Prevention excels Correction –
Early Ergonomic Assessment as part of the
Product Development Process

Dr. Lars Fritzsche, imk automotive GmbH
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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.
Automotive industry, mechanical engineering, industrial commodities, renewable energies, information systems, and aerospace industry.

Worldwide dedicated to the success of our customers.
Cross-industry engineering services and consulting.

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**Strategic Development**<br>Dr. Wolfgang Leidholdt
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Ergonomic work design is becoming an economic need and a competitive edge.

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

- Increases efficiency through 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)

- **Days of Sick Leave**
  - Lowest 25%
  - Highest 25%
  - **Ergonomic strain in the team (AAWS)**

- **Number of Errors**
  - Lowest 25%
  - Highest 25%
  - **Ergonomic strain in the team (AAWS)**

- **Up to 20% more absenteeism days** in teams with high ergonomic strain
- **Up to 40% more assembly errors** in teams with high ergonomic strain
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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So start early, but based on what?

Methods for Early Ergonomic Assessment

Concept Design
- Early ergonomic assessment with simulation tools
- Risk Prevention

Development & Production Planning
- Chance for redesign

Production Trials & Ramp-Up
- Costs for redesign
- Corrective Measures

Project Start
- Concept Decision
- Design Freeze & 1st Prototype
- Production Trials
- Start of Production

PM
KE
DF
BF
VFF
SOP

Dr. L. Fritzsche, October 2013
www.imk-automotive.com
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!
Methods for Early Ergonomic Assessment

(1) Motion Capturing and Virtual / Mixed Reality Technologies

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

**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“*
Methods for Early Ergonomic Assessment

(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
**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

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!
But again, prevention excels correction. So better simulation tools are needed!
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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.
The production planner is not a Pixar animator!

emař 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)
**emaf\textsubscript{5}** Motion Capturing

**emaf\textsubscript{5}** complex operation sequences are based on extensive research studies.

**emaf\textsubscript{5}-approach:** algorithms derived from multiple motion capturing studies calculate typical workers’ movements, specifically adapted for industrial tasks.

\[
\psi_{\text{EIib}} = f_{183} t^5 + f_{184} t^4 + f_{185} t^3 + f_{186} t^2 + f_{187} t + f_{188}
\]
The task library is continuously growing by adding more predefined operations and movements (e.g., Lay down).
Process definition by drag-and-drop using predefined operation sequences supplemented by the specification of task parameters (target location, etc.)
- 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.

Examples of Application:

- Moving Assembly Line
- Welding
- Car Ingress / Egress
- Interior/Footwell Assembly
- Commissioning / Logistics
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® 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.)
ema5 supports the Product Development Process from Concept until EOP!
Durchgängiger Ergonomie-Prozess
– die richtigen Werkzeuge in jeder Prozess-Phase

Quelle: AUDI AG, Dr. Markus Becker, Leiter I.E. Planung
Examples of Application: Aerospace

Connecting virtual with real world

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

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

As is:
• Ergo Analysis (LMM)
• Time Analysis (Ticon)
Both by workplace investigations
Customers from Industry, Science and Education

[Logos of various companies such as Audi, BMW, Volkswagen, Daimler, Porsche, KIEFEL, Scherdel, Fraunhofer, IAD, Hochschule Offenburg, Airbus, Karl Mayer, and others]
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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 ema₅.
- 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
Contact Data:

Dr. Lars Fritzsche
Division Manager Ergonomics

Mobil: +49 (0)162 250 03 47
lars.fritzsche@imk-automotive.de
www.imk-automotive.de