Prevention excels Correction –

Early Ergonomic Assessment as part of the Product Development Process

Dr. Lars Fritzsche, imk automotive GmbH

@ Montagesysteme Intensiv, Hannover, 01.10.2013

Agenda

1. imk Profile

2. Motivation for Early Ergonomics

3. Methods for Early Ergonomics

4. ema Planning Software

5. Conclusions

innovations

- **are our passion.**
  Creative thinking is embedded in our company culture.
  Innovation enables us to generate long-term competitive advantages for our customers.

methods

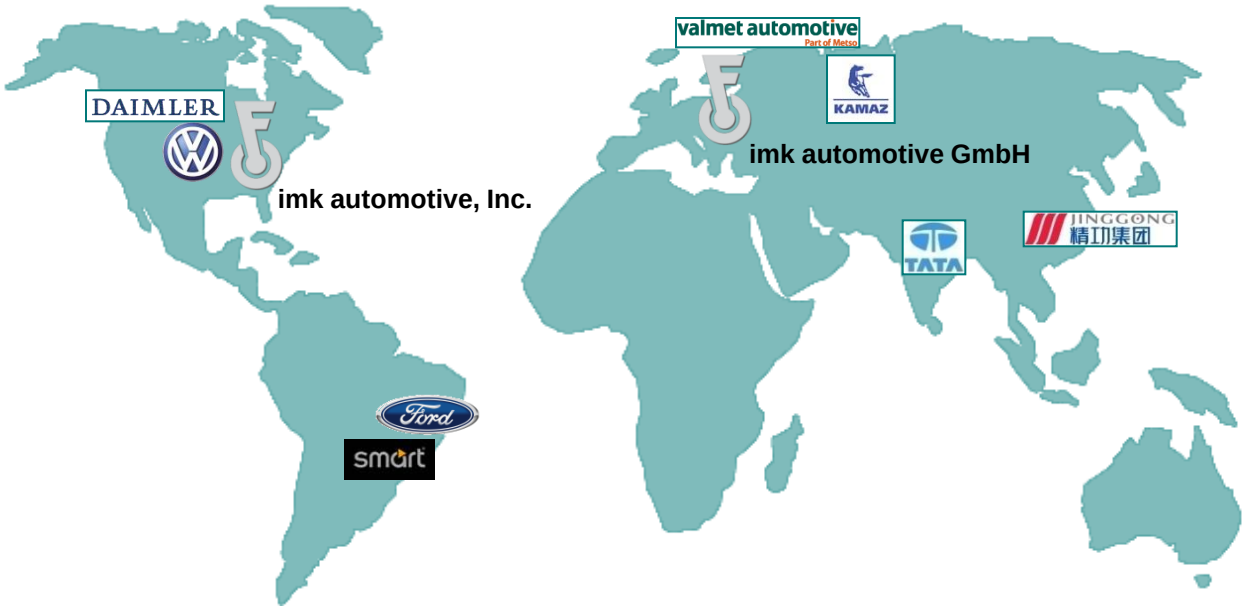
- **are our foundation.**
  They assure quality and ensure our project deadlines.
  We continuously improve our performance by developing and extending our range of methods.

koncepts

- **are our result.**
  They are created by the interaction of innovation, methods, and professional experience.
  Our success is defined by measurable customer success.

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
Dr. Jens Trepte

- Mechatronic Systems
- Structural Components

Production Planning
Carsten Otto

- Assembly
- Bodyshop

Information Technology
Gerson Heuwieser

- Software Development
- Support and Service

Consulting

Ergonomics
Dr. Lars Fritzsche

- Ergonomic Workplace Design
- Qualification and Training

Consulting
Ingolf Grüßner

- Production Strategy
- Product and Production Optimization

Strategic Development
Dr. Wolfgang Leidholdt

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Motivation for Early Ergonomic Assessment

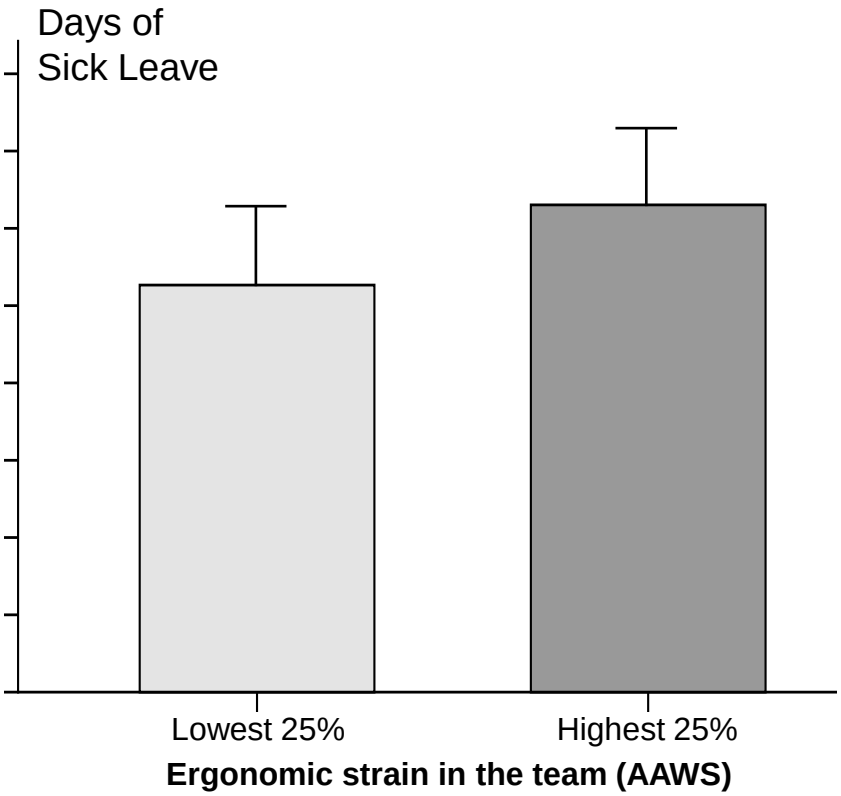
Ergonomic work design is becoming an economic need and a competitive edge.

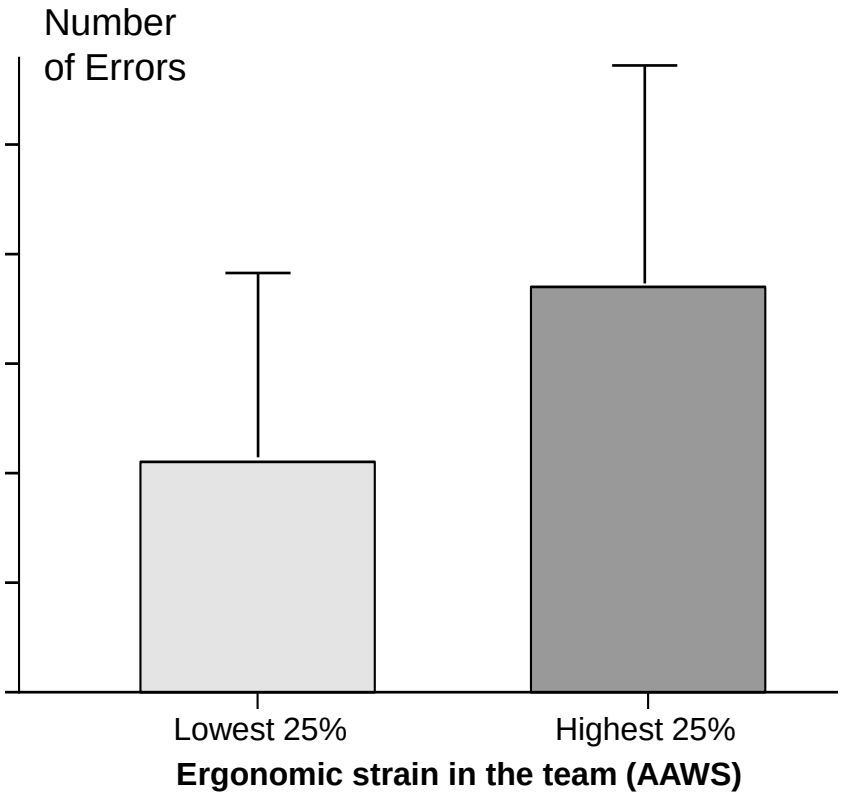
Good Ergonomics is good Economics! (H. Hendricks, 1996)

- Increases efficiency trough reduction of unnecessary motion (“waste”)
- Increases flexibility by providing more jobs for older and/or restricted employees
- Increases motivation of employees and reduces turnover rate (“Top Employer”)
- Reduces sickness absenteeism and lowers costs for workers compensation
- Reduces quality issues that are due to high forces/loads and awkward postures

Motivation for Early Ergonomic Assessment

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





- Up to **20% more absenteeism days** in teams with high ergonomic strain

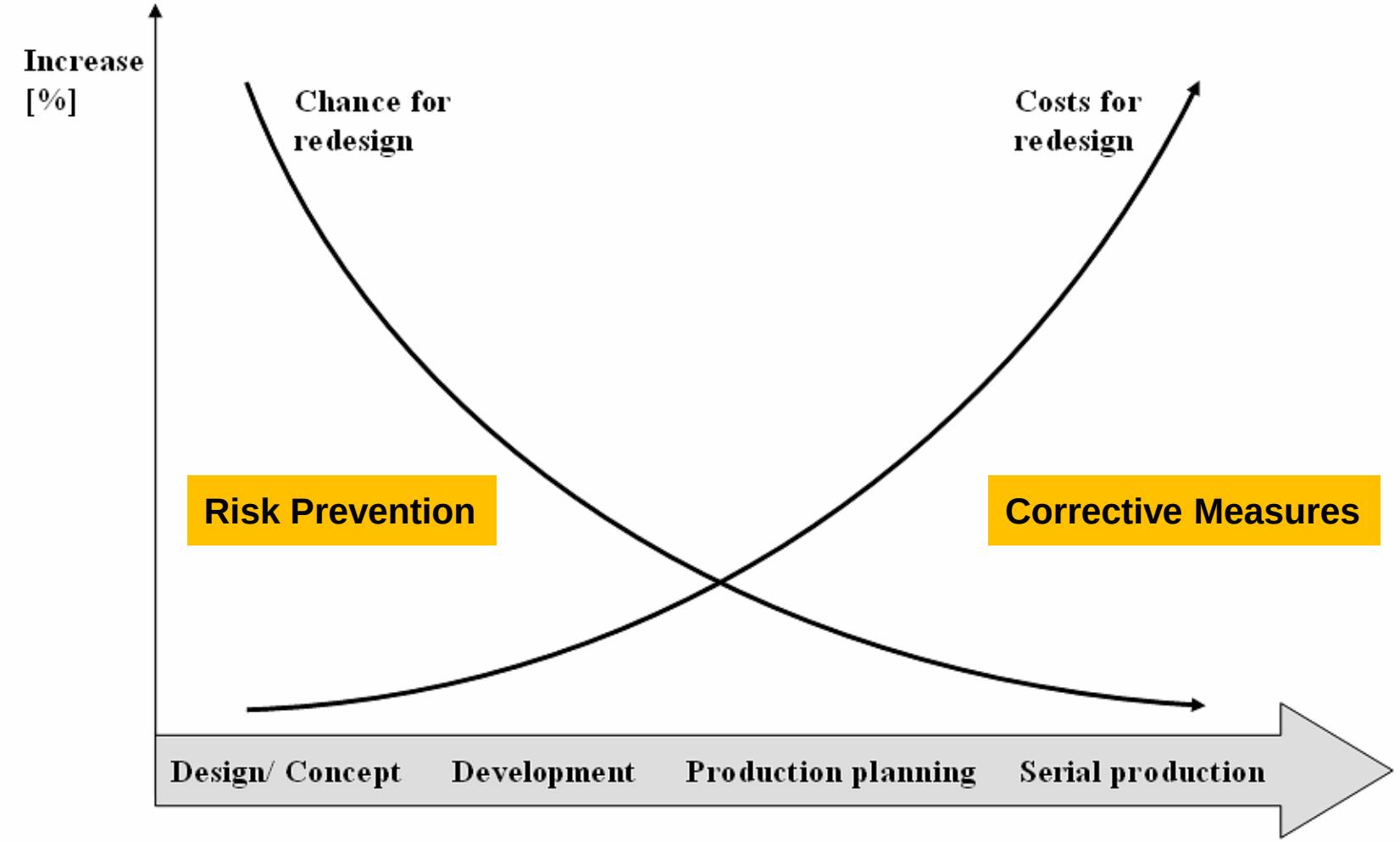
- Up to **40% more assembly errors** in teams with high ergonomic strain

Motivation for Early Ergonomic Assessment

Digital production planning tools facilitate human-centered work design.

- Chances for redesign are best in an early stage of development due to strongly increasing costs after the design phase (“Design Freeze”).
- Digital tools enable efficient testing of alternative planning and design scenarios without physical mock-ups or any risk for operators.
- 3D visualization helps to create a common understanding and thereby supports collaboration between design, planning, production, safety, etc.
- Digital data is readily available by now, e.g. for many products, tools and other equipment in most companies’ PLM software systems.

Motivation for Early Ergonomic Assessment



(adapted from Sanzenbacher, 2007)

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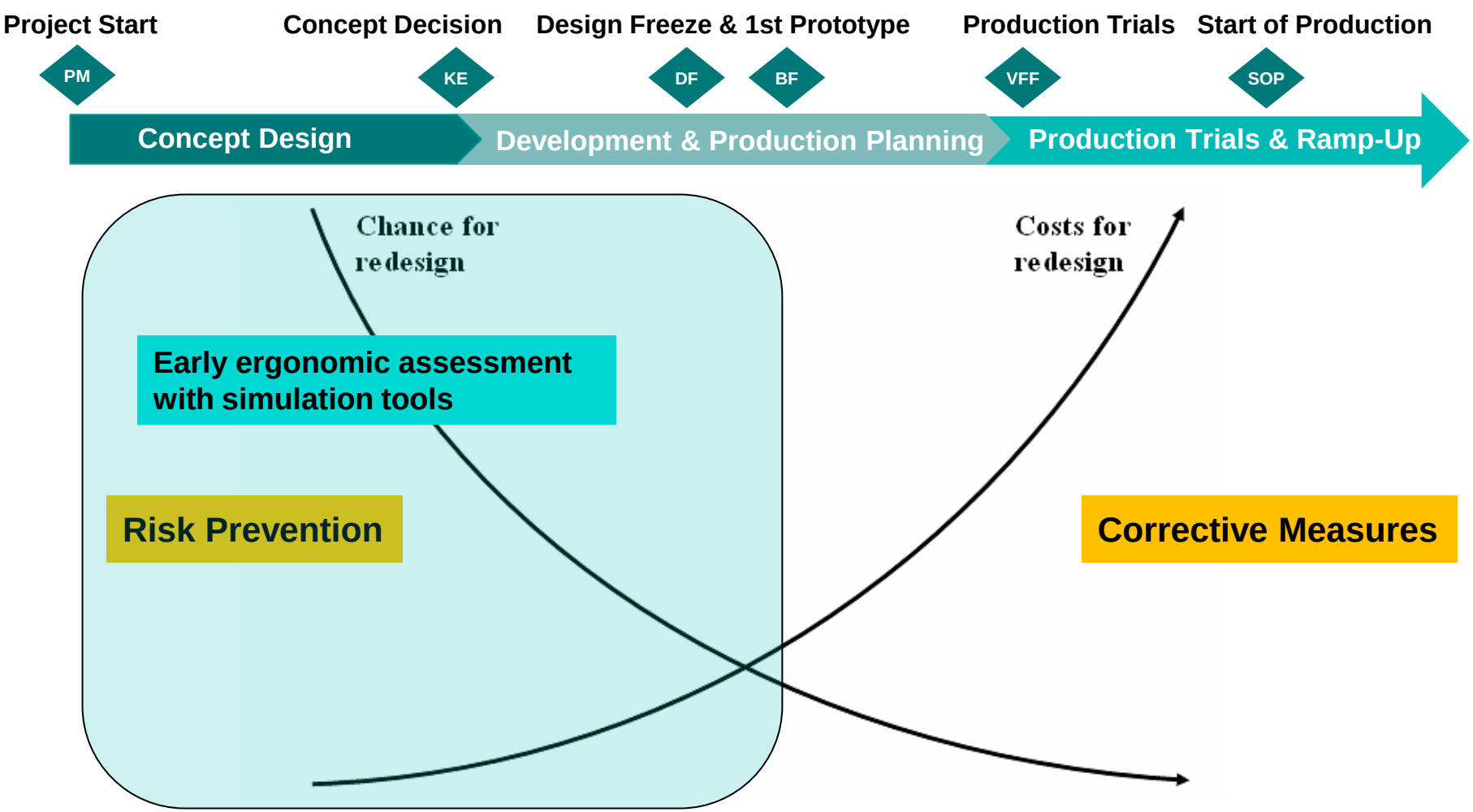
Methods for Early Ergonomic Assessment



So start early, but based on what?

Methods for Early Ergonomic Assessment

ER1

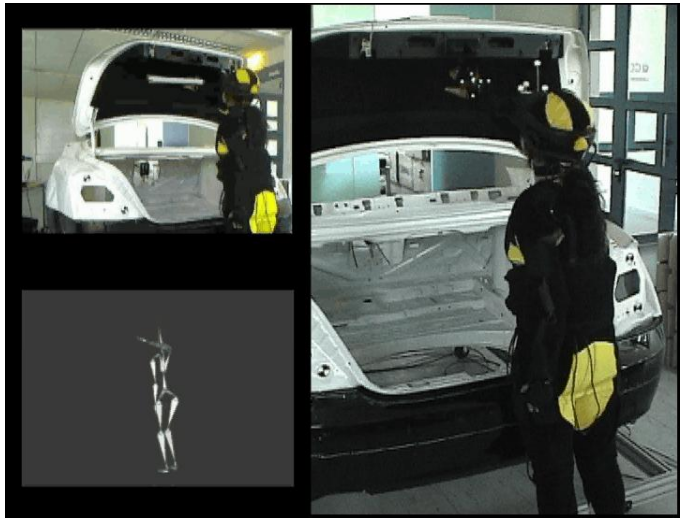
Ergonomic Milestone #1:

List of all critical parts and processes based on standard assessment tools (e.g., EAWS)

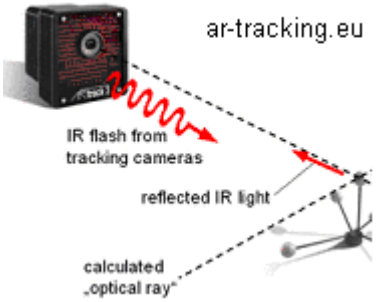
Prior to concept decision: concept evaluation should consider impact on top ergonomic issues

Now simulation tools are needed to start early ergonomic investigations!

(1) Motion Capturing and Virtual / Mixed Reality Technologies

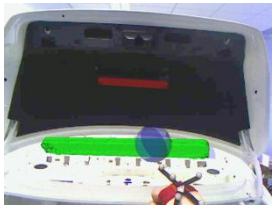


Optical tracking



Head Mounted Display

Real and augmented objects



Motion Capturing Suit

Benefits:

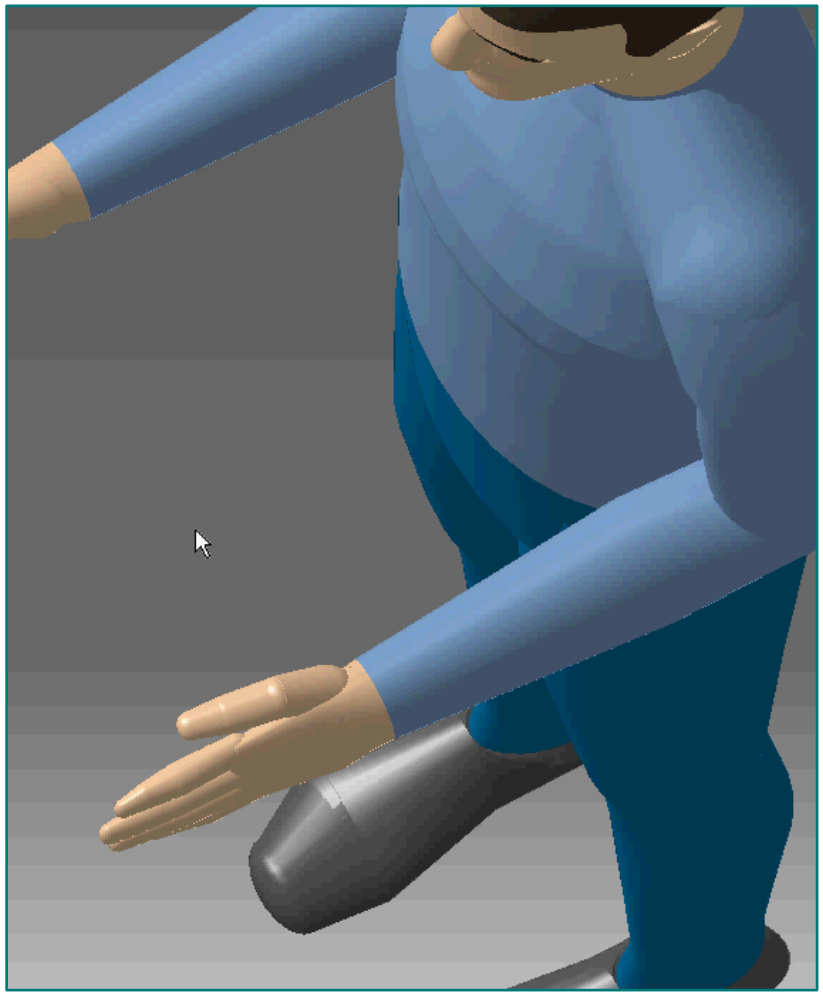
- Recordings of realistic human motions in action
- Physical feedback, automatic human collision avoidance

Drawbacks:

- High effort for scenario preparation and alternation
- Individual data is not replicable (lack of reliability & validity)

Developed in EU-Project "CyberManS"

(2) Digital Human Simulation (Traditional tools)



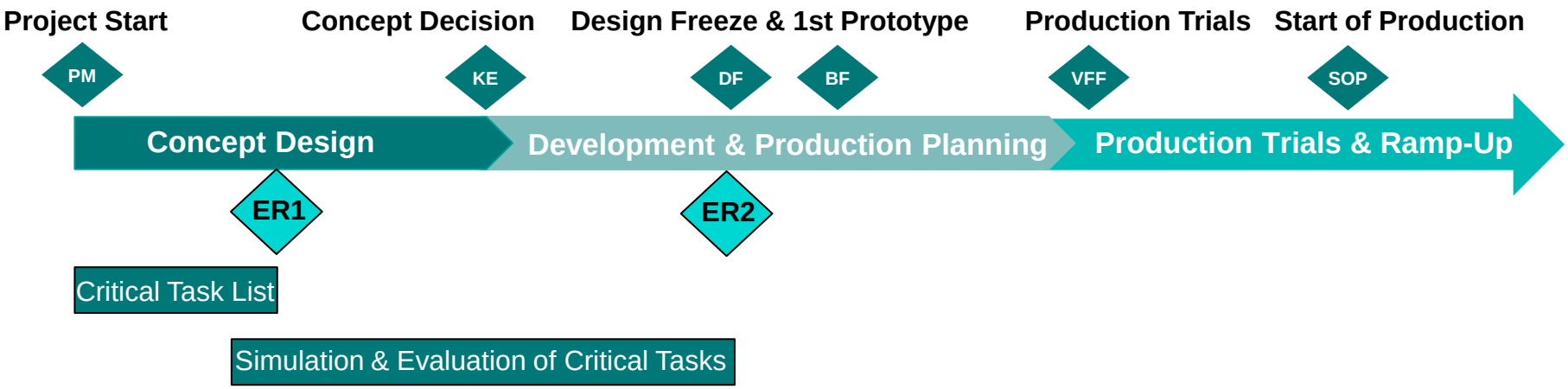
Benefits:

- Seamless integration of CAD/PLM software architecture
- Replicable data through generic motion generation

Drawbacks:

- High effort for scenario preparation and alternation
- Partly unrealistic movements, not based on realistic time estimation

Methods for Early Ergonomic Assessment



Risk Prevention

Corrective Measures

ER2

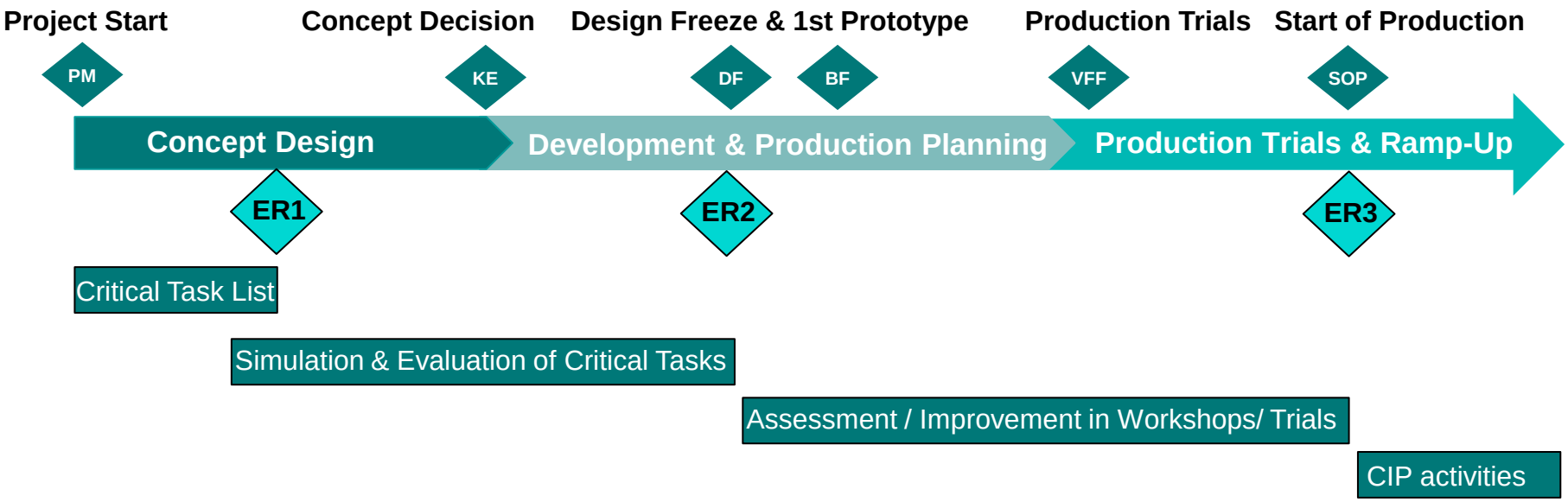
Ergonomic Milestone #2:

Evaluation of all “old” and “new” ergonomic issues based on standard assessment tools; cost-benefit analyses for improvement measures

At Design Freeze, prior to 1st prototype car

After all the simulation and evaluation, let’s work on the “real” object!

Methods for Early Ergonomic Assessment



ER3

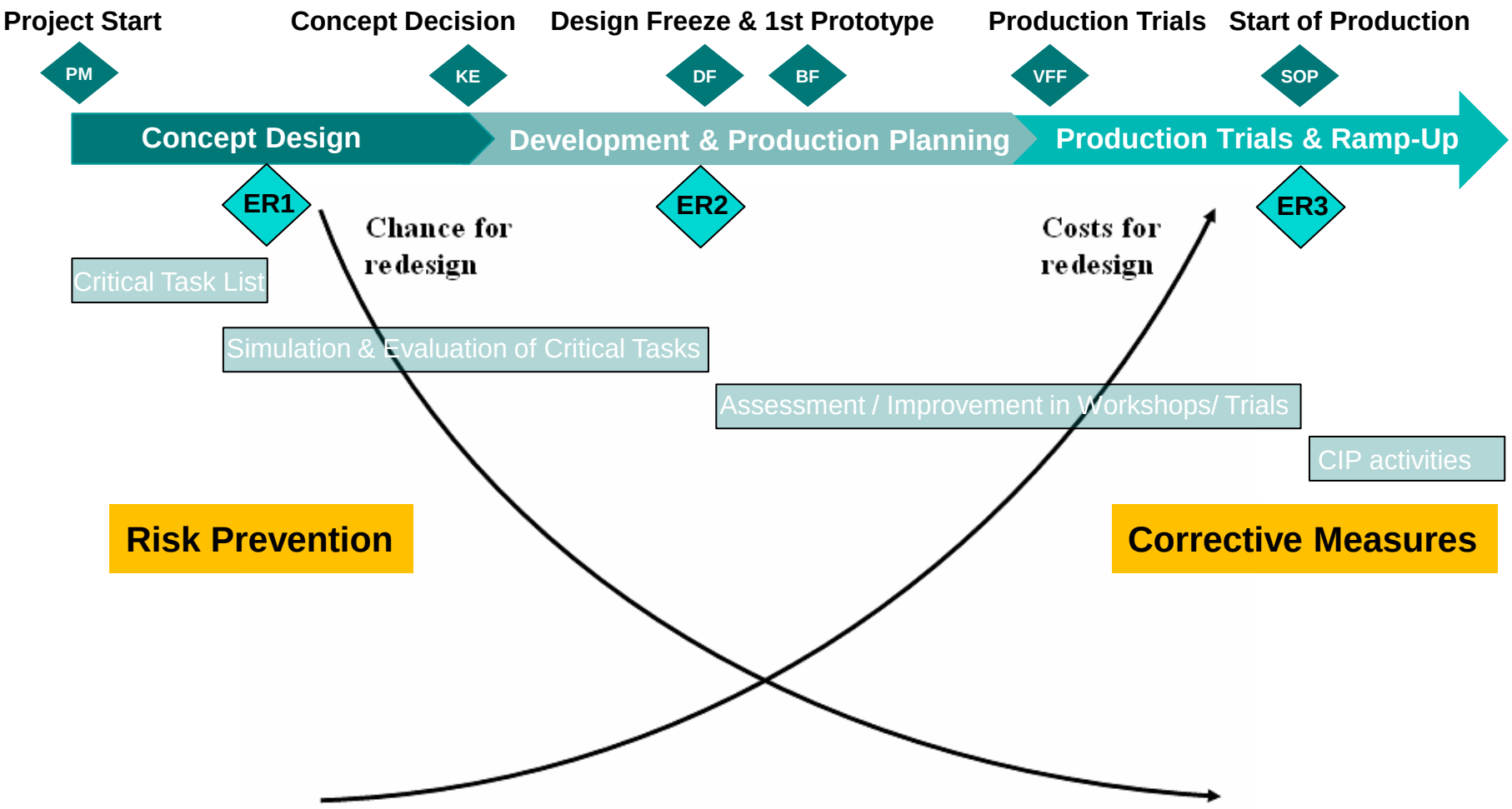
Ergonomic Milestone #3:

All manual processes are evaluated based on standard assessment tools; development and implementation of improvement measures

Target: zero “red” ergonomic issues at SOP

After SOP, CIP activities are still needed to ensure sustainable ergonomics!

Methods for Early Ergonomic Assessment



But again, prevention excels correction. So better simulation tools are needed!

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Ergonomic Simulation Today

Ergonomic simulations usually need high effort and have restricted validity.

- Digital human models cannot understand standardized work instructions (i.e., typical planning language such as MTM).
- Each particular movement has to be taught manually for creating dynamic work simulations.
- Thus, simulations of the entire work process are very time consuming.
- Currently available simulation models do not include comprehensive methods and tools for analyzing assembly time and ergonomic risks.

→ **Our objective: make dynamic human simulation of manual work easier, quicker, and more accurate by using standard operations.**

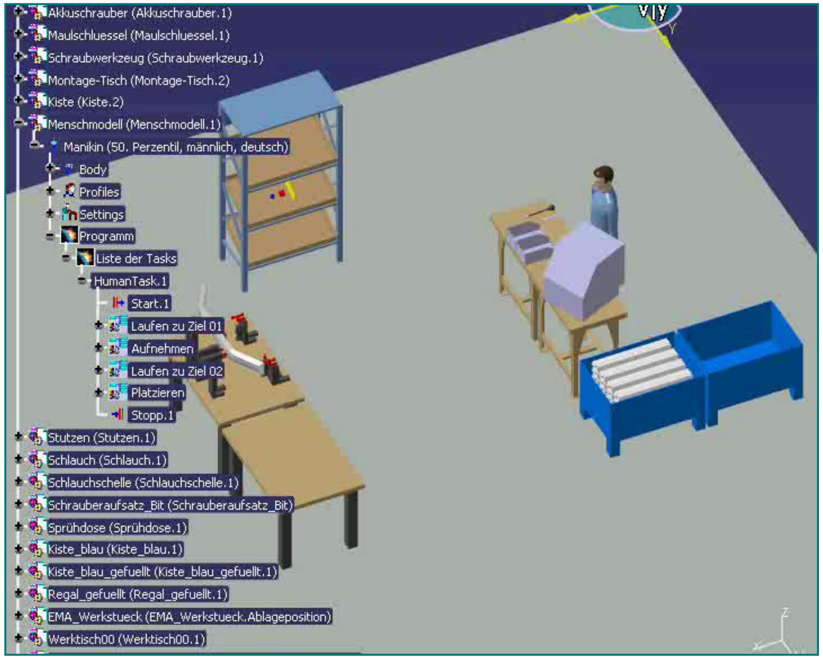
What makes ema unique?

ema = “Editor for manual work activities”

The production planner is not a **Pixar animator!**

ema uses complex operation sequences instead of teaching each single posture, for example:

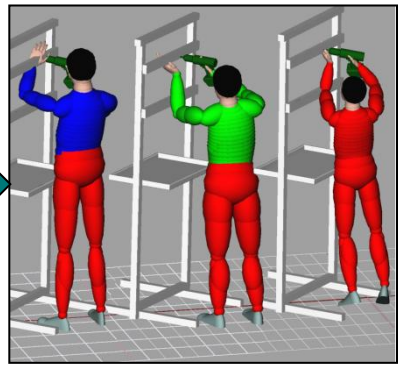
- get and place object
- use manual or automatic hand tool
- ingress / egress car
- etc.



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

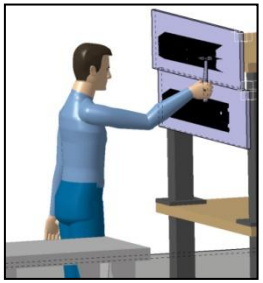
Instead: take part out of box and place into corresponding device *(= object reference)*

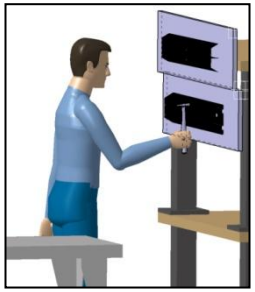
ema complex operation sequences are based on extensive research studies.

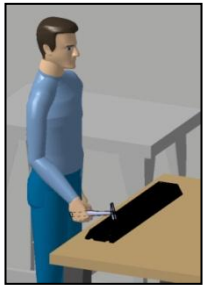


ema-approach: algorithms derived from multiple motion capturing studies calculate typical workers' movements, specifically adapted for industrial tasks

$$\psi_{EIIb} = f_{183}\,t^5 + f_{184}\,t^4 + f_{185}\,t^3 + f_{186}\,t^2 + f_{187}\,t + f_{188}$$







ema Task Library

imk automotive

Object handling

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

Object handling (extended)

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

Hand-Arm-Movements

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

Body movements

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

Body movements (extended)

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

Manual activities

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

Tool handling

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

Head movements

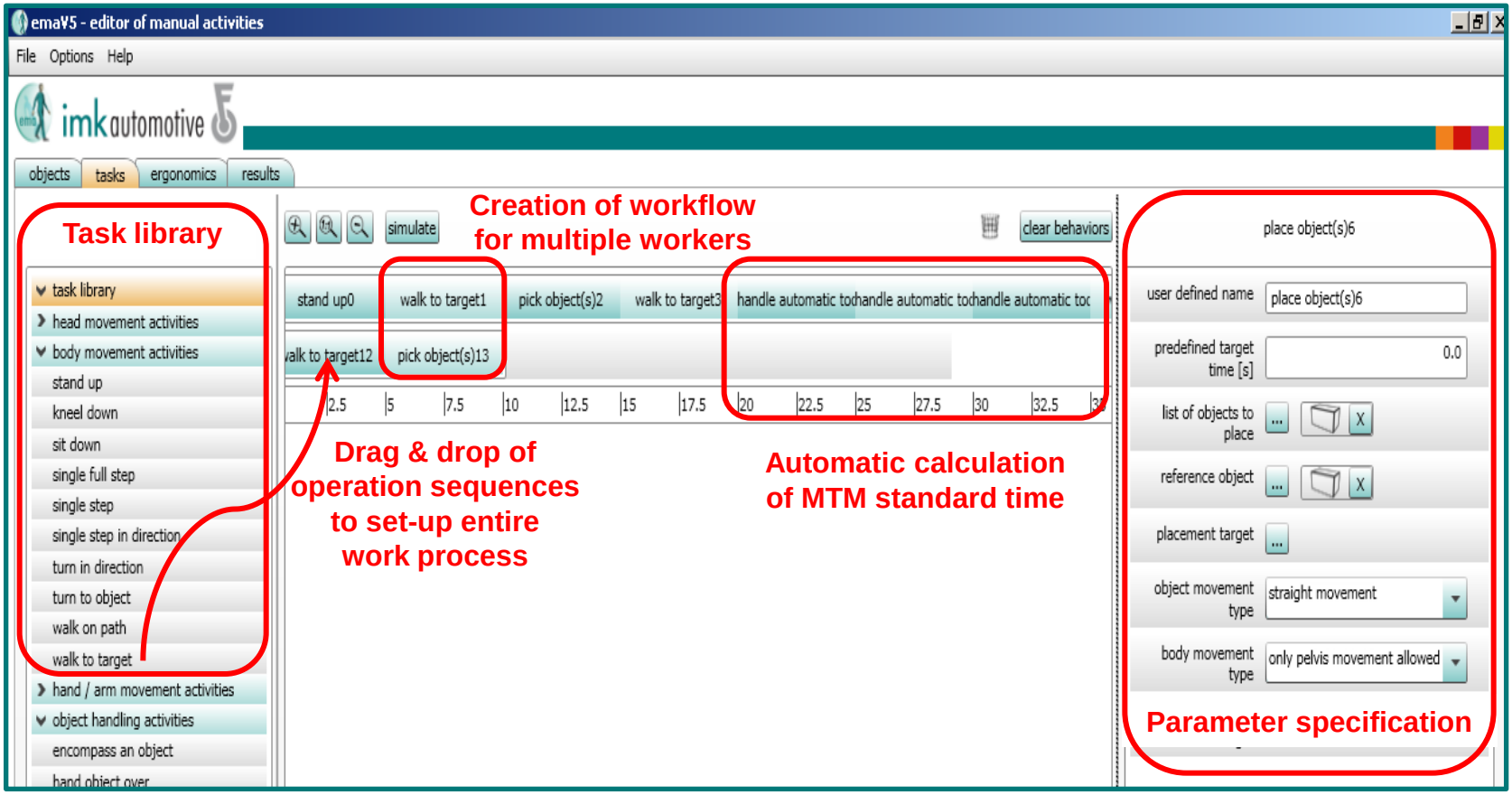
- **Look at**
- **Check / Read**

Synchronization

- **Wait**

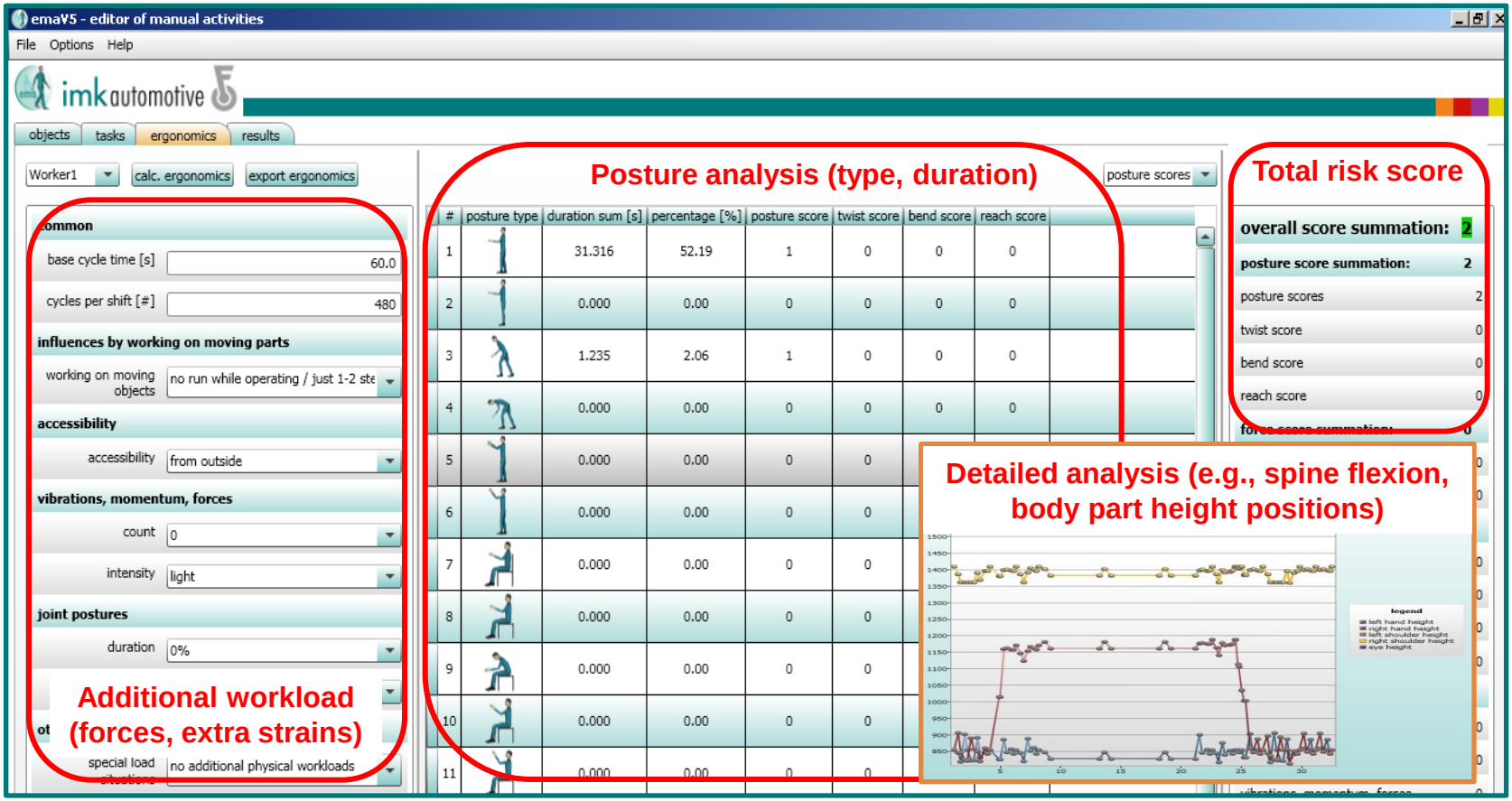
The task library is continuously growing by adding more predefined operations and movements (e.g., Lay down).

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

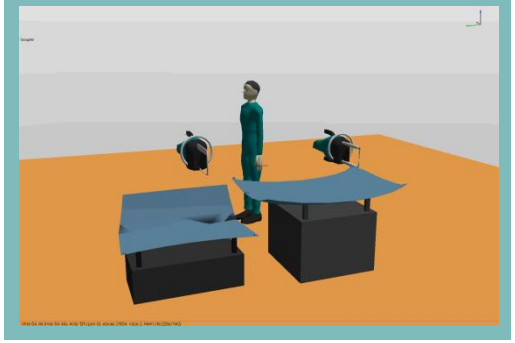


- Semi-automatic ergonomic evaluation based on standardized EAWS tool (Ergonomic Assessment Worksheet V1.3.3 © IAD and AMI 2012)

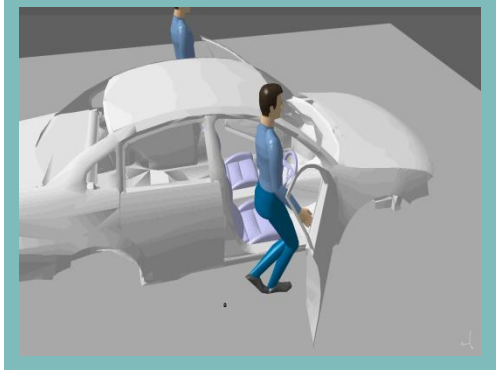
ema may be used for various applications in different industry sectors.

Moving Assembly Line

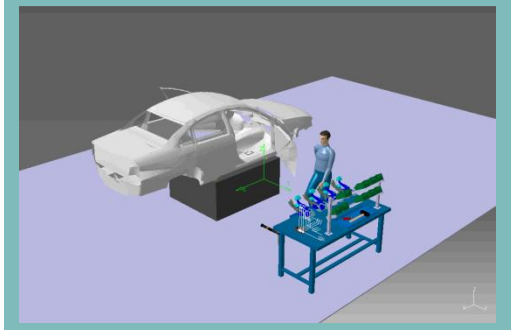
Welding

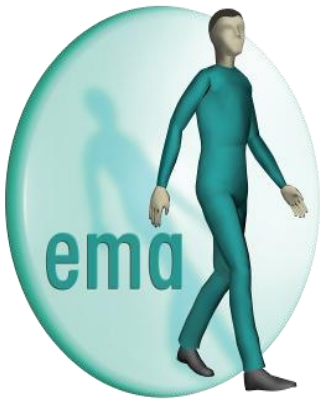


Car Ingress / Egress



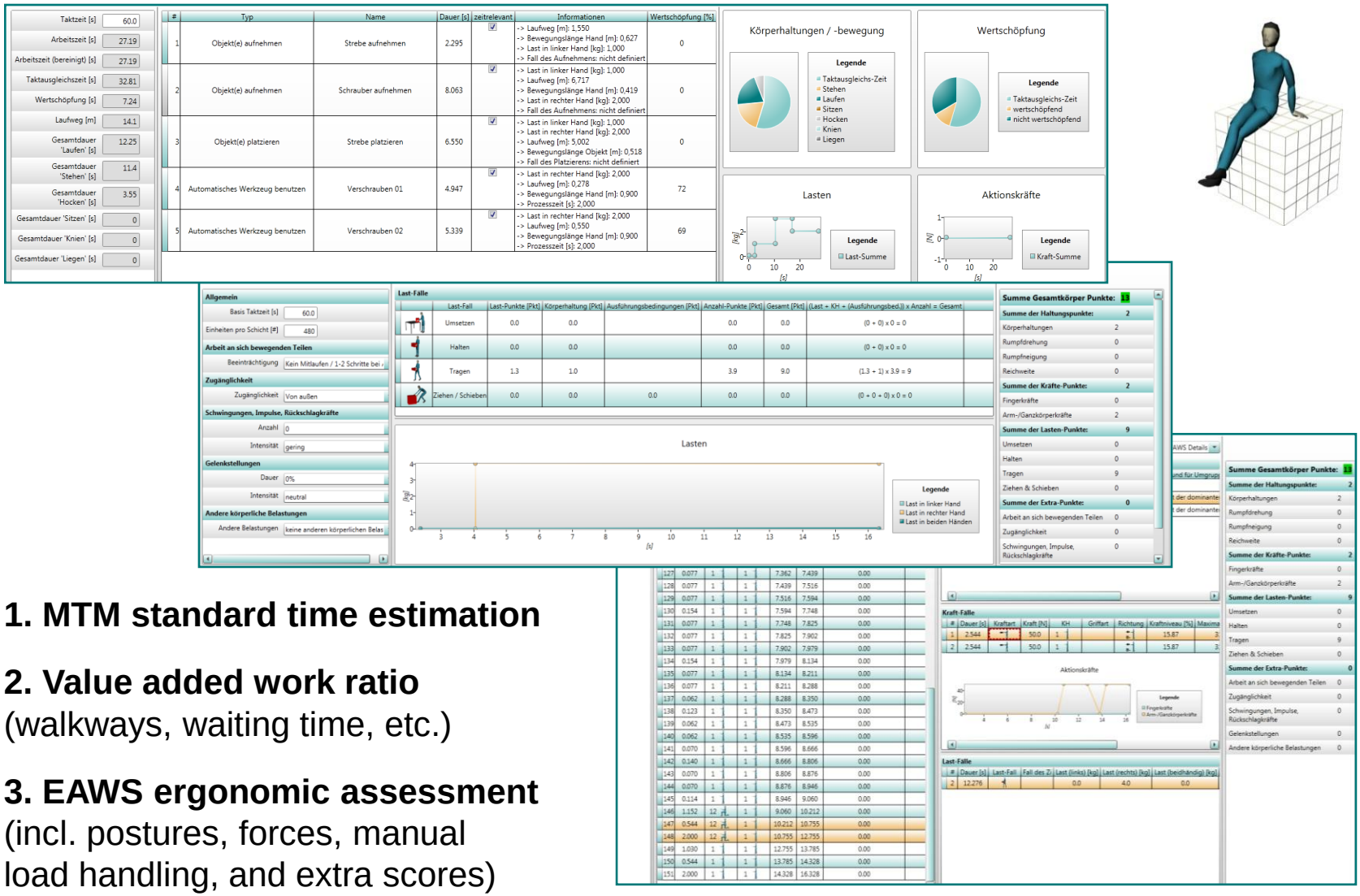
Interior/Footwell Assembly





Commissioning / Logistics

ema Results and Evaluation Toolset



1. MTM standard time estimation

2. Value added work ratio
(walkways, waiting time, etc.)

3. EAWS ergonomic assessment
(incl. postures, forces, manual load handling, and extra scores)

ema Development Partners

- **ema-V5** plug-in for Catia/Delmia V5 Human by Dassault Systemes:
  → ema-V5 available since 2011
  → continuously updated for latest Delmia releases (R19 and higher)

- **ema** stand-alone software suitable for SIEMENS data format (.jt) and for small-/medium sized companies developed with Chemnitz University
  → available since Q3-2012

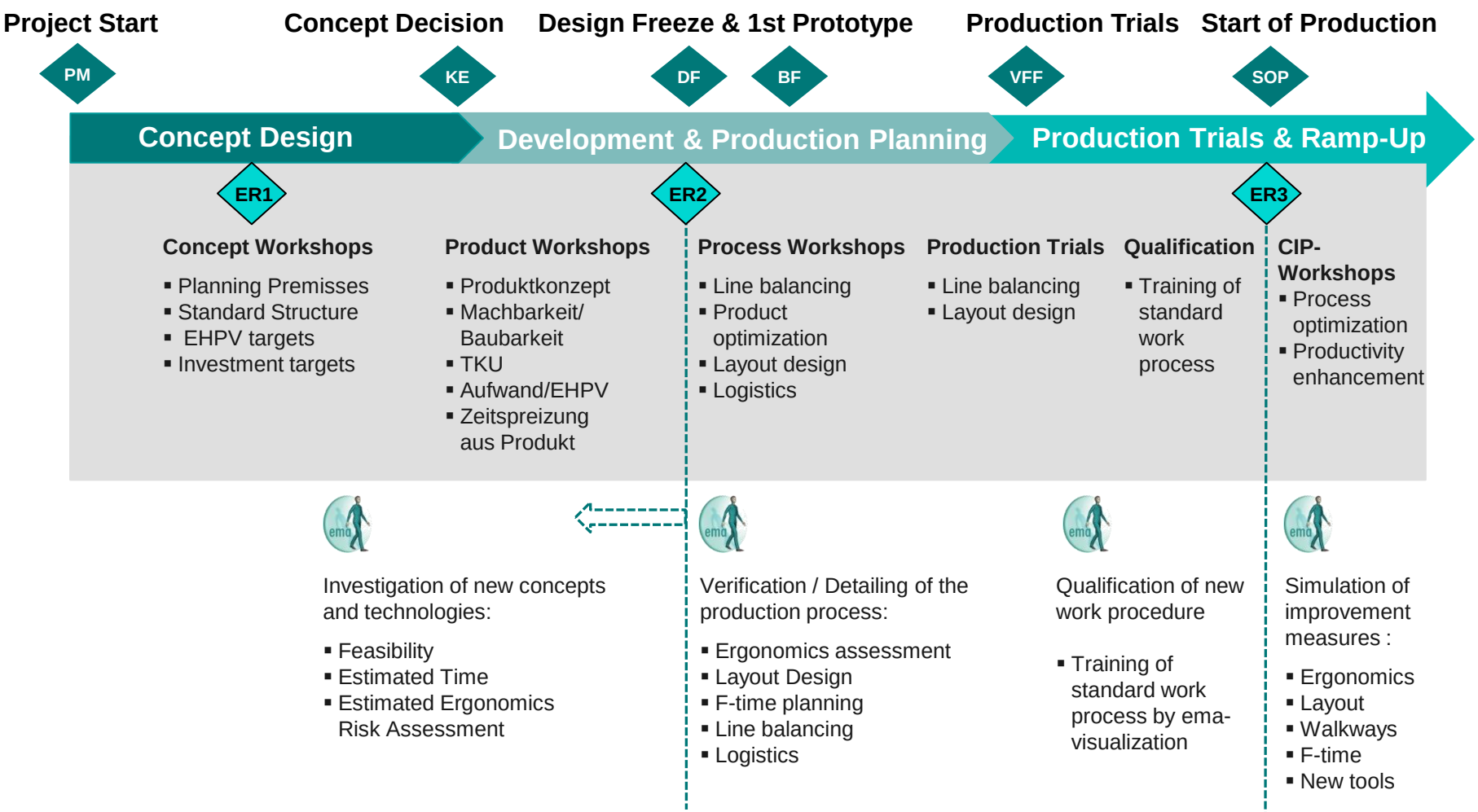
- **Ticon-ema** to supplement MTM-Ticon software developed with MTM
  → first release planned in Q4-2013

ema Benefits for our Customers

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

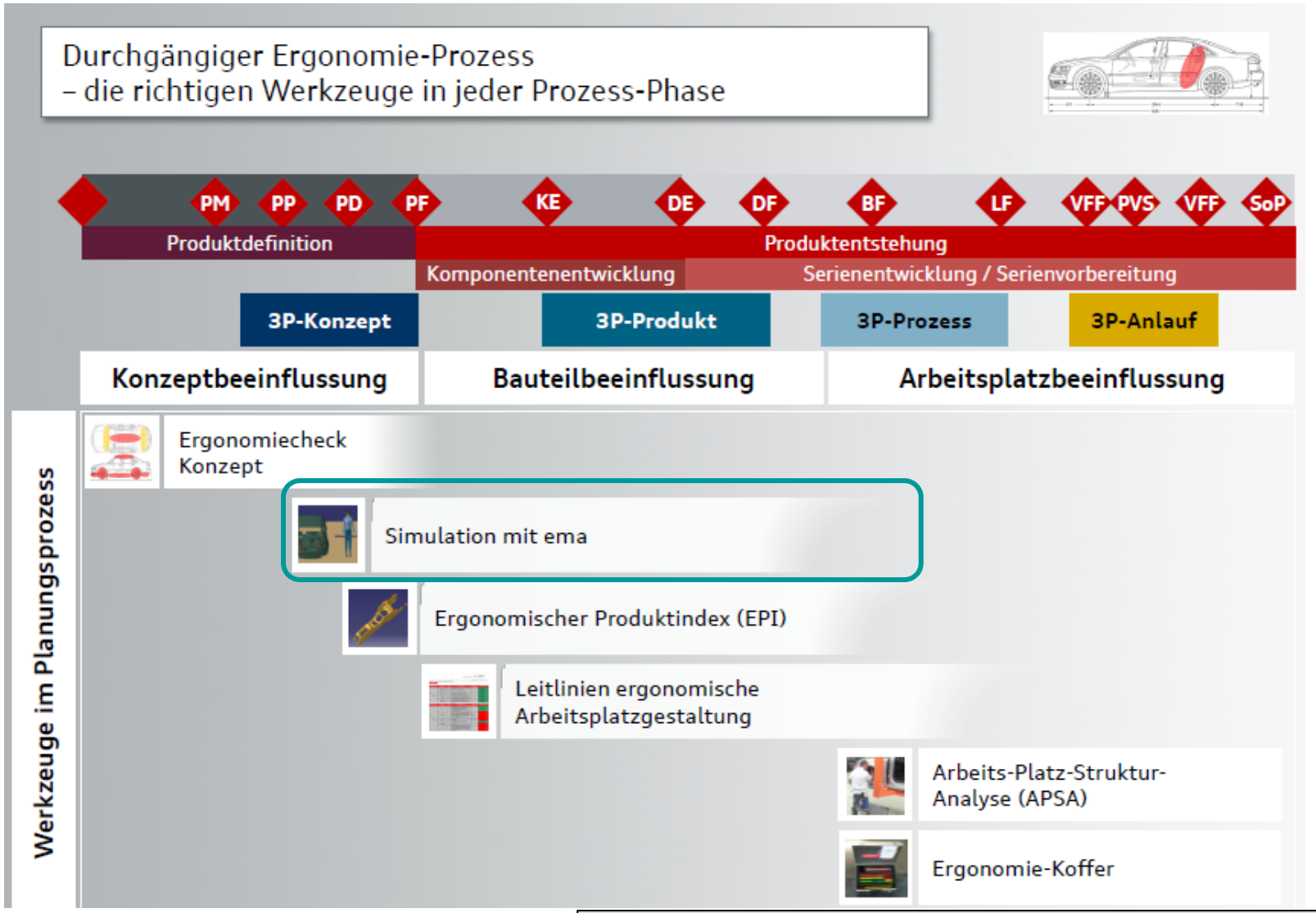
- ☑ **Easy verification of planning results in 3D environment**
- ☑ **Very quick alternation/ testing of scenario options**
- ☑ **Uses MTM standards for time estimation**
- ☑ **Uses EAWS for ergonomic risk assessment**
  (and possibly any other standard method like OWAS, etc.)

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

Connecting virtual with real world

As Is:
- Process Planning (DPE, alphanum.)
- Assembly/Installation simulation (DPM partly)

As Is:
- Ergo Analysis (LMM)
- Time Analysis (Ticon)

Both by workplace investigations

Inital idea:
- Easy to use simulation capability
- Based on standard processes (Lean)
- Based on standard procedures (MTM, EMMA)
- Integrated into Airbus ME environment

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AIRBUS

Customers from Industry, Science and Education

Volkswagen

DAIMLER

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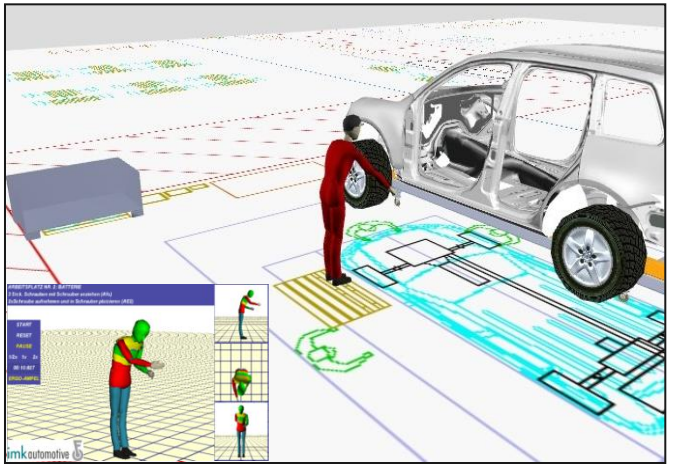
Conclusions

Early Ergonomic Assessment during Product Development is now possible.

- Indeed, good Ergonomics is good Economics!
- Prevention excels correction because it is much more cost-effective.
- Standard tools and criteria are needed throughout the entire PDP.
- Simulation tools that are easy to use and based on ergonomic and time standards are needed, and now available with ema.
- However, in many cases internal processes of IT and work organization are not ready, yet (e.g., definition of roles and responsibilities).

Experts for designing ergonomic and efficient production processes.

- Ergonomic analysis and consulting
  - Preventive production planning:
    identification of ergonomic weaknesses in the design of products, processes, and equipment
  - Optimization of series production:
    improvement of ergonomic conditions to keep workers' health and increase efficiency
- Customized trainings in Ergonomics
- Digital Production Planning / 3D validation
- Lean manufacturing & Industrial engineering
- Customized pilot applications of ema



Ergonomic work design for ramp-up of Volkswagen Chattanooga plant (USA).

- Ergonomic evaluation of all manual work in assembly, body, paint, and logistics
- Status visualization on “Ergonomic Map”
- Development of counter measures for improving ergonomic conditions (e.g., optimized work process, auxiliary tools, new parts design)
- Follow-up workshops to test and facilitate implementation of counter measures
- Documentation and continuous status reporting to plant management

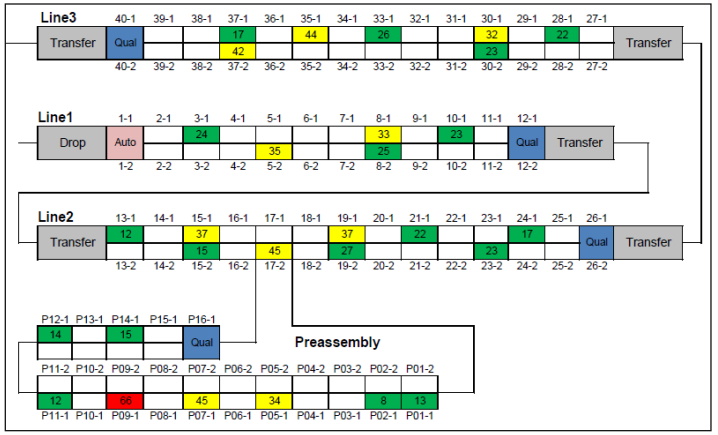


Figure 1: Status visualization on Ergonomic Map

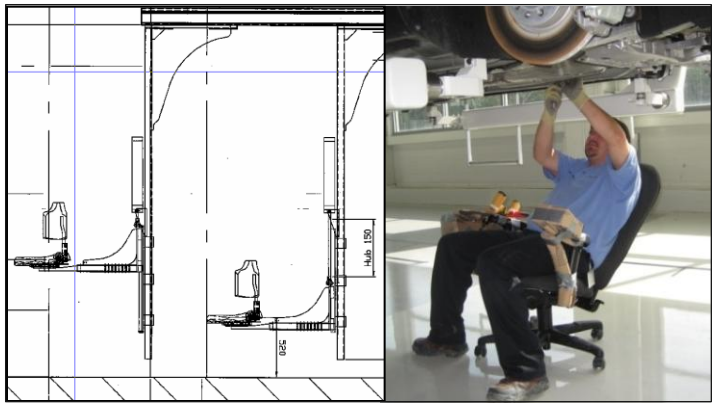


Figure 2: Development and testing of counter measures

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