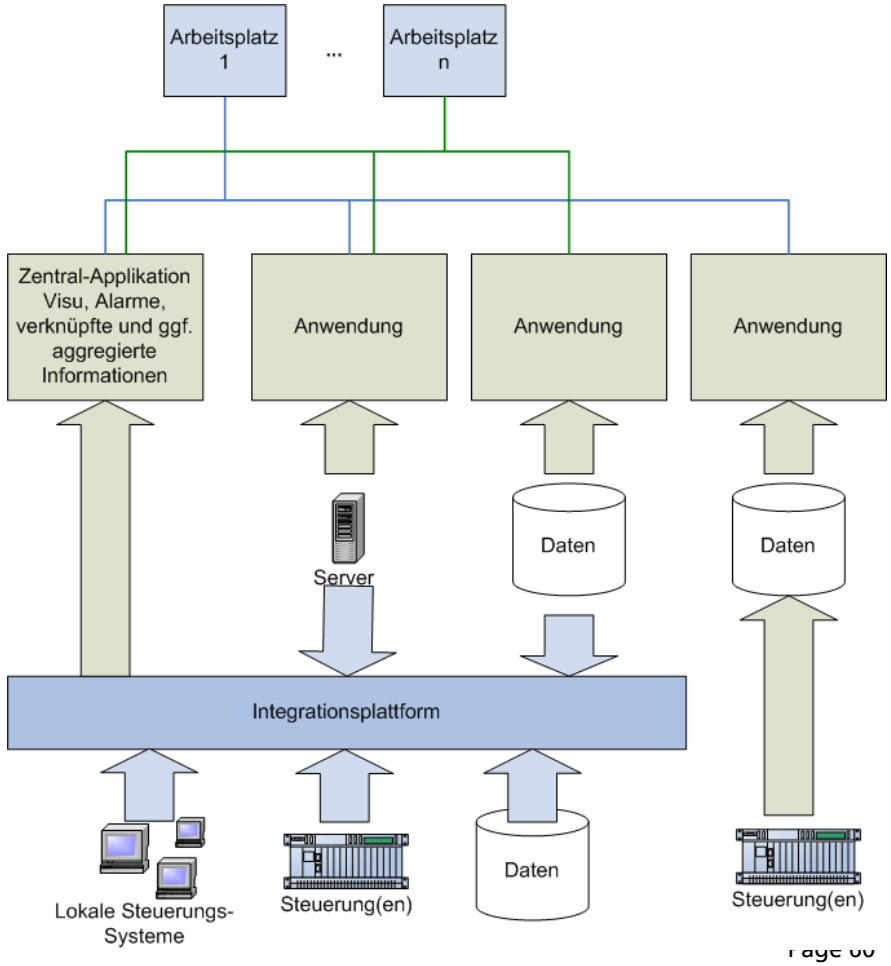


3. Design options for the central control room (2)

Cross-linking of existing applications through an integration platform; pick relevant data for central control tasks and visualize it in shared application.

Existing applications keep their functionality and autonomy; people in charge of existing systems will keep their know-how and their responsibility for the systems administration

Only data that are worth combining will be combined and integrated via the integration platform; stand alone systems keep alive

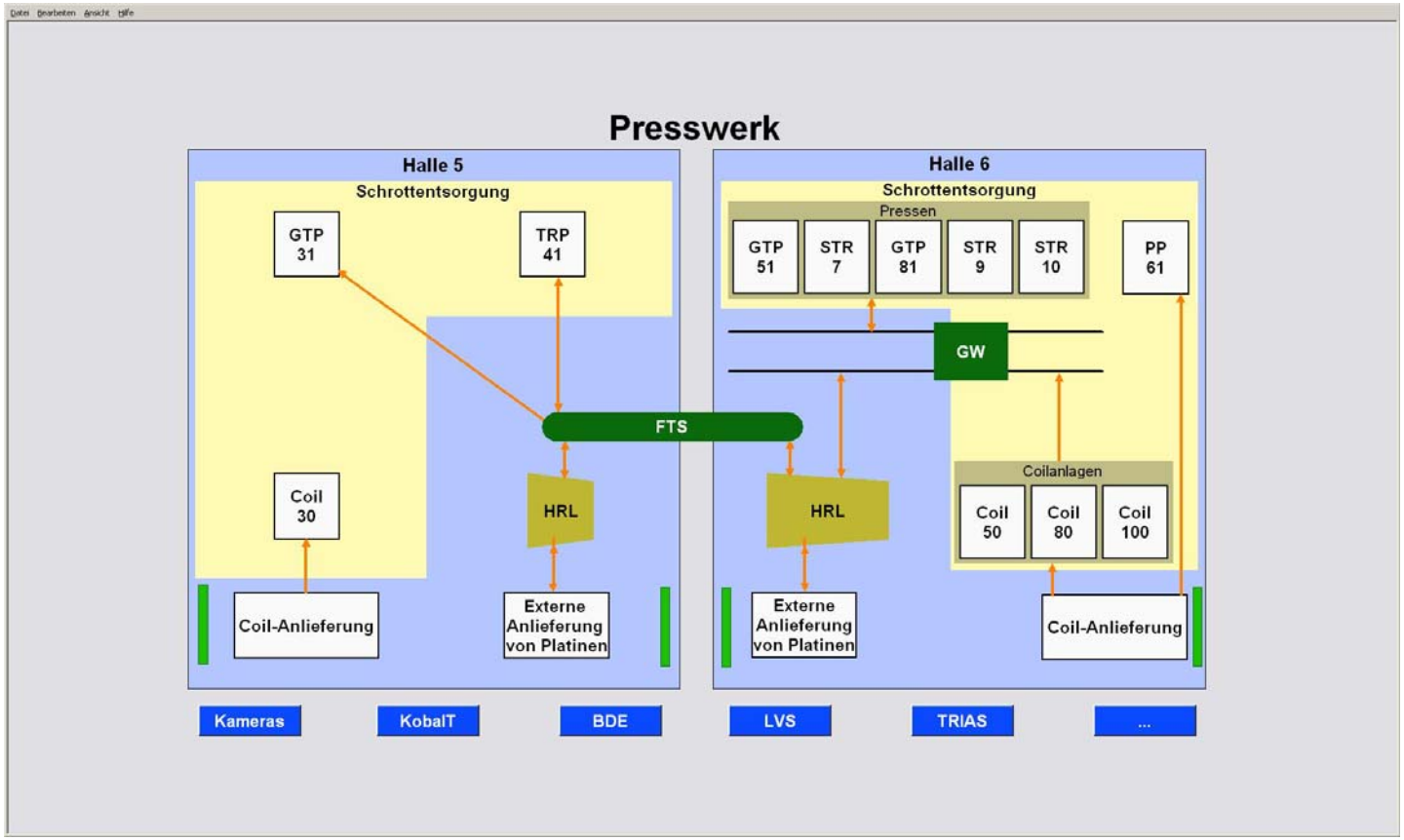


3. Details of the chosen option

Overall picture allowing overview over the entire process, e.g. on a large central display.

In case of an alarm the concerned process indicates a failure; by clicking on the process people in the control room can navugate through the pictures easily on their desktop.

Existing applications can be started directly by clicking the buttons.



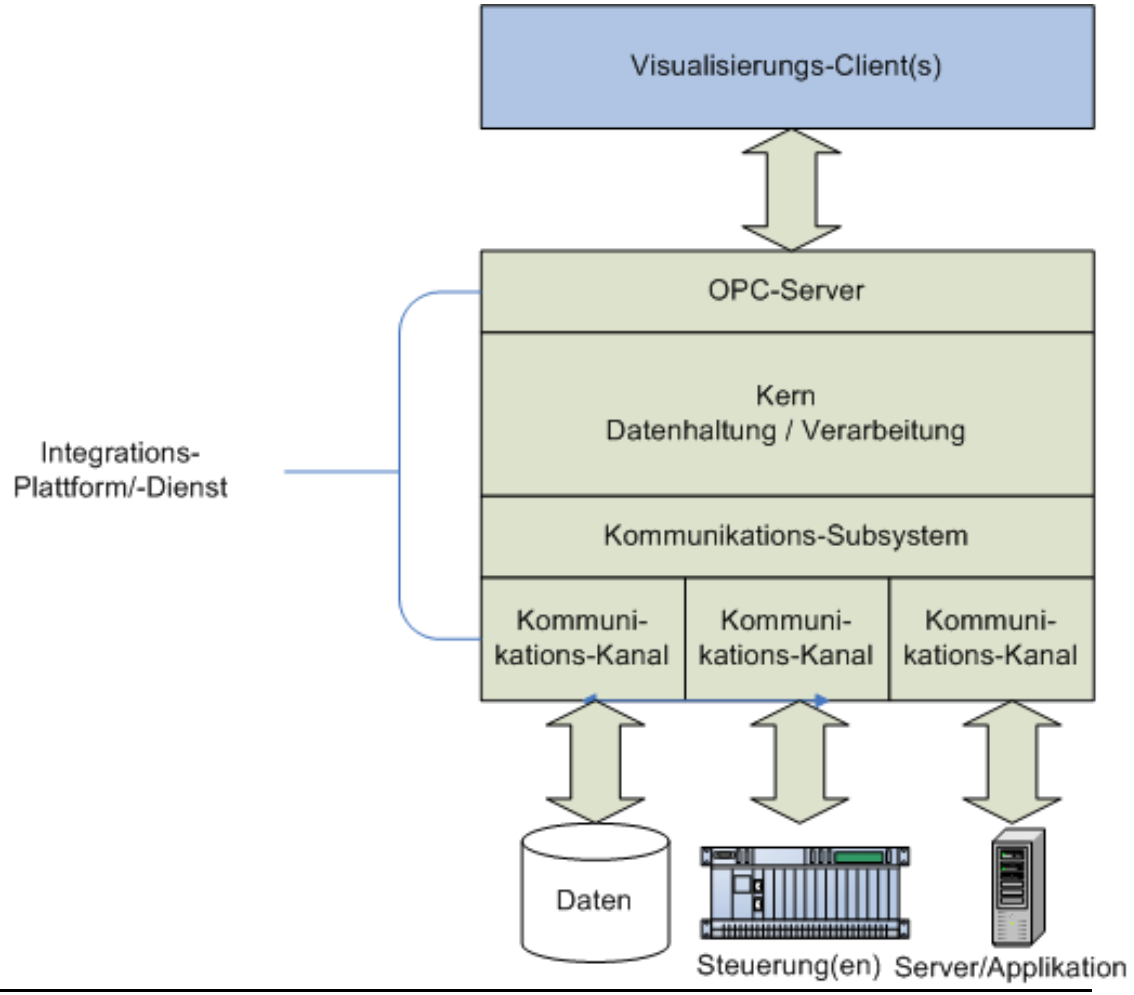
3. Details of the chosen option (2)

Draft architecture of the integration platform:

- ‚active component', d.h. application gets data from existing systems

- Standard interface to the central visualization via OPC

- Existing systems communication interfaces are still used, e.g. data base access, RFC 1006, etc.



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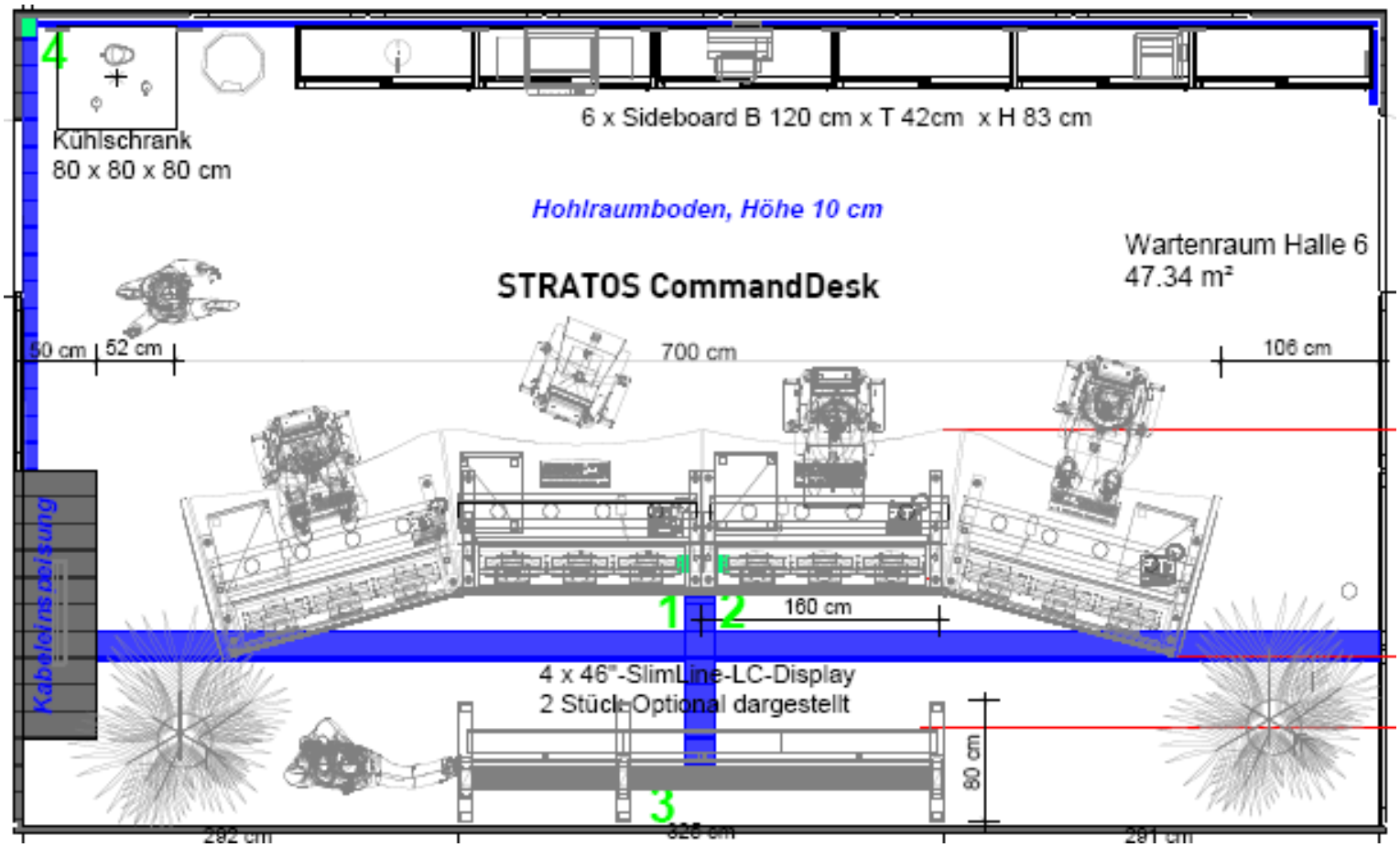
3. Details of the chosen option (3): layout of the control room

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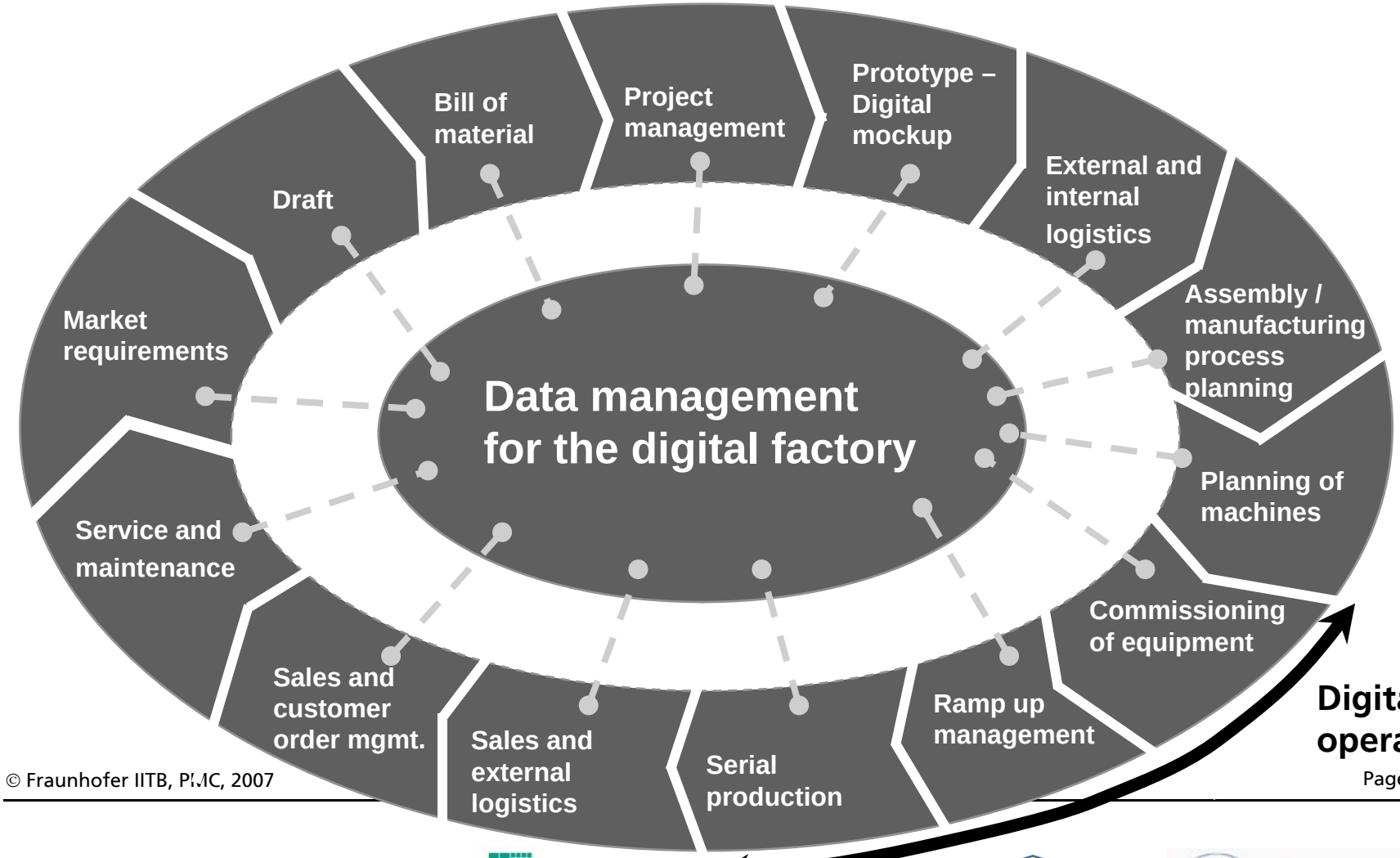
3. Manufacturing execution systems for automotive production

- integration of MES with digital factory

3. Digital operation is part of the digital factory



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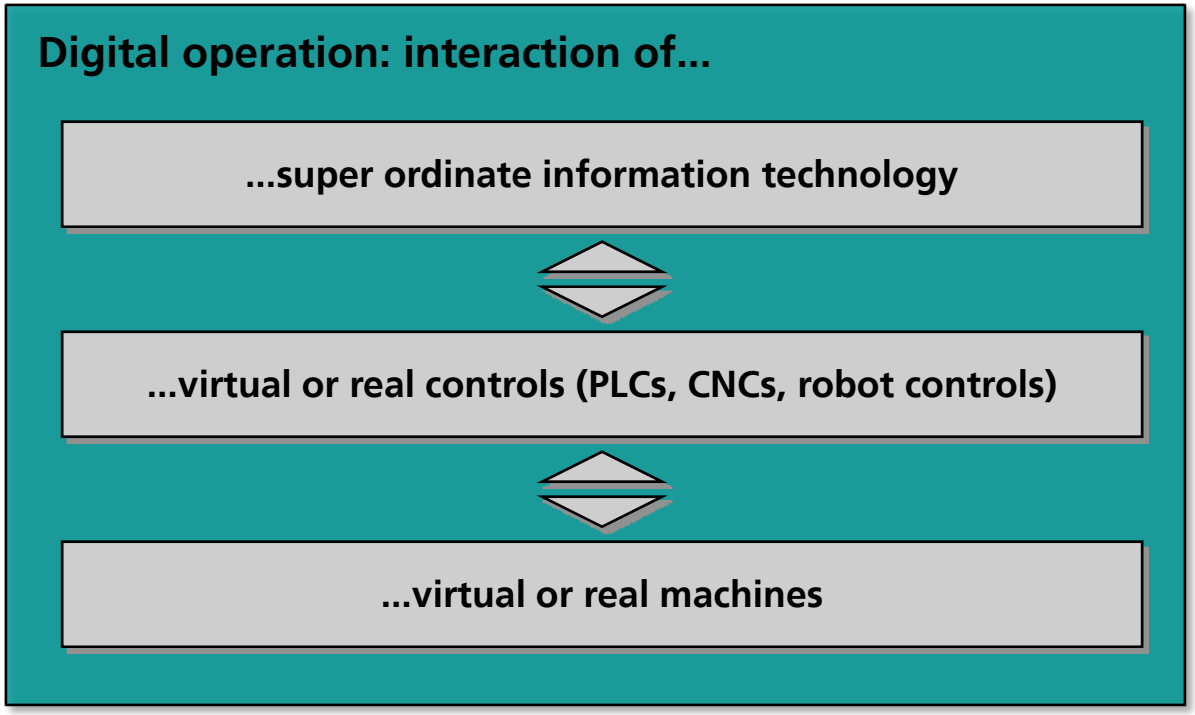
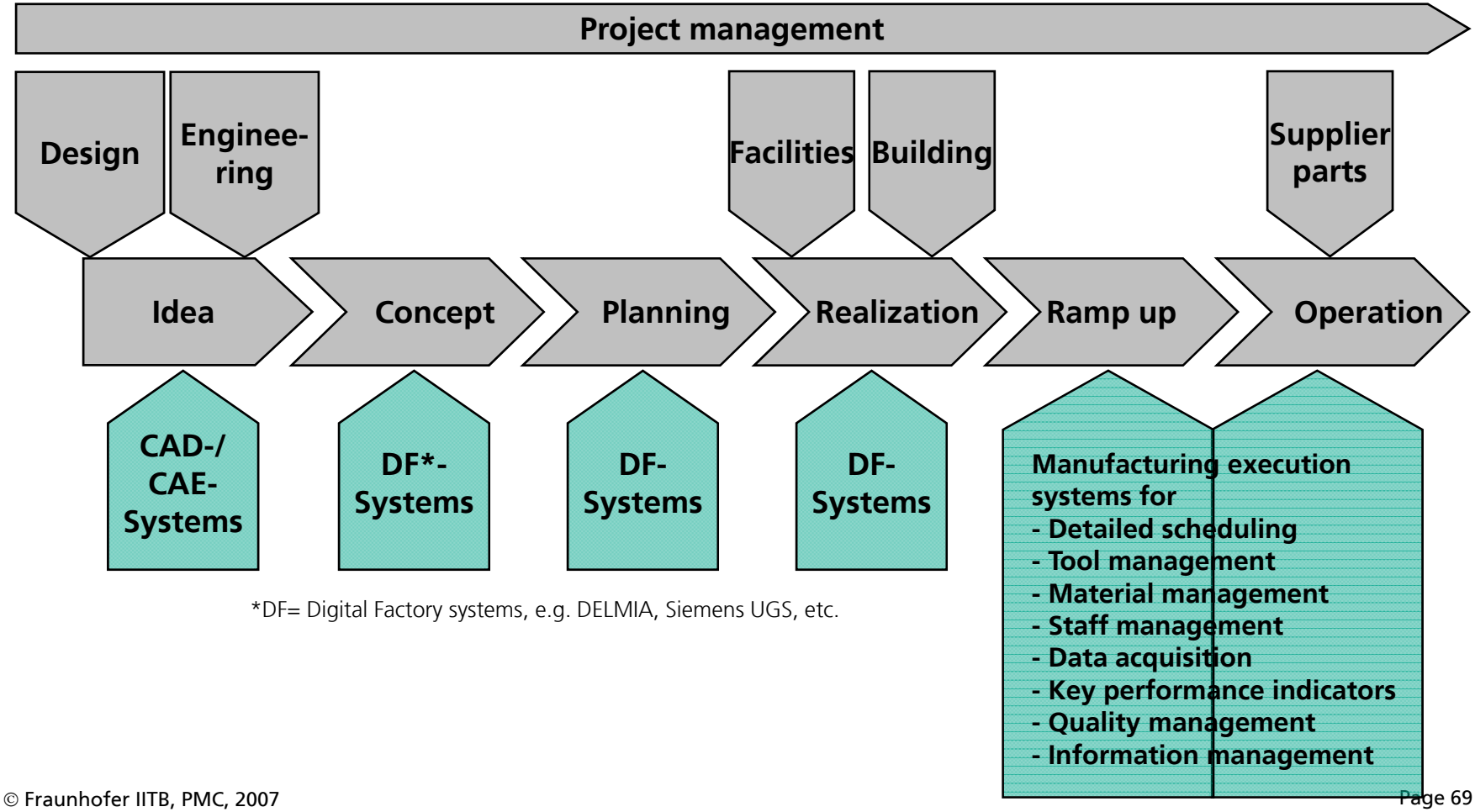
3. Digital operation is part of the digital factory (2)



3. Reference model for factory planning: connection of planning and operations



*DF= Digital Factory systems, e.g. DELMIA, Siemens UGS, etc.

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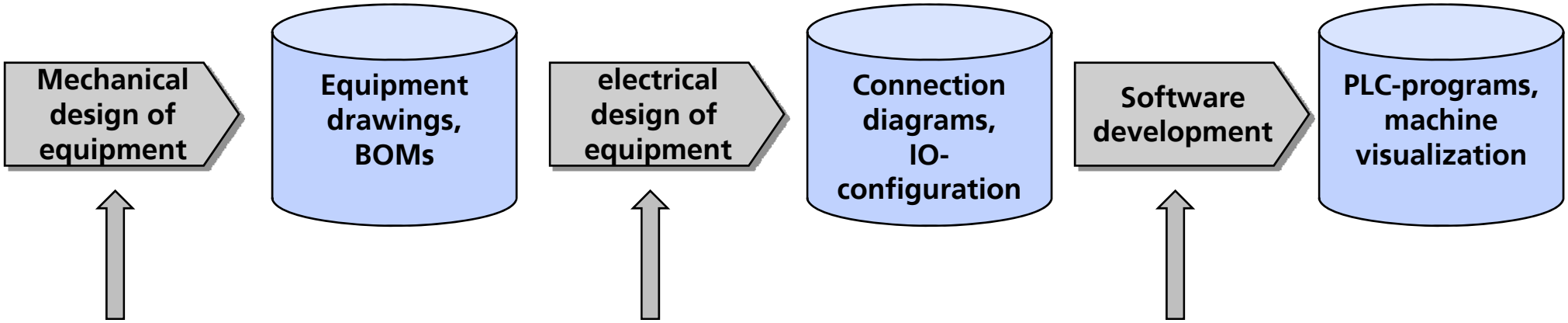
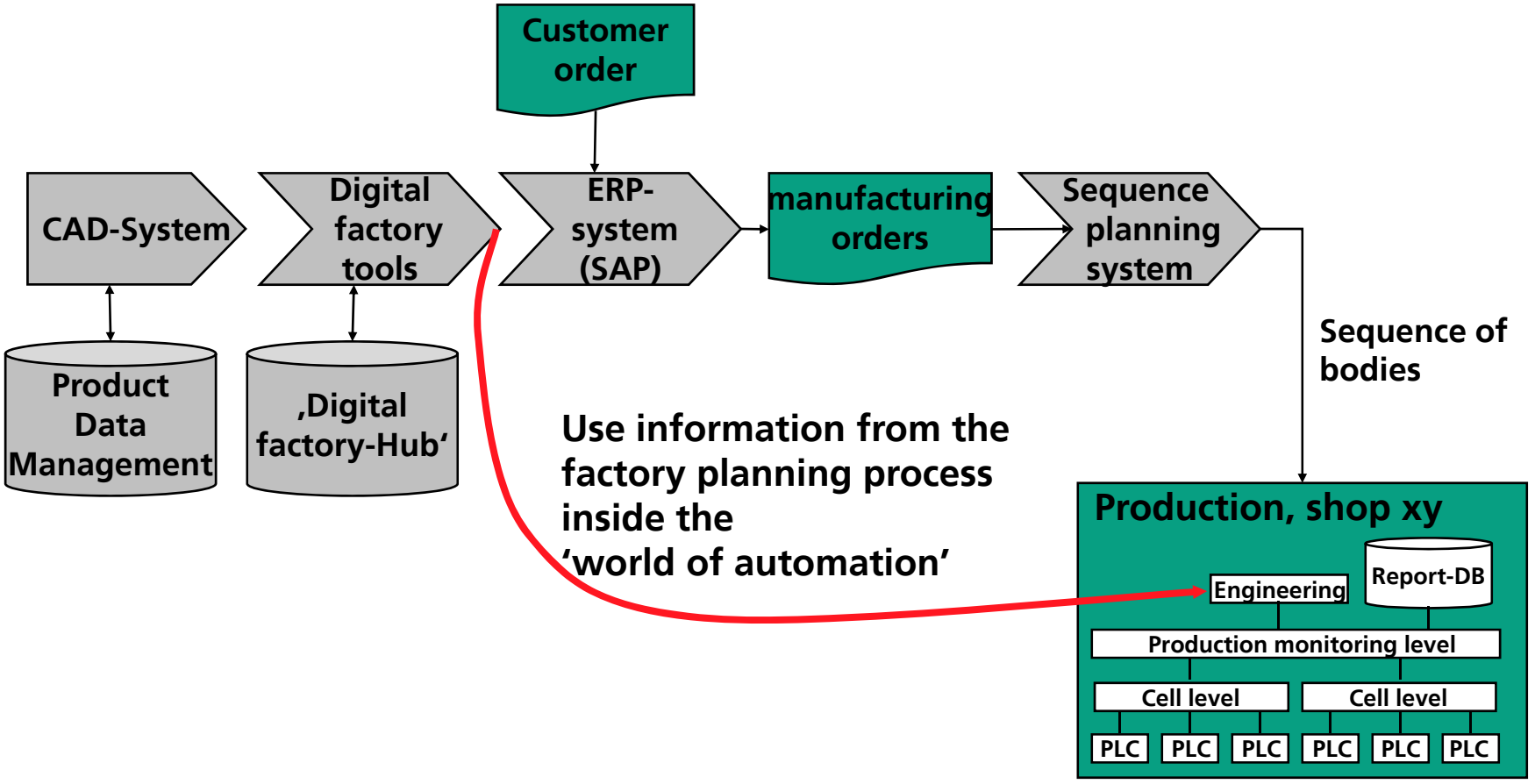
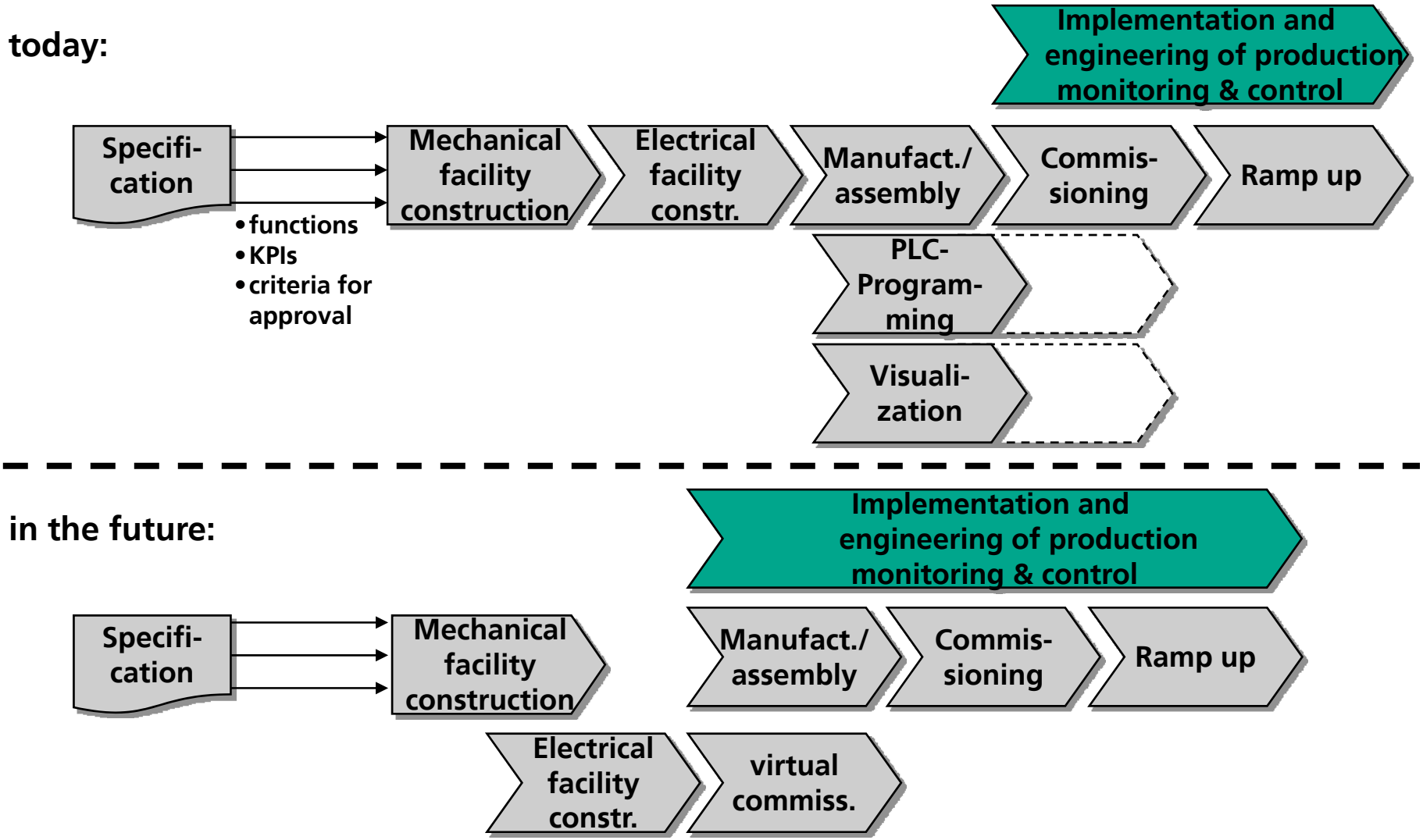
3. Digital operation includes…



3. Main idea for connection of planning and operations



4. Benefits from early connection of planning and operation



Thank you for your attention!

Impressum

Production control applications in the automotive industry

- Examples from Fraunhofer IITB projects -

Shenyang, November 22, 2007

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