Smart Work Design –
Improving Ergonomics and Efficiency of Assembly Processes by Virtual Production Planning

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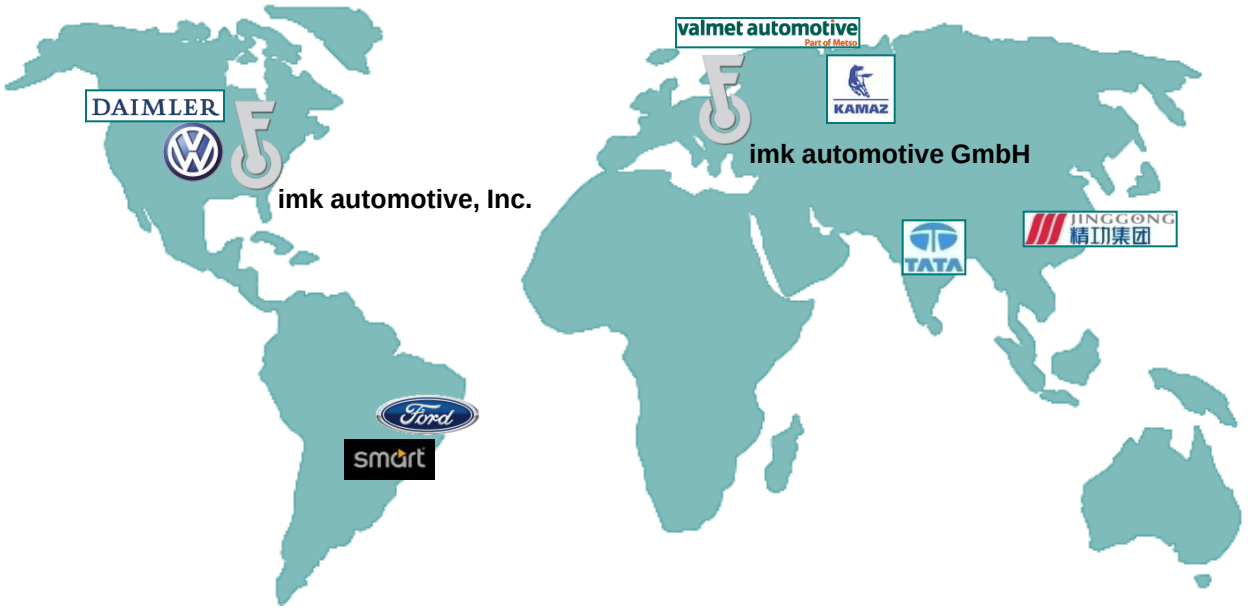
Agenda

I	imk … innovations – methods – koncepts
II	Motivation for Virtual Planning
III	emaß Software for Human Work Planning
IV	Conclusions

imk Group of Companies
Locations and Customers

Worldwide dedicated to the success of our customers.



Automotive industry, mechanical engineering, industrial commodities, renewable energies, information systems, and aerospace industry.

European Customers

imk Group of Companies
Business Segments

Cross-industry engineering services and consulting.

Engineering

Product Development
Ronny Göpfert

- Mechatronic Systems
- Structural Components

Production Planning
Carsten Otto

- Assembly
- Bodyshop
- Logistics

Information Technology
Dr. Jens Trepte

- Software Development
- Support and Service

Consulting

Ergonomics
Dr. Lars Fritzsche

- Ergonomic Work Design
- Qualification and Training

Technical Consulting
Ingolf Grüßner

- Production Strategies
- Product and Production Optimization

Strategic Development
Dr. Wolfgang Leidholdt

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Motivation for Virtual Planning

Digital production planning tools facilitate human-centered work design.

Costs

- Chances for redesign are best in an early stage of development due to strongly increasing costs after product design freeze.

Efficiency

- Digital tools enable efficient testing of alternative planning and design scenarios without physical mock-ups and any risks for operators.

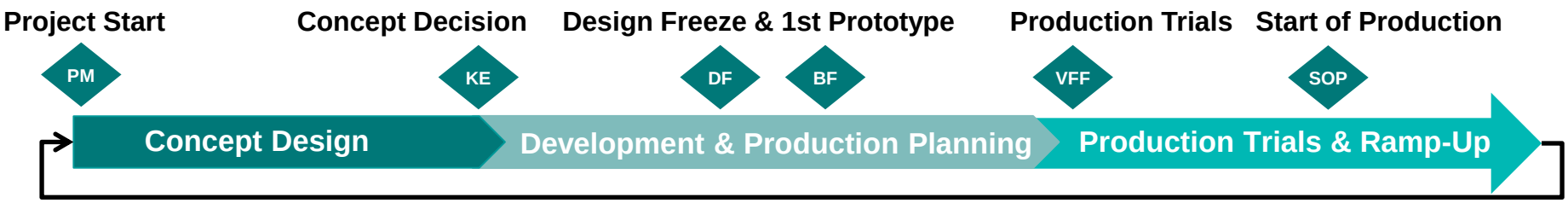
Understanding

- 3D visualization helps to create a common understanding and thereby supports collaboration between design, planning, production, safety, etc.

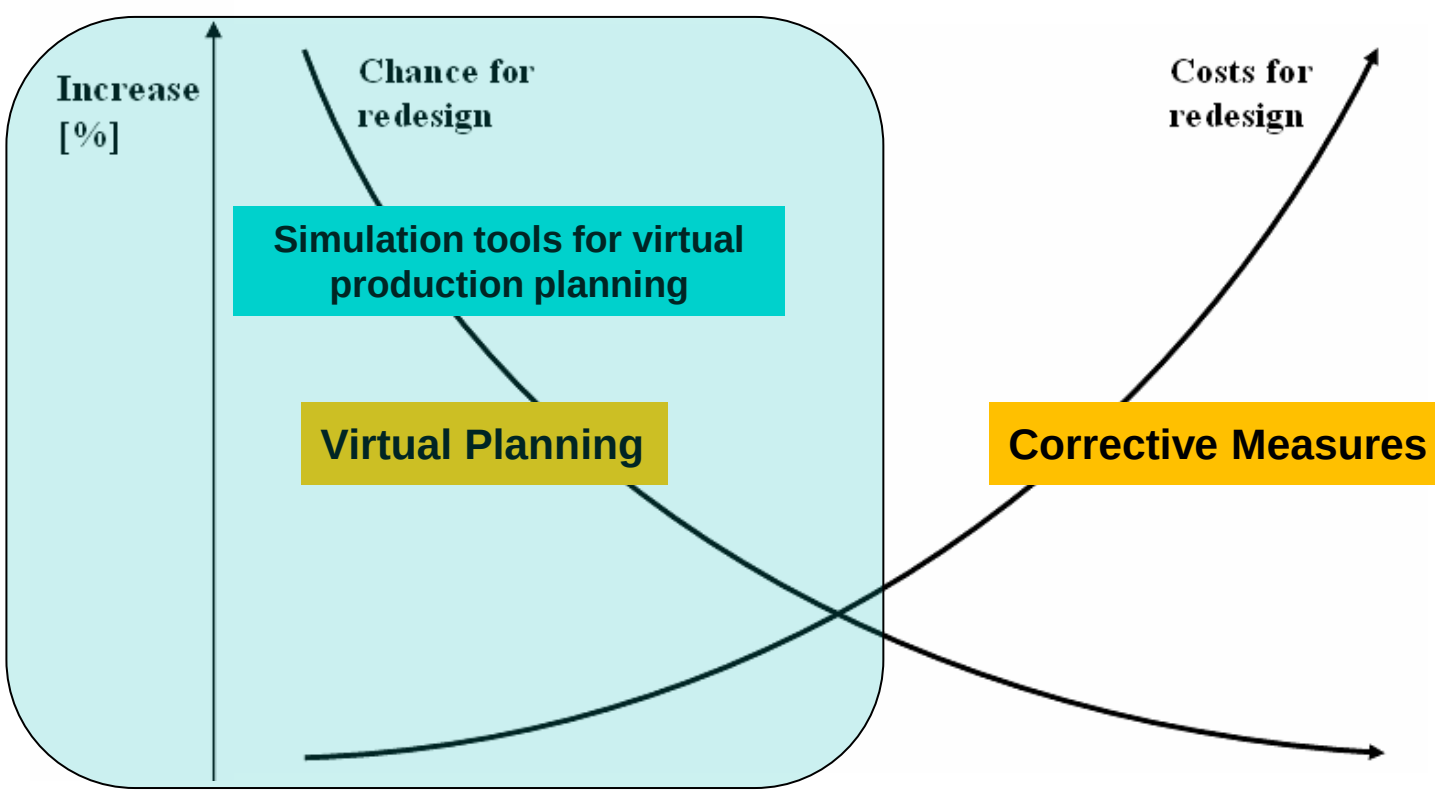
Availability

- Today, digital data is readily available in most companies' PLM systems.

Motivation for Virtual Planning

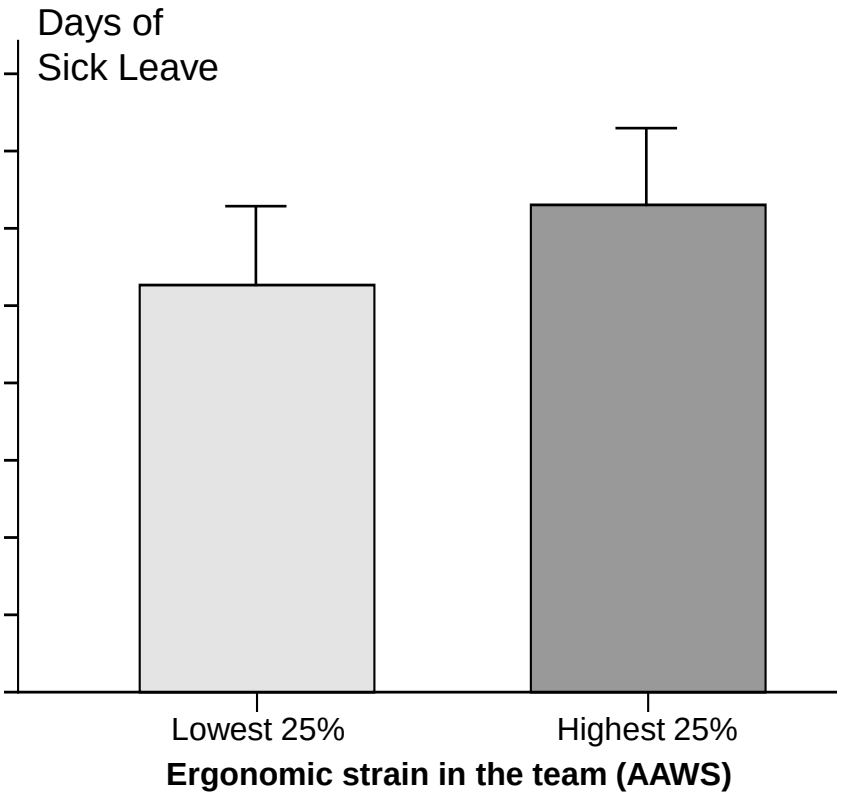


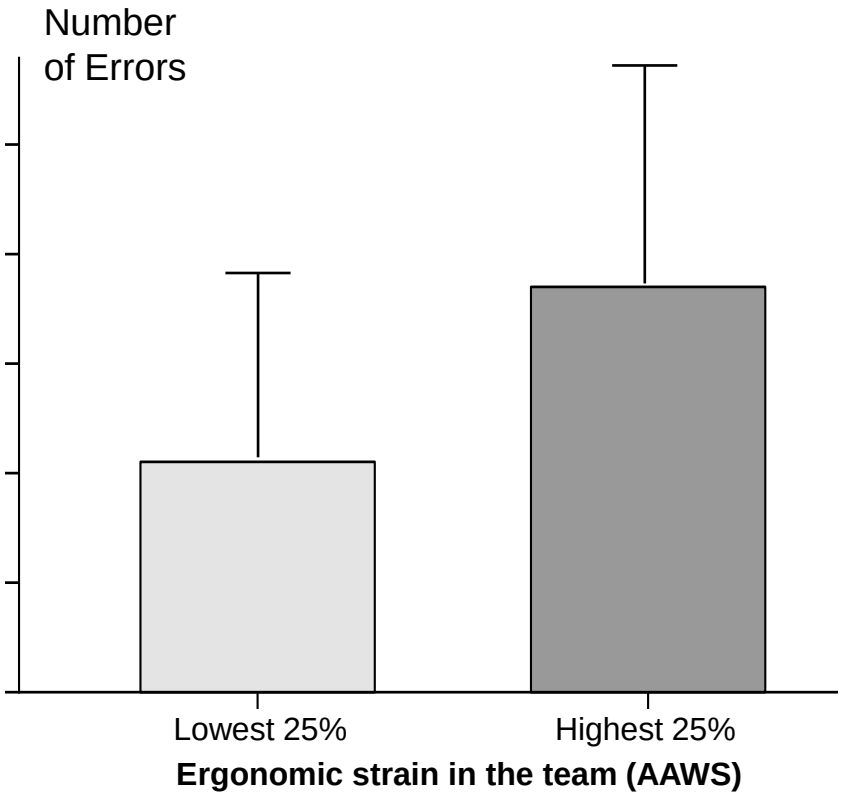
"Lessons Learned" What parts and processes are critical in Productivity and Ergonomics?



Reminder: Ergonomics = Productivity

Study of 56 teams (623 persons) at Mercedes-Benz assembly line. (Fritzsche, 2010)



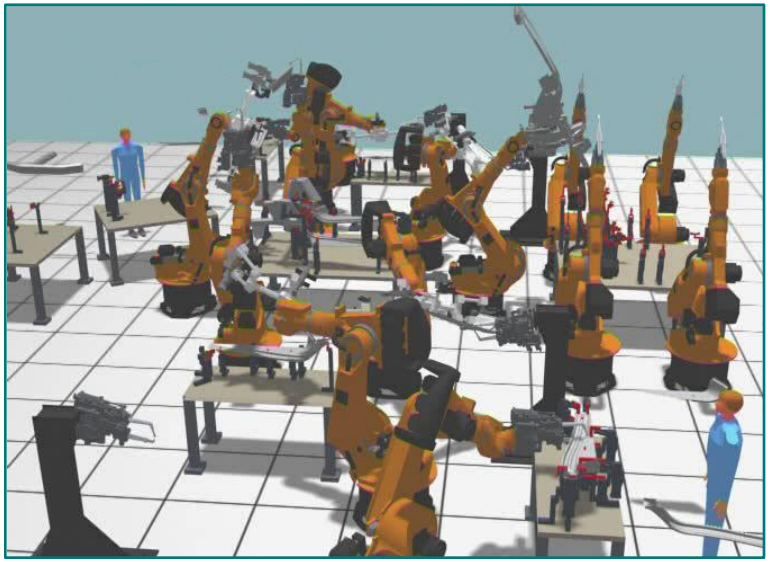


- Up to **20% less absenteeism days** in teams with low ergonomic strain

- Up to **40% less assembly errors** in teams with low ergonomic strain

Humans in the “Digital Factory“

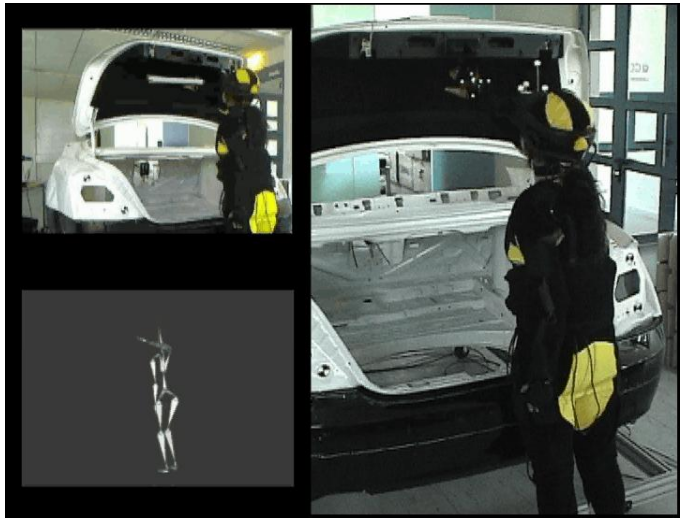
In the past, humans were merely “background actors“ in the digital factory.



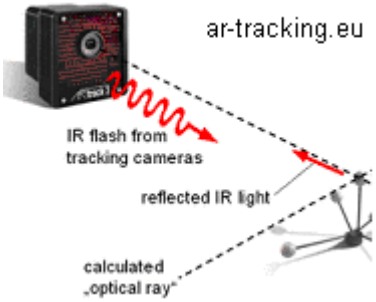
Requirements for human simulations were NOT fulfilled:

- Realistic movements in 3D
- Human-machine interactions
- Reasonable effort for gernerating simulations
- Analysis of production time and ergonomics based on industry standards

Motion Capturing in Virtual / Mixed Reality

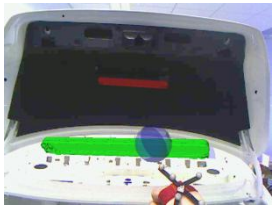


Optical tracking



Head Mounted Display

Real and augmented objects



Motion Capturing Suit

Benefits:

- Recordings of realistic human motions in action
- Physical feedback, natural collision avoidance

Drawbacks:

- High effort for scenario preparation and alternation
- Individual data is not objective and reliable → results lack validity

Results from EU-Project "CyberManS"

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Human Simulations based on Standards

Concept Design → **Production Planning and Optimization**

3D-Simulation

- *3D simulation of robots*
- *Feasibilty and reachability*
- *Estimated tact time*

Specific controller

Offline programming

- *Verified 3D robot simulation*
- *Reachability analysis*
- *Exact tact time*

3D-Simulation

- *3D simulation of human work*
- *Ergonomic risk estimation*
- *Estimated tact time*

Specific controller (MTM & EAWS)

3D verification

- *Verified 3D human simulation*
- *EAWS ergonomic analysis*
- *MTM time analysis*

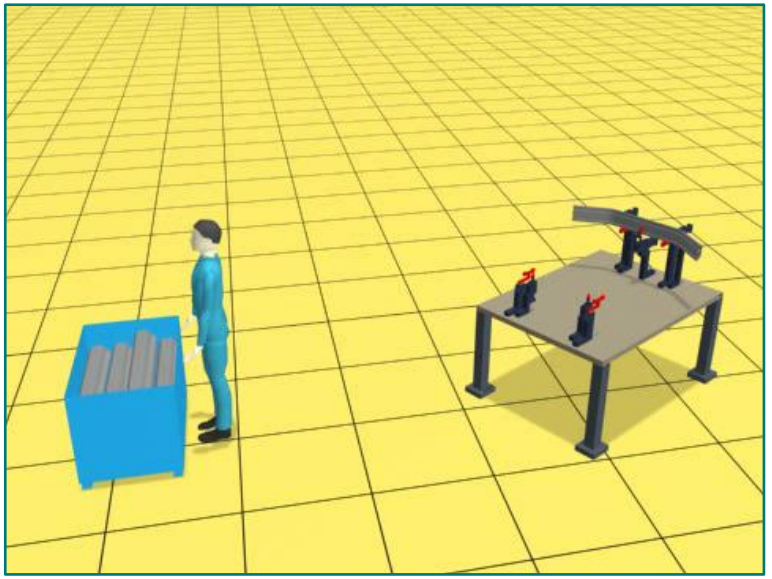
Introducing the “Skilled Virtual Worker“

ema = “Editor for Manual work Activities”.

ema uses a standard process language

and a library of predefined operations:

- get and place object
- use automatic tool
- ingress / egress car
- etc.



Not: step(s) forward → stand upright → bend → hand to object → pick → object to body → step(s) sideward → turn → step(s) forward → bend → object to target → release → hand back

Instead: take part from box and place into device *(= object reference)*

ema Task Library

imk automotive

Object handling

- **Pick object(s)**
- **Place object(s)**
- **Move object(s) to target**
- **Move object(s) to position**

Object handling (extended)

- **Hand over object(s)**
- **Regrasp on object(s)**
- **Move object(s) on path**
- **Create link to object(s)**
- **Remove link to object (s)**

Hand-Arm-Movements

- **Grasp**
- **Move hand(s) on path**
- **Move hand(s) to target**
- **Move hand to default position**

Body movements

- **Walk**
- **Kneel / squat / stoop**
- **Single step in default direction**
- **Single step to target**

Body movements (extended)

- **Full step**
- **Turn**
- **Get into vehicle**
- **Get off vehicle**
- **Slide to target**
- **Sit down**
- **Stand up**

Manual activities

- **Press / activate**
- **Bolt down manually**
- **Wipe on surface**

Tool handling

- **Use hand tool**
- **Move tool on path**
- **Move hand to tool center point**

Head movements

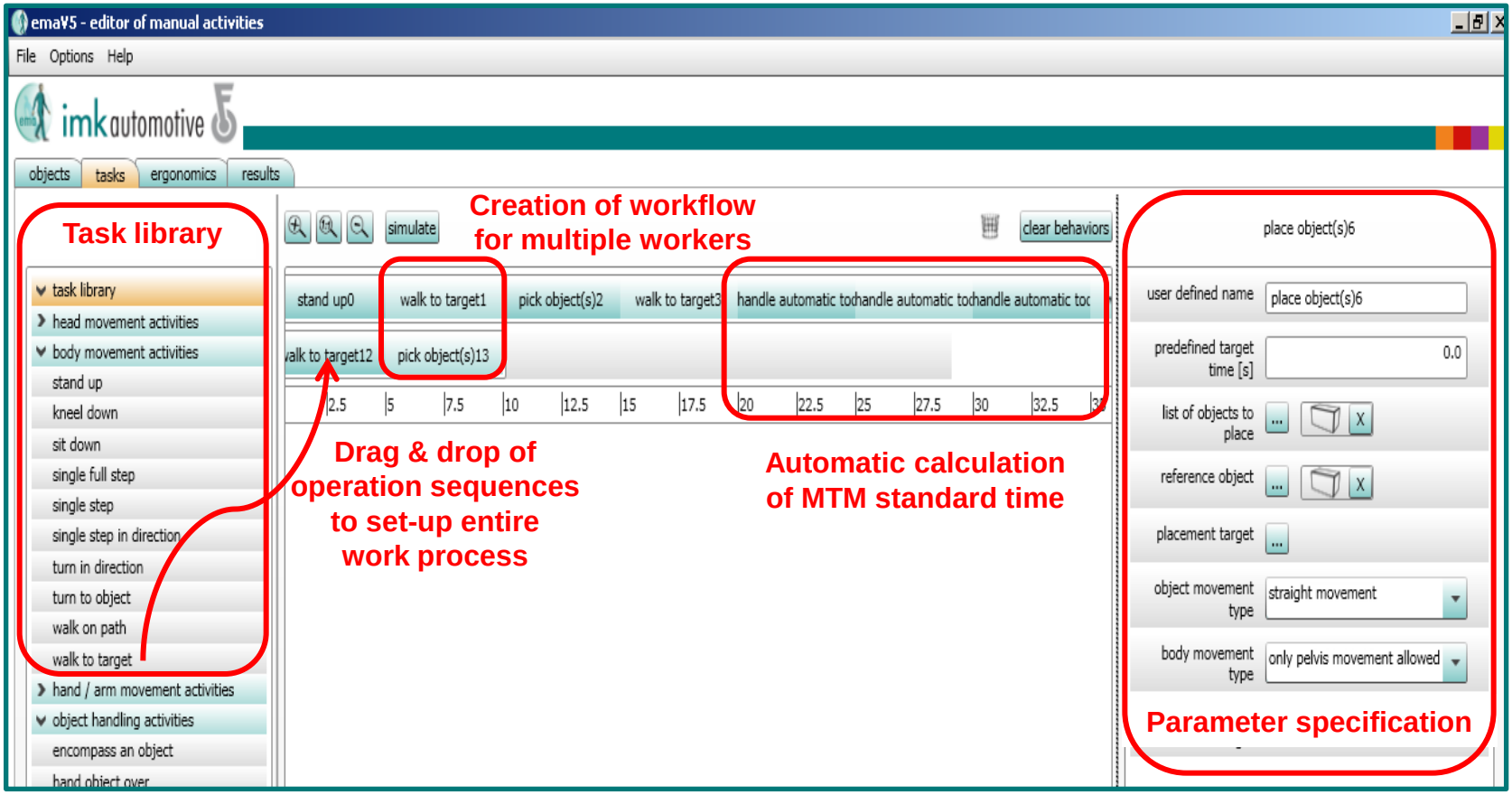
- **Look at object**
- **Check / read**

Synchronization

- **Wait**

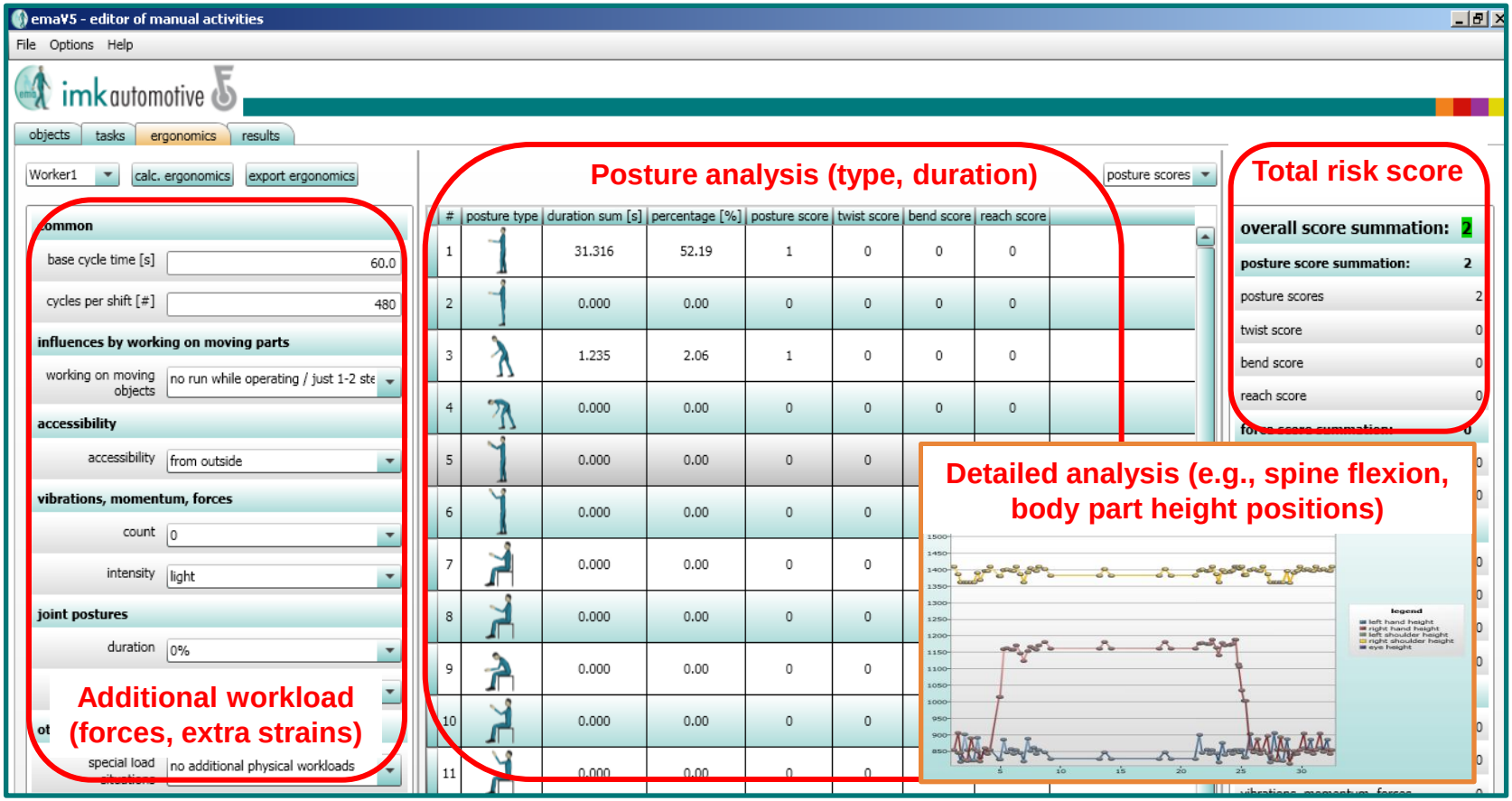
The task library is continuously growing integrating more predefined operations and movements.

ema Interface for Process Definition



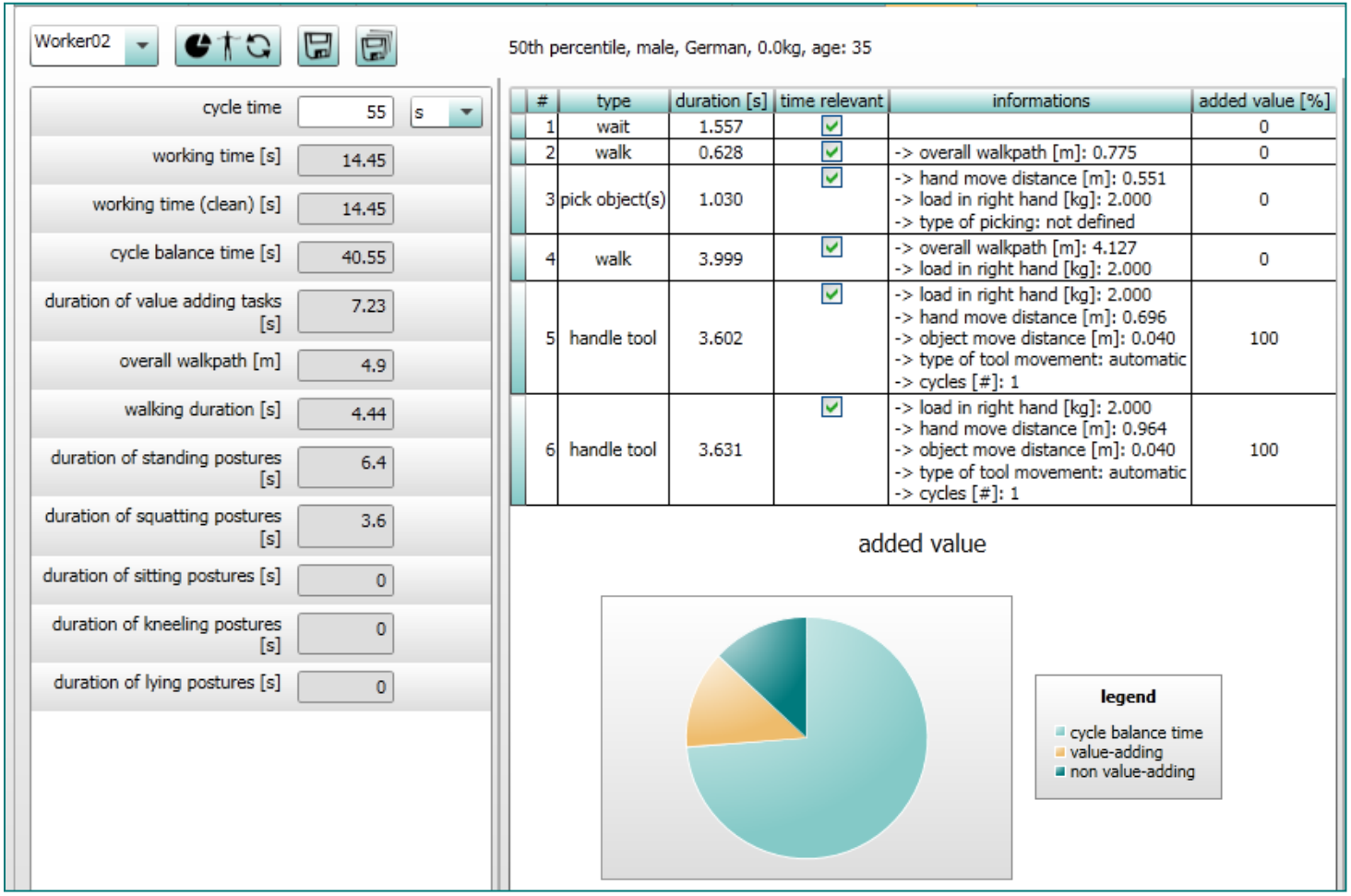
- Process definition by drag-and-drop using predefined operation sequences, supplemented by the specification of task parameters (target location, etc.)

ema Interface for Ergonomic Evaluation



- Semi-automatic ergonomic evaluation based on standardized EAWS tool (Ergonomic Assessment Worksheet V1.3.3 © IAD and AMI 2012)

ema Interface for Productivity Evaluation



- Analysis of value-added time, waiting, walk ways, workload balance, etc.

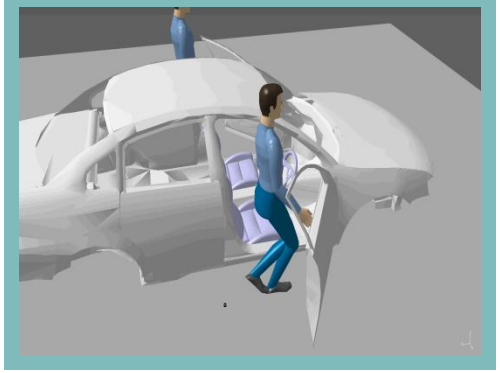
ema Examples of Application

ema may be used for various applications in different industries.

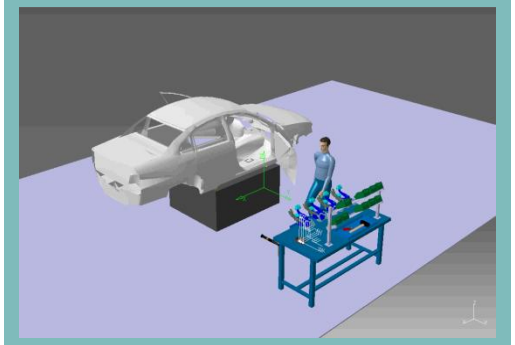
Moving Assembly Line

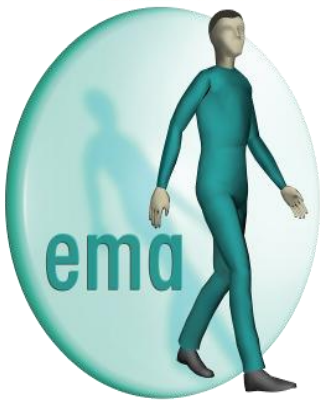
Welding

Car Ingress / Egress



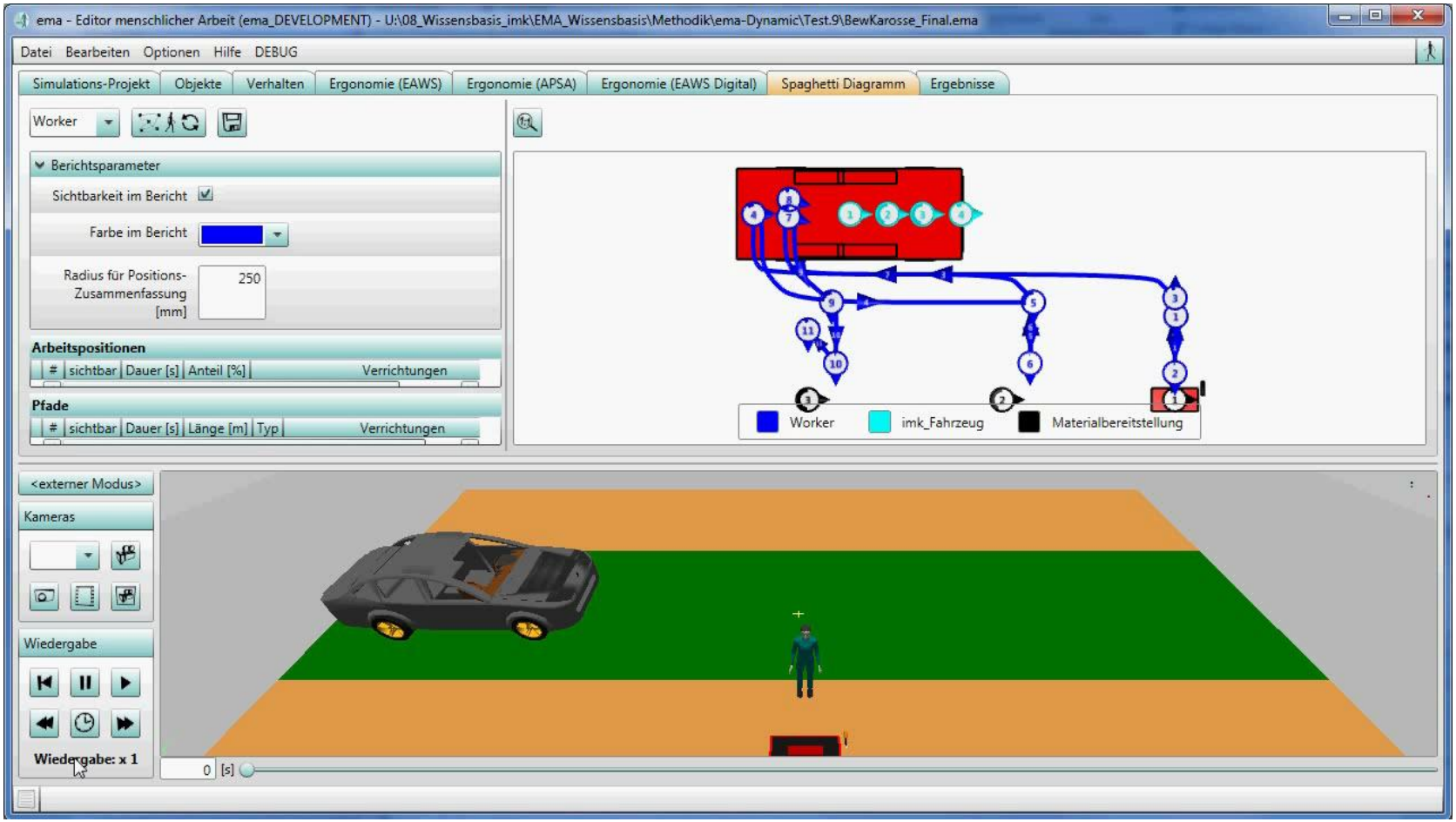
Interior/Footwell Assembly



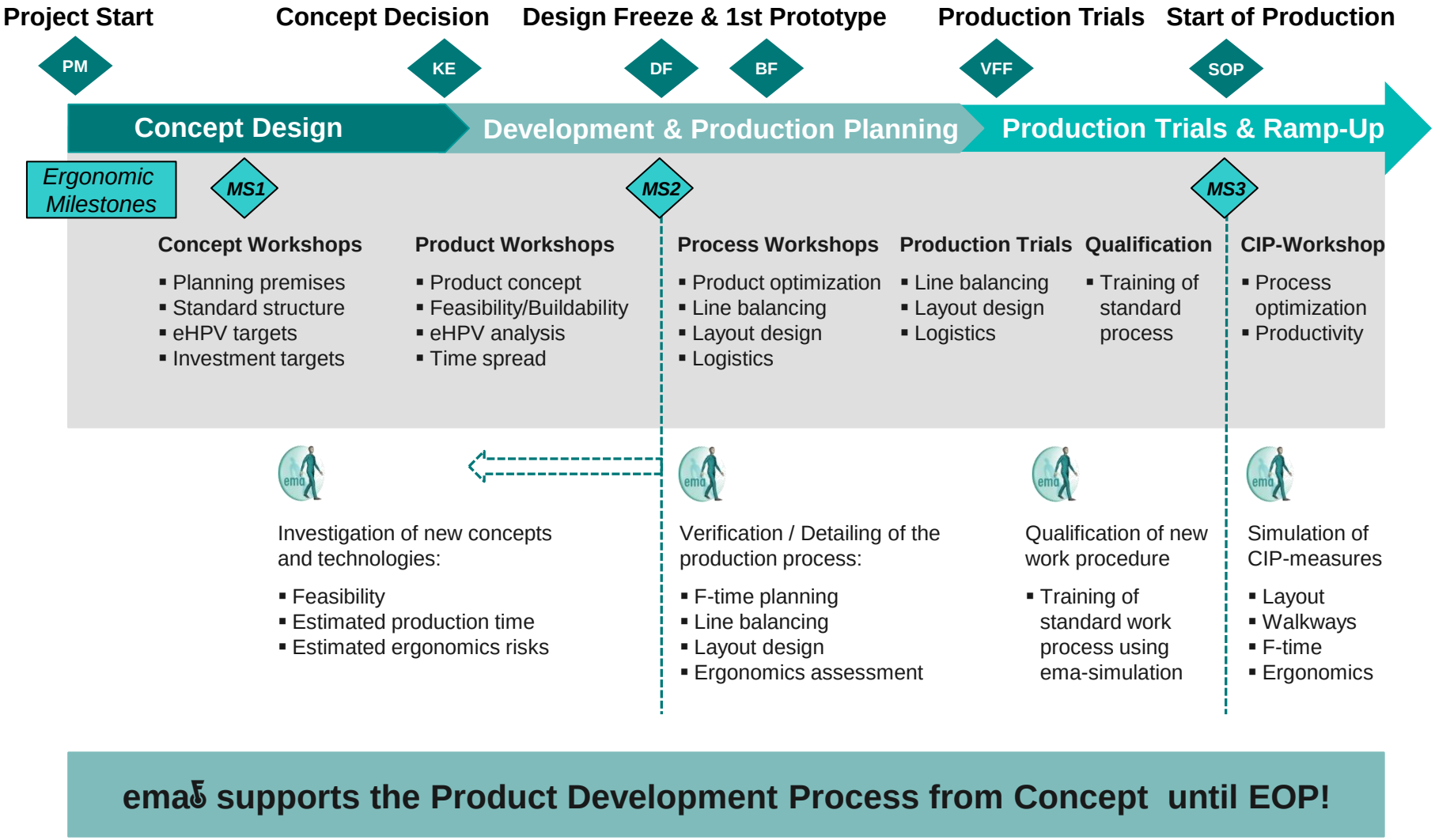


Commissioning / Logistics

ema analysis of walkways with moving assembly line.

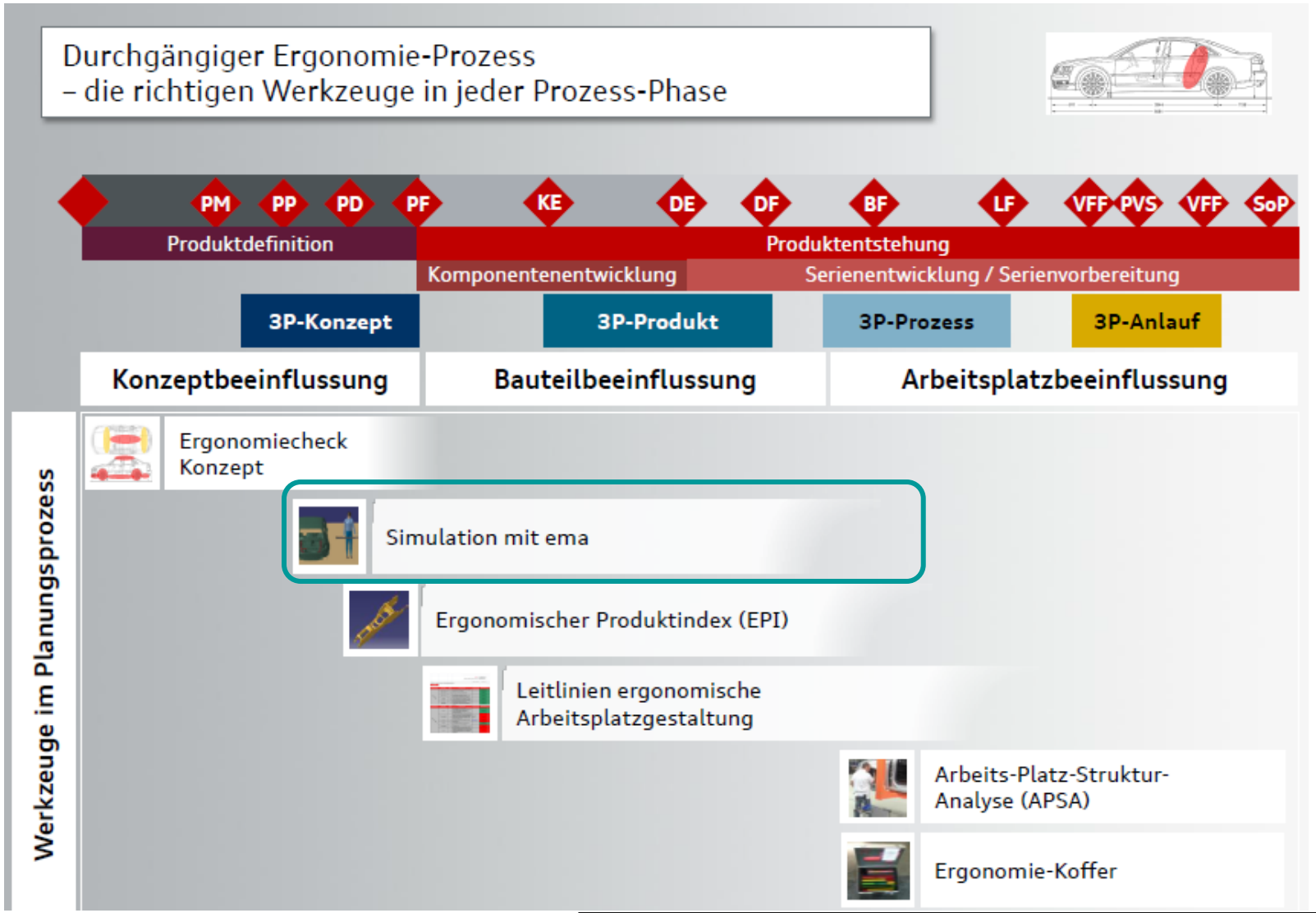


ema in Product Development Process



ema supports the Product Development Process from Concept until EOP!

ema in Product Development Process



Quelle: AUDI AG, Dr. Markus Becker, Leiter I.E. Planung

ema Benefits for Customers

ema helps to avoid mistakes in planning and to reduce costs for redesign.

- ☑ **Easy verification of planning results in 3D environment**
- ☑ **Quick alternation and testing of scenario options**
- ☑ **Uses MTM standards for time estimation**
- ☑ **Uses EAWS for ergonomic risk assessment**
  (and possibly any other standard method like OWAS, etc.)
- ☑ **Compatible with all common data formats** (.cgr, .jt, .dae)

Customers from Industry, Science and Education.

Audi

Volkswagen

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BMW

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Fraunhofer FKIE

Westsächsische Hochschule Zwickau
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iad Technische Universität Darmstadt Institut für Arbeitswissenschaft

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Fachhochschule Jena
University of Applied Sciences Jena

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Conclusions

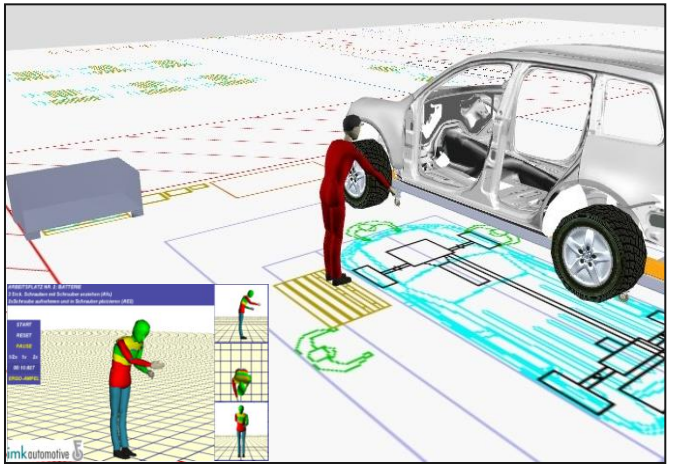
Designing efficient assembly systems by using virtual production planning.

- Virtual production planning saves costs for redesign and late correction.
- The complex human workforce needs to be considered proactively.
- ema enables easy simulation that leads to objective results.

→ However, in many companies a change of culture is needed to respect and understand the requirements of (manual) assembly systems early in product development – digital human simulations may be the key!

Experts for designing ergonomic and efficient production processes.

- **Ergonomic risk assessment:**
  using standard methods (EAWS, LMM, etc.)
- **Proactive ergonomics:**
  ergonomic analysis and improvement of the design of products, processes, and equipment
- **Ergonomic optimization:**
  ergonomic analysis and improvement of work conditions in series production
- **Trainings in ergonomics:**
  customized trainings in basic knowledge, standard methods, and ergonomic behavior
- **Pilot applications of ema**



Customers and Partners of Ergonomic Division.

Volkswagen

Volkswagen Nutzfahrzeuge

Volkswagen Sachsen GmbH

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