Novel applications in assessing manufacturing and assembly of complex composite structures

A pace towards Industry 4.0 in composite manufacturing

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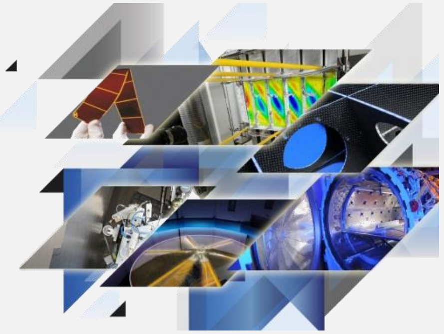
Introduction

Institute of Composite Structures and Adaptive Systems

Prof. Dr.-Ing. M. Wiedemann

Our Professional Competences – Bricks of the **Process Chain of High Performance Lightweight Structures**



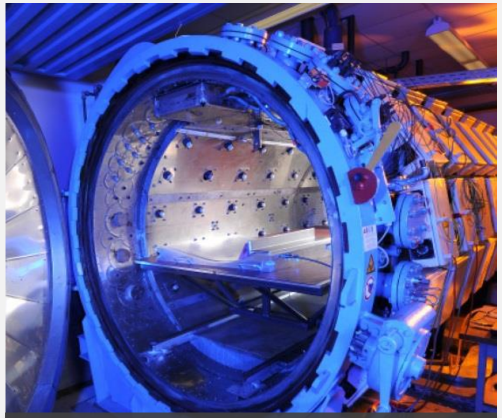
We align our research along the entire process chain for building adaptable, tolerant, efficiently manufactured light weight structures.

For excellent results in the basic research and industrial application.

Department of Composite Technology

Dr. -Ing. M. Kleineberg

Tailored manufacturing concepts



From the idea via processes to prototypes

- New technologies for manufacturing
- Hybrid manufacturing
- Assembly
- Repair
- Process automation

Process Assessment

Dr. -Ing. P. Hilmer, A. Al-Lami

Process development

Process analysis **Process assessment**

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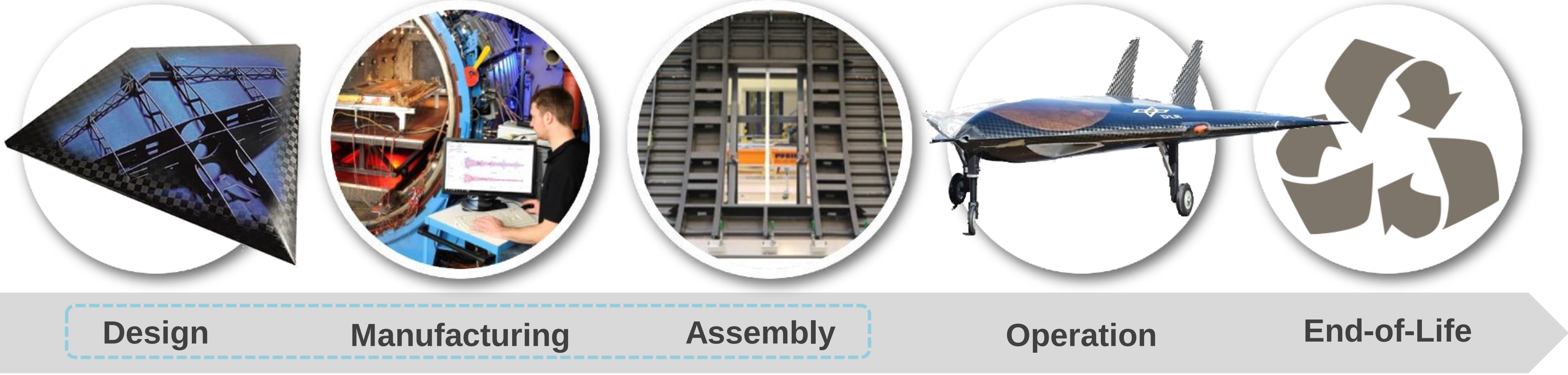
Motivation
benefit assessment



Simplified product life-cycle

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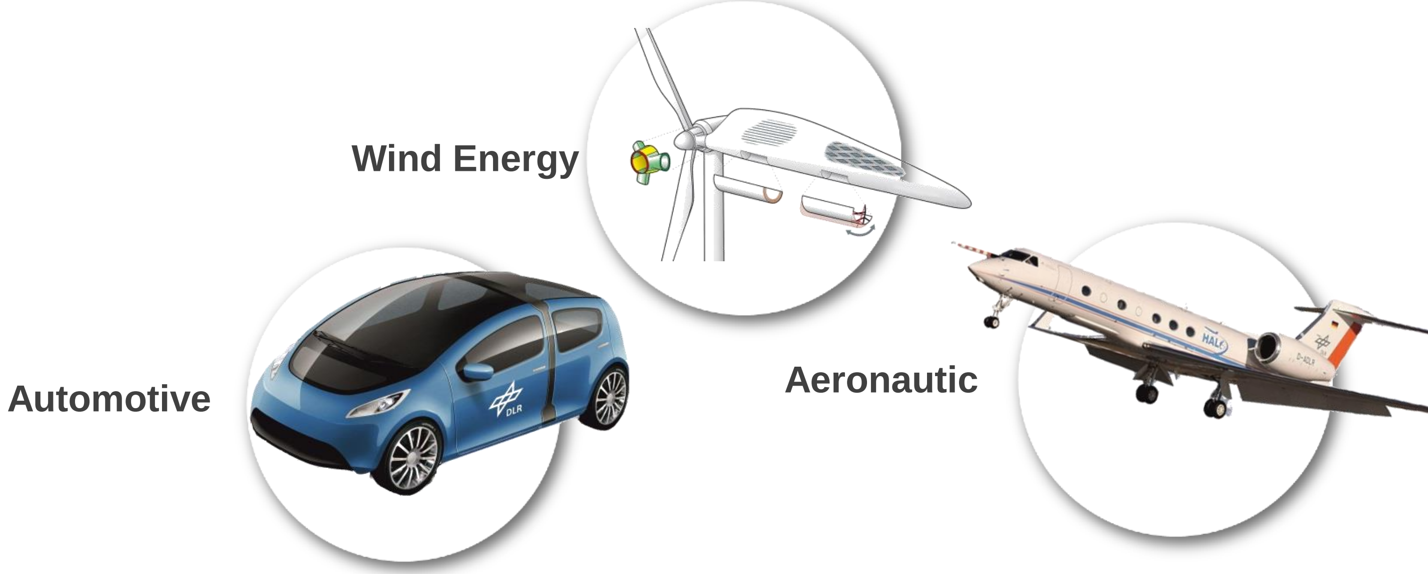
Motivation
Industry 4.0

The term ‘**Industry 4.0**’ describes the **integration** of **product development**, **production**, logistics and customers within **intelligent networks**. **Materials** and **precursor products**, **production machines** and consumer products will connect with the digital network and be **modelled in a virtual world**.

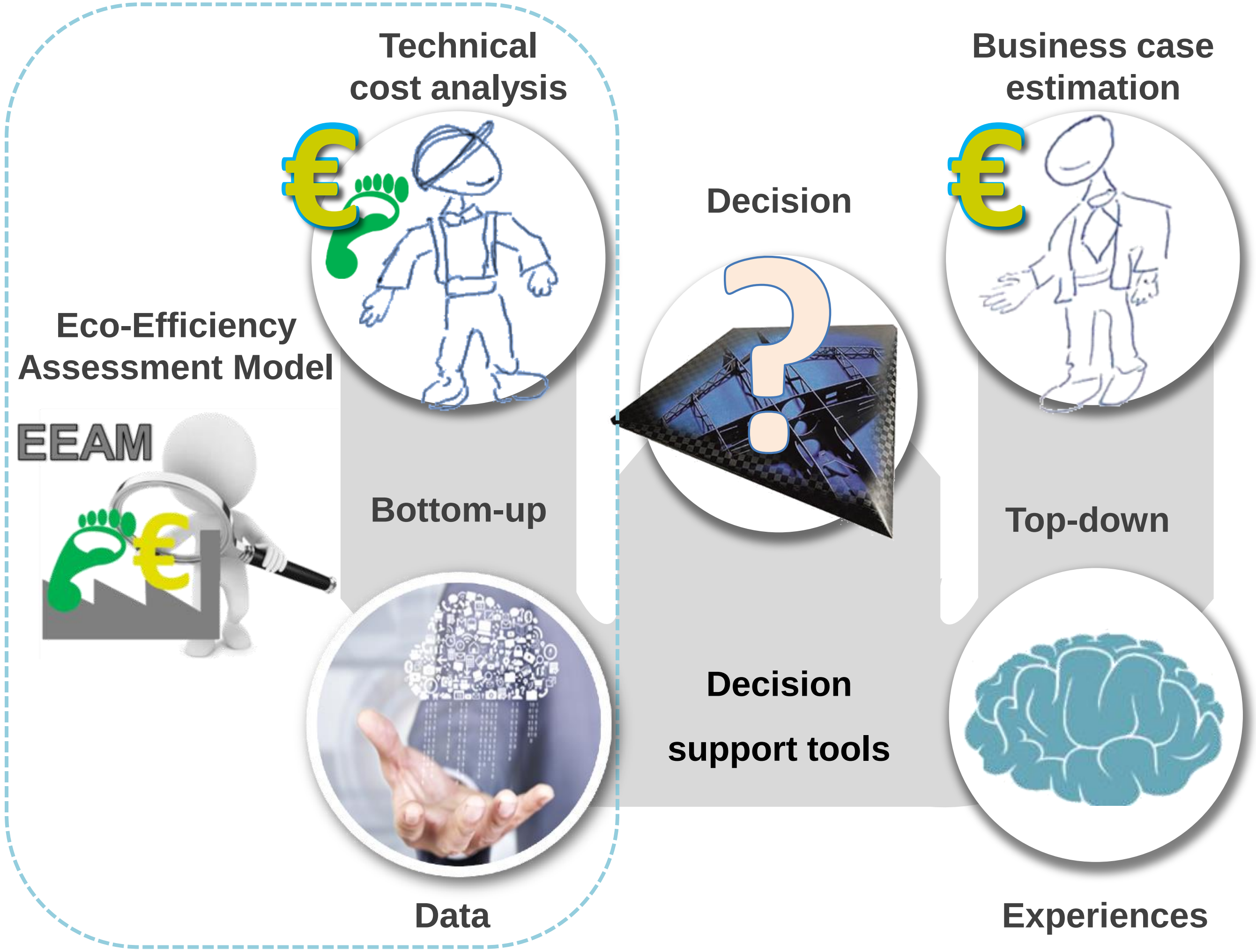
Production processes, logistics, sales, service and entire business models can be **simulated** on a computer to **evaluate** and **assess** their viability.



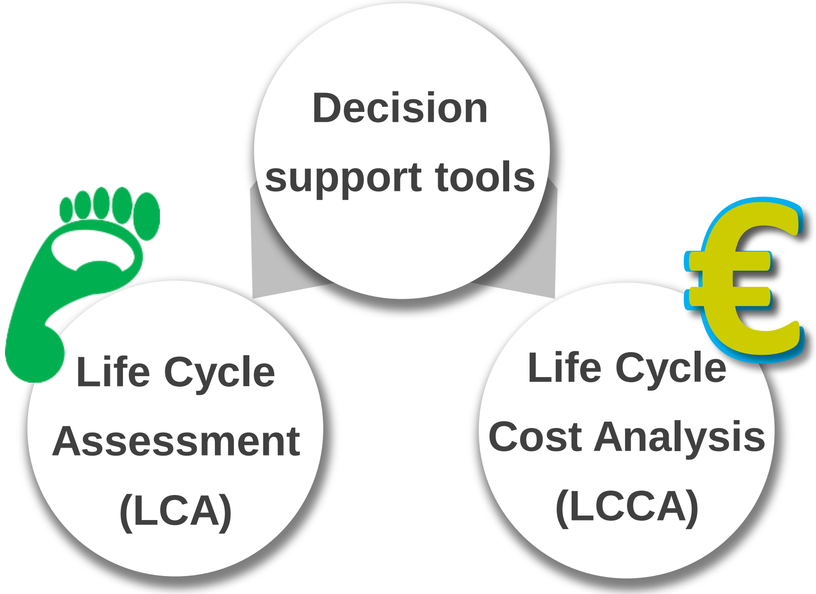
Source: DLR, Industry 4.0, Industry of the future

Assessment models

Criterions	Bottom-up	Top-down
- Data quality	☺	☹
- Single technology evaluation	☺	☹
- Data collection effort	☹	😐
- Recurring Cost (RC)	☺	☹
- Non-Recurring Cost (NRC)	😐	☺



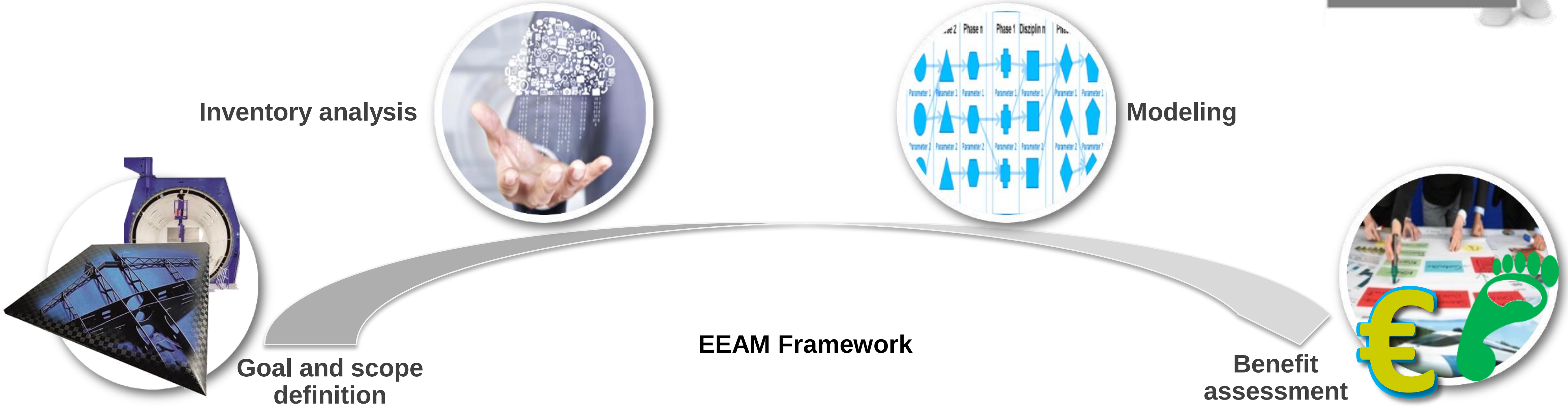
Eco-Efficiency Assessment Model (EEAM) description



Designed and developed by DLR

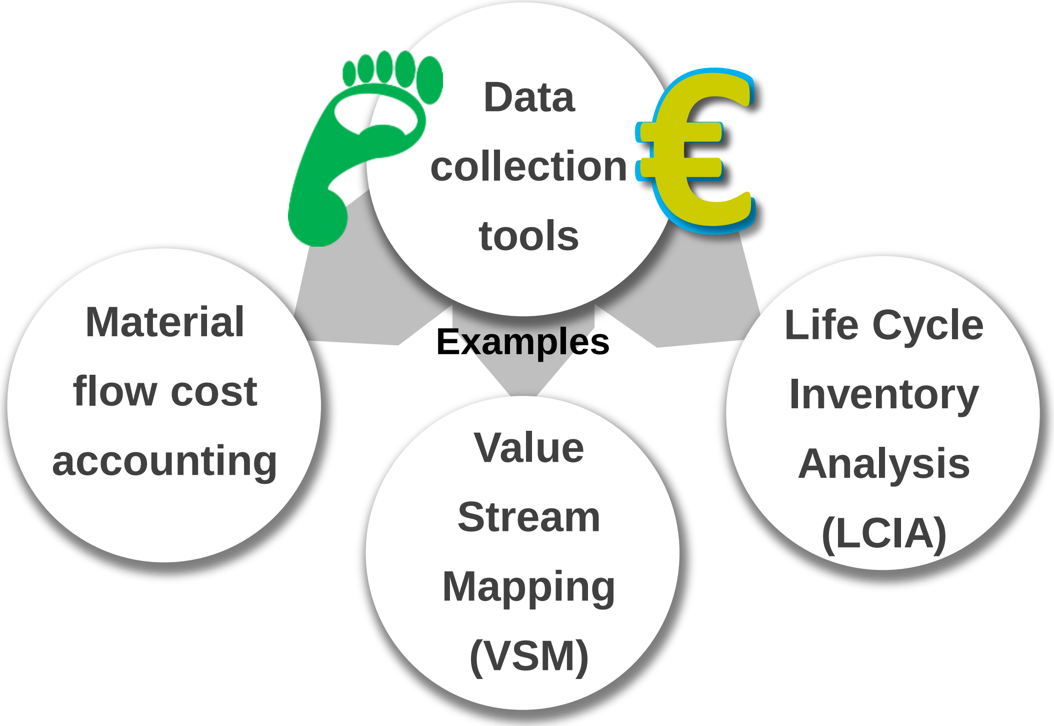
- Based on the Life Cycle Assessment (LCA): ISO 14040:2006
- Gate-to-Gate: Manufacturing and Assembly
- Process modeling: Business Process Modeling and Notation (BPMN): ISO/IEC 19510
- Combined framework of LCA and BPMN

Eco-Efficiency Assessment Model (EEAM) framework



Conventional data collection

Inventory analysis

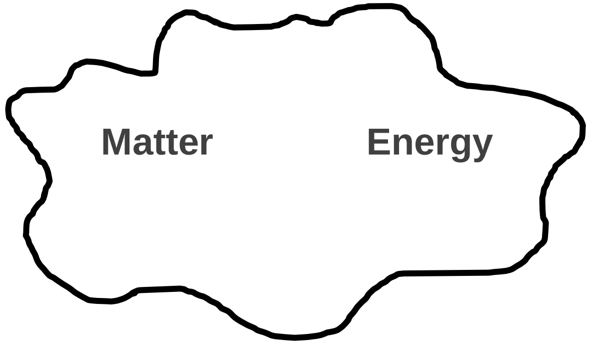


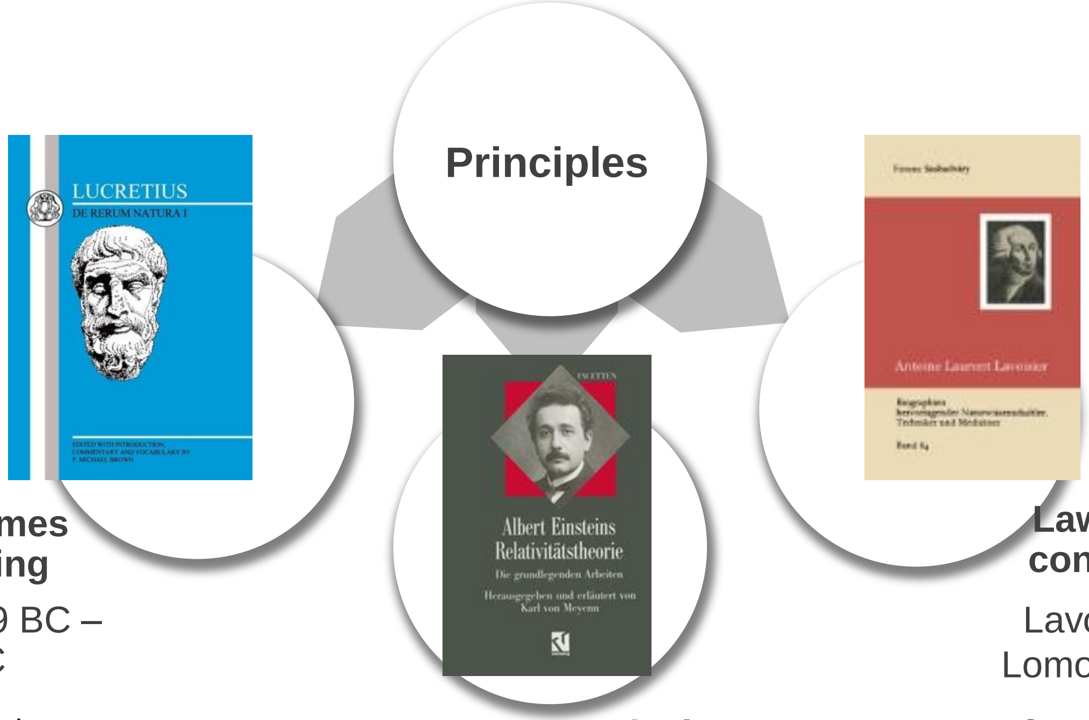
Conventional data collection

- Dedicated data collector
- Dependent data quality
- Time consuming data collection
- Offline data mining
- Offline assessment
- Automation is required for digitalization

Concept of Smart Work Station (SWS) principles

System boundary





Nothing comes from nothing

Lucretius c. 99 BC – c. 55 BC

Source: Bloomsbury

Mass–energy equivalence

Einstein's 1905

Source: Springer

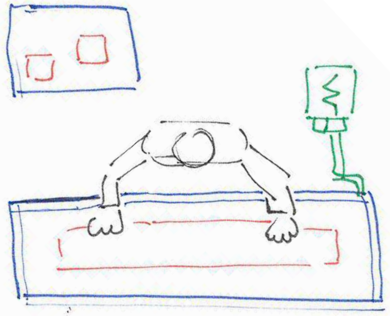
Law of mass conservation

Lavoisier 1774
Lomonosov 1756

Source: Springer

Concept of Smart Work Station (SWS) principles implementation

Smart Work Station (SWS)



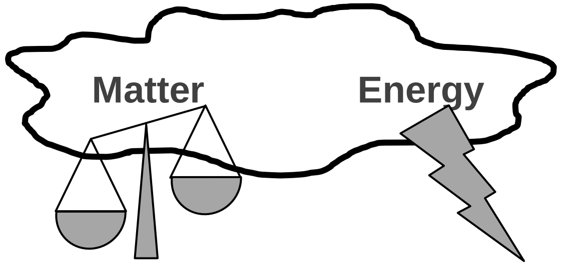
Adaptation	
- System:	UP
- System boundaries:	
- Physical:	Work station
- Time:	UP duration
- Technical:	UP Inputs

Manufacturing/ Assembly (M&A)

Unit Process (UP) 1 Unit Process (UP) n

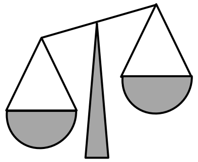
Product

System boundary

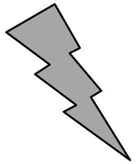


Benefits

Smart Work Station (SWS) in manufacturing and assembly of composites description



Mass

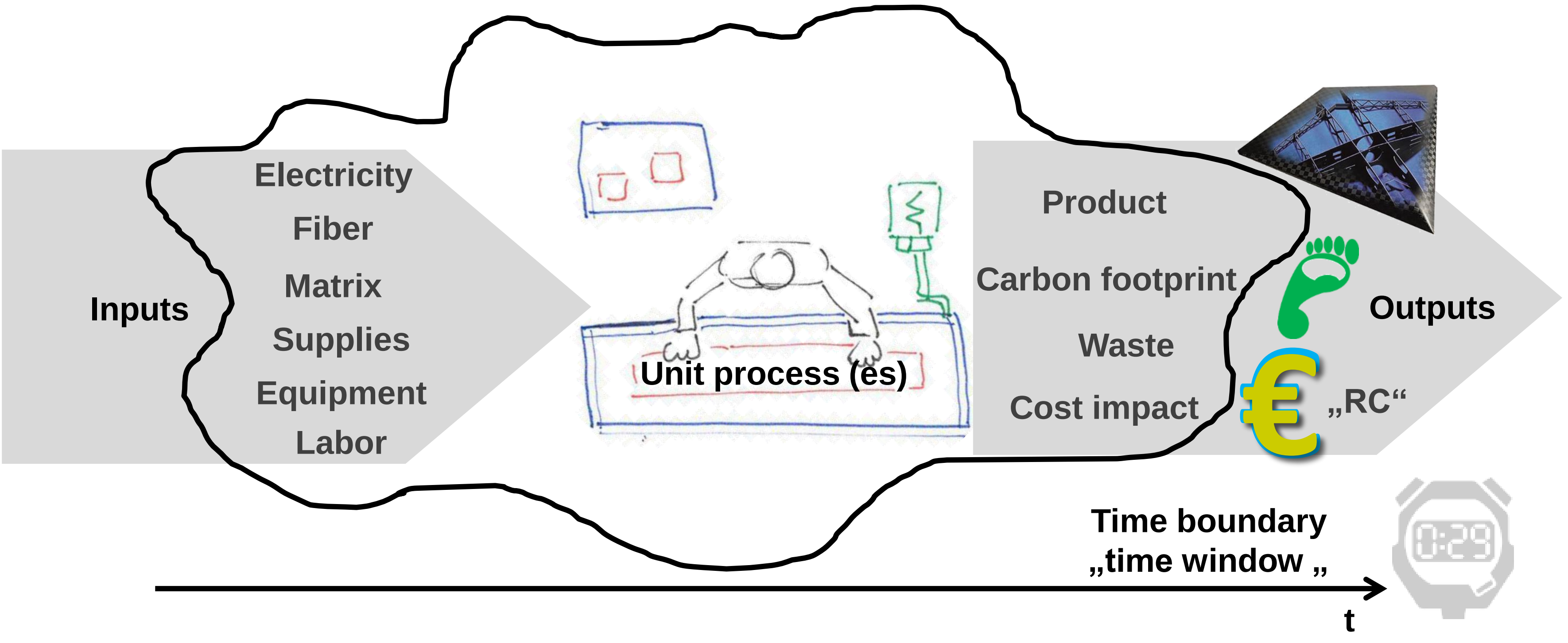


Power

Matter	Energy
Fiber	Electricity
Matrix	Equipment
Supplies	„Labor“

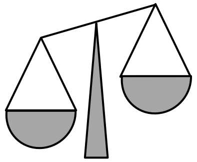
Time

Physical system boundary: Work station

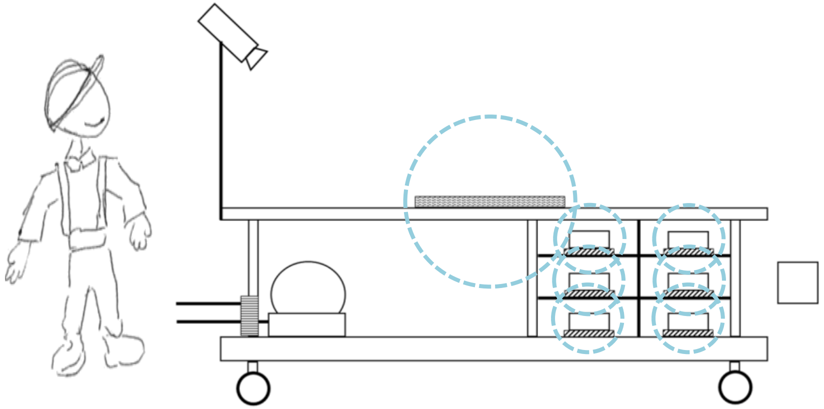


Functionality of Smart Work Station (SWS)
matter: materials

Matter
Fiber
Matrix
Supplies



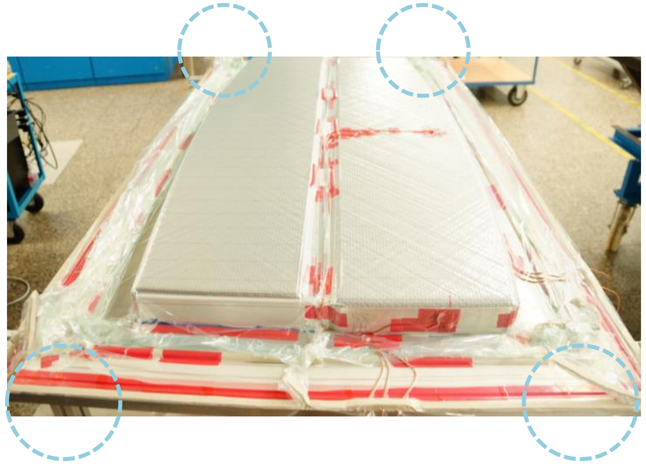
Mass



Source: HBM

Digital scale system

- Fiber holder integrated scale system (Cutter)
- Mold integrated scale system (preforming, bagging, ..)
- Scale-integrated matrix vessels
- Dedicated mini-platform scale for each supply material
- Or/ universal work mini-platform scale for all supplies with barcode detector to identify the supplies



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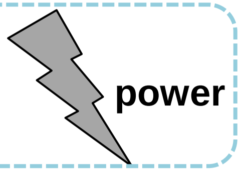
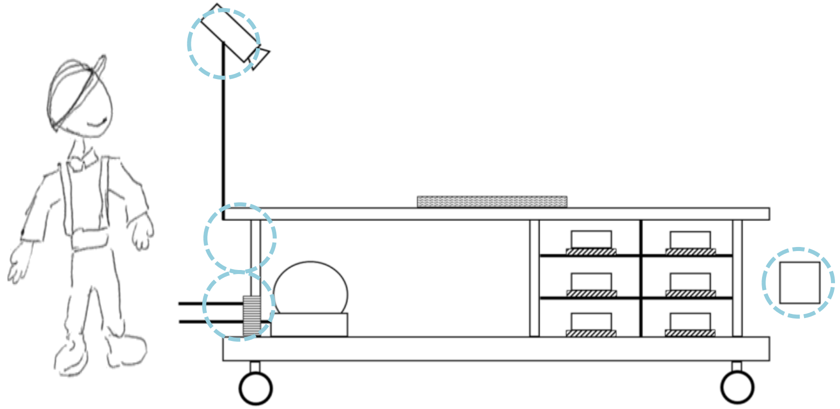
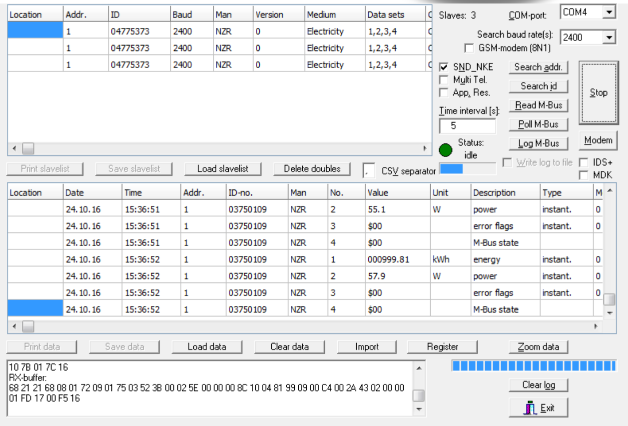
Functionality of Smart Work Station (SWS)
energy: electricity & equipment

Energy
Electricity
Equipment
„Labor“





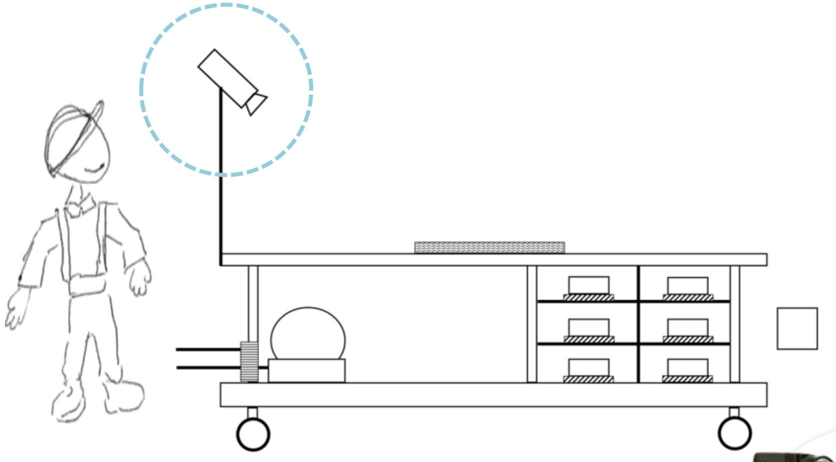


Digital electric meter system
- Defined electricity source of each work station
- Defined electricity source of each equipment
- Dedicated electric meter for each equipment

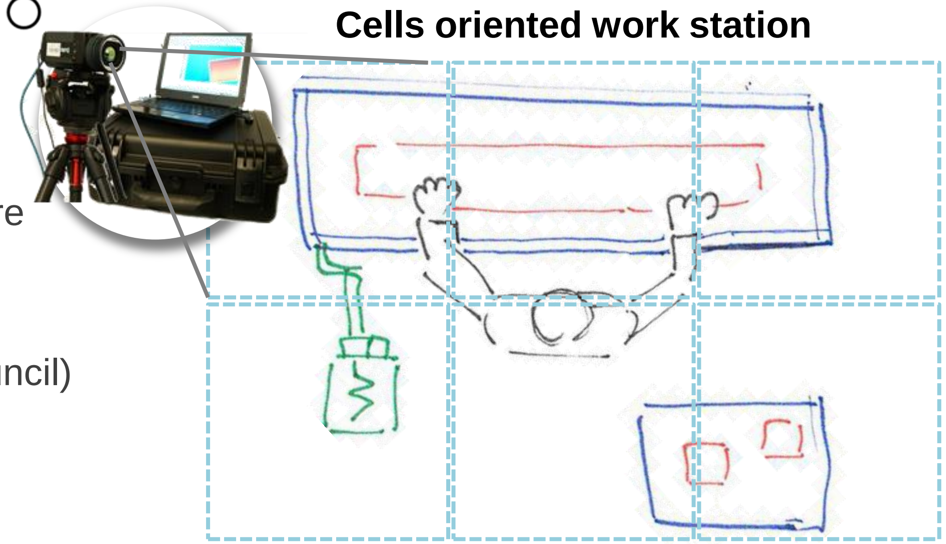
Functionality of Smart Work Station (SWS)
energy: labor work

Energy
Electricity
Equipment
„Labor“

Time



Cells oriented work station



Digital work time detection

- Cells oriented work station to detect the work efforts (in case of more than one worker)
- Video camera with motion detection functionality for each cell
- Infra-red camera with thermal detection (allowed by German works council)
- Labor work is measured as simplified input (either yes or no: no effort measurement)

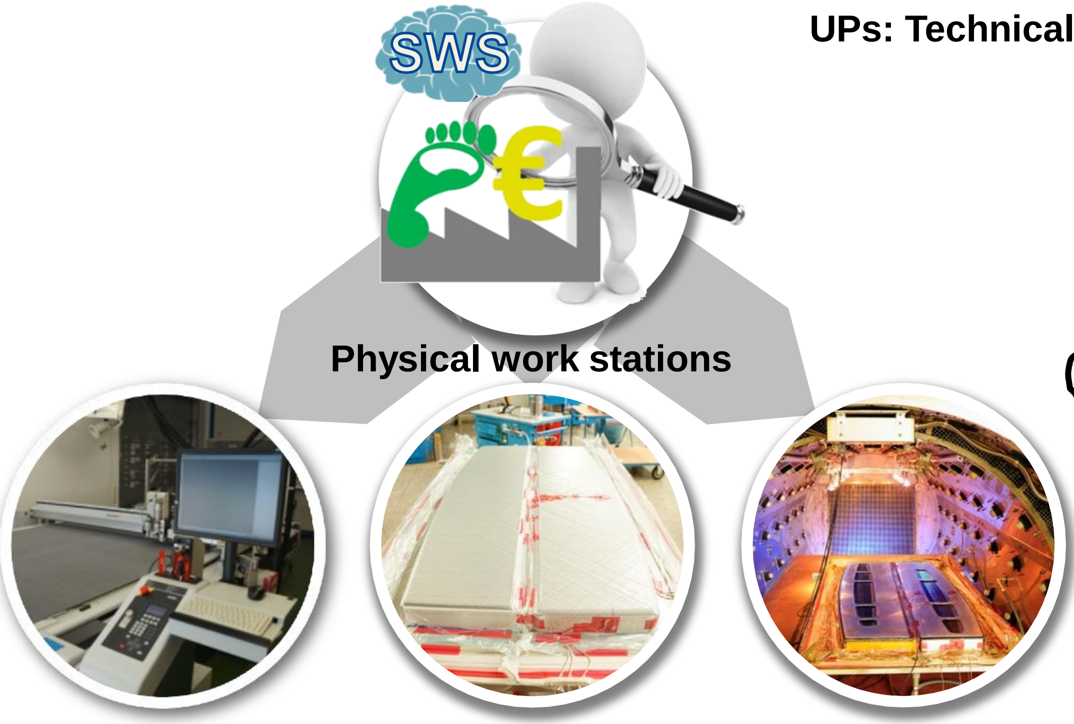
Smart Work Station (SWS) example

Manufacturing of fiber reinforced polymers (FRP)

Cutting → Preforming → Bagging → Infusion → Tempering → Demolding

Example of CFRP

UPs: Technical system boundary

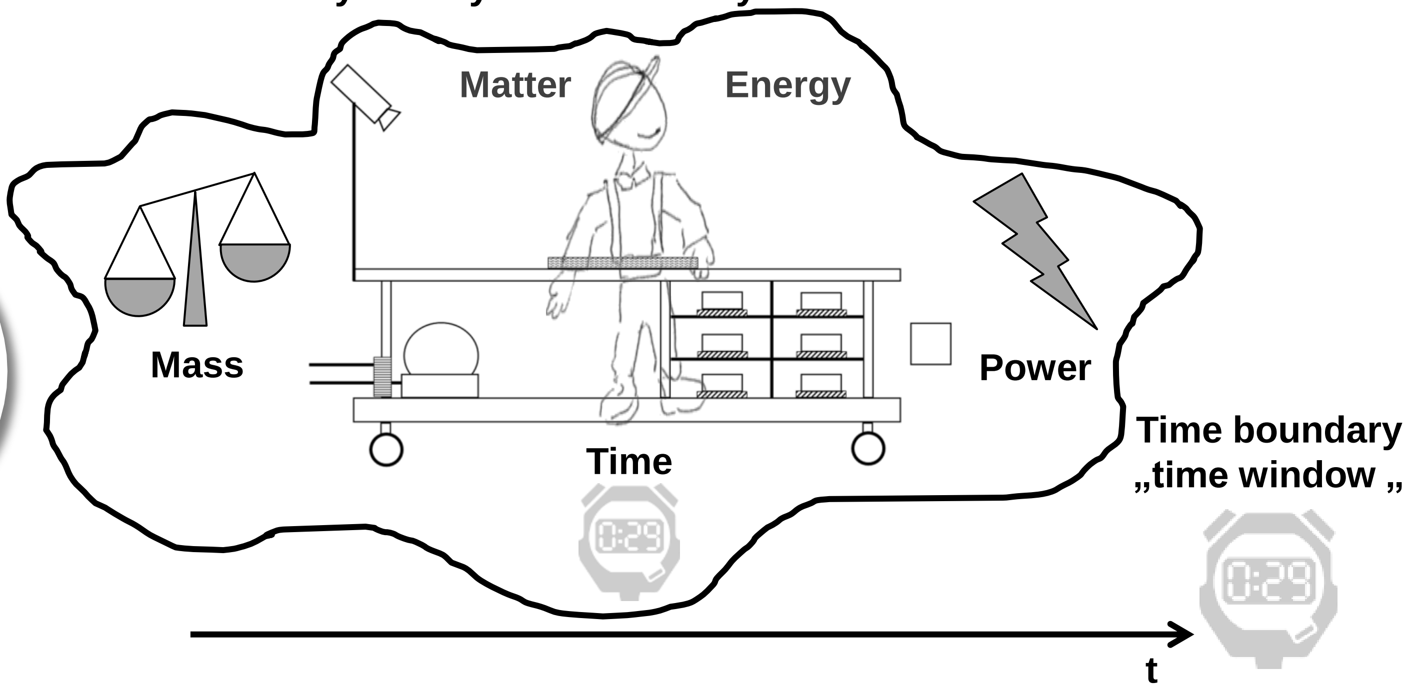


Cutting

Preforming
Bagging

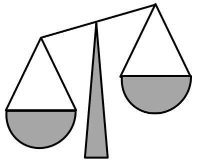
Infusion
Tempering
Demolding

Physical system boundary



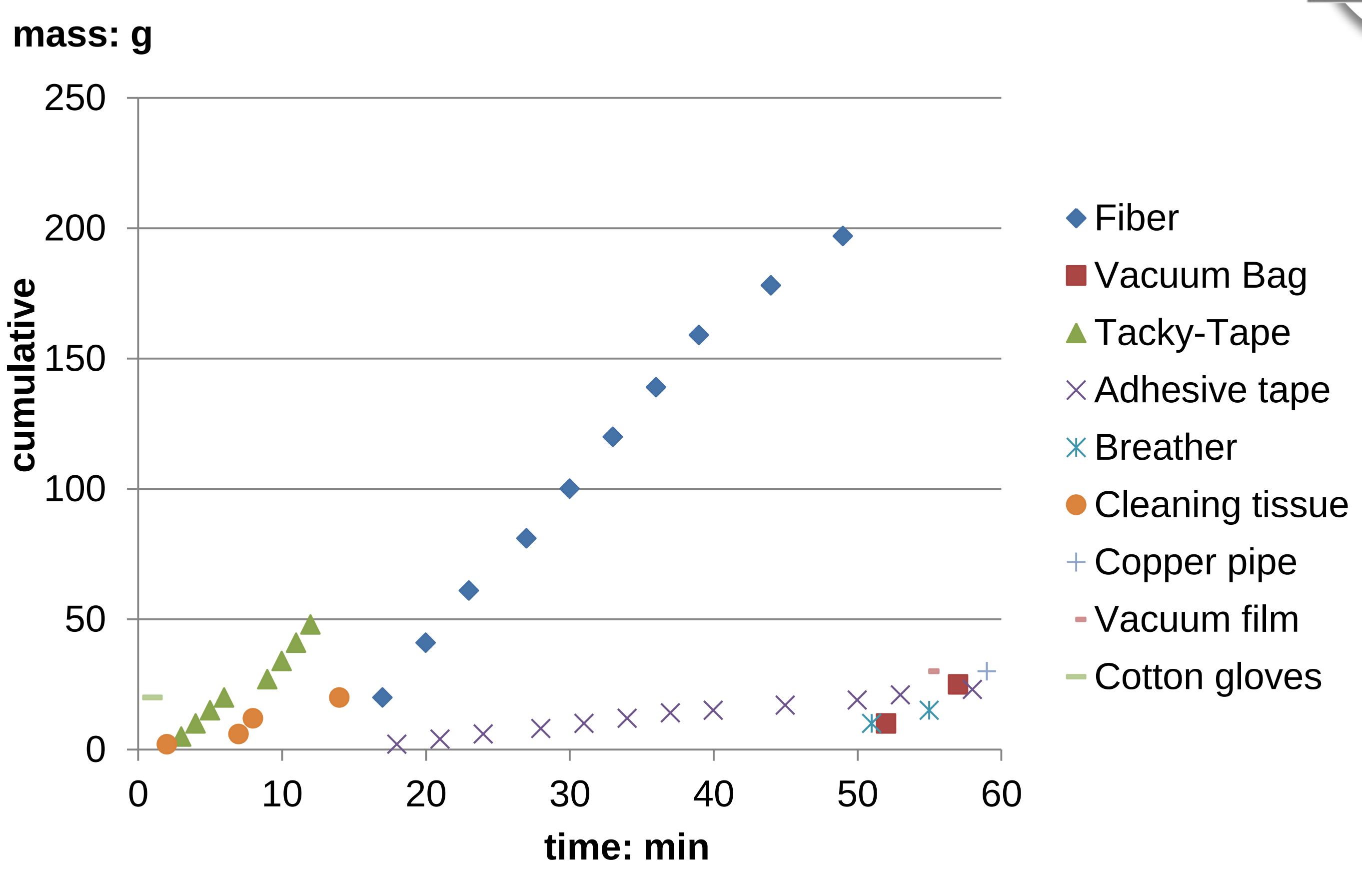
Results of Smart Work Station (SWS)
example of materials data

Matter
Fiber
Matrix
Supplies



Mass

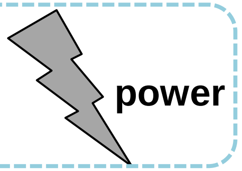
Preforming
Bagging



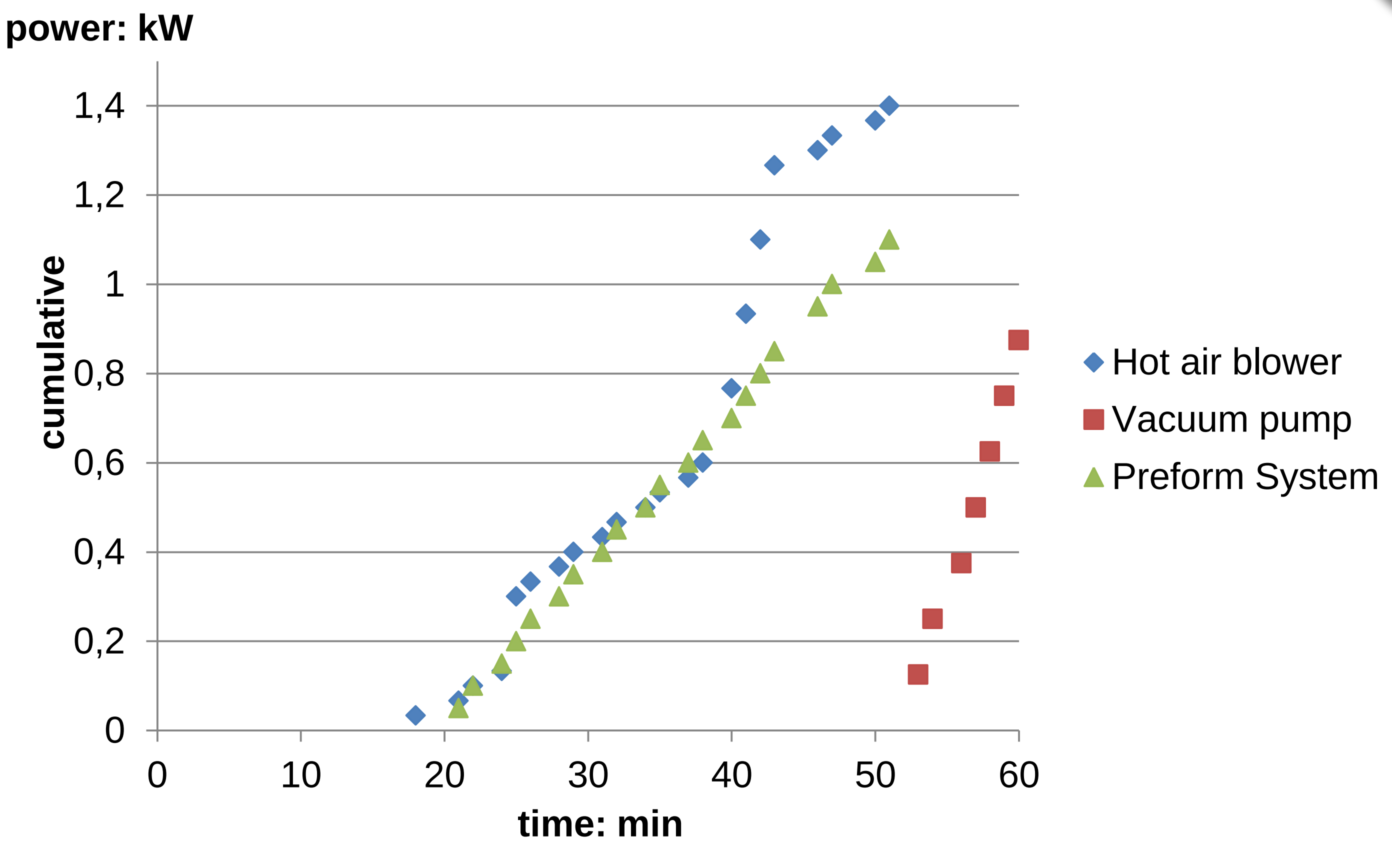
these data are estimated and not collected

Results of Smart Work Station (SWS)
example of electricity & equipment data

Energy
Electricity
Equipment
„Labor“



Preforming Bagging



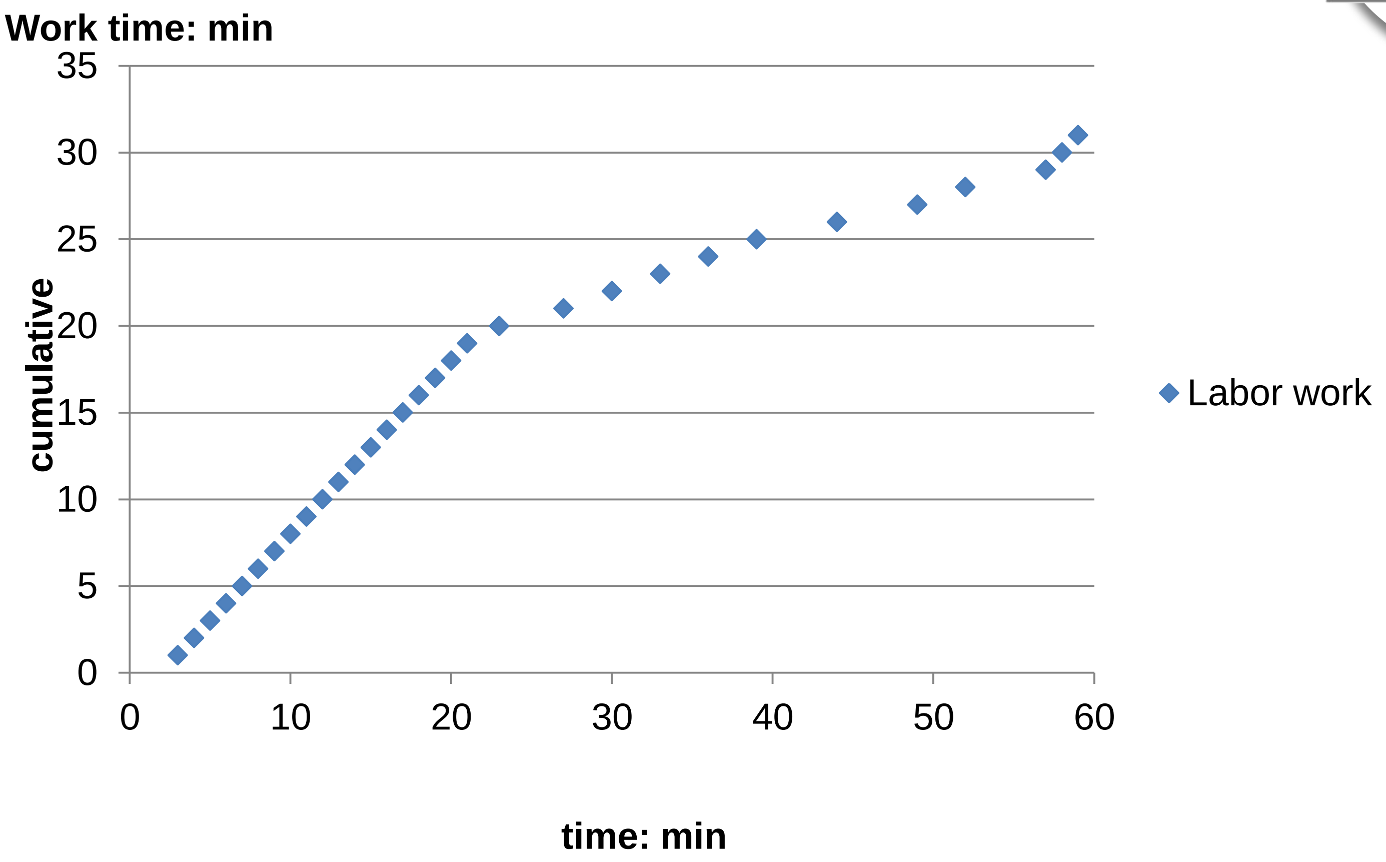
these data are estimated and not collected

Results of Smart Work Station (SWS)
example of labor work data

Energy
Electricity
Equipment
„Labor“

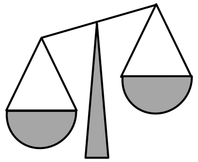
Time

Preforming
Bagging

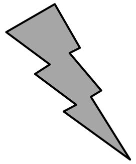


these data are estimated and not collected

Results of Smart Work Station (SWS)
example of combined inputs



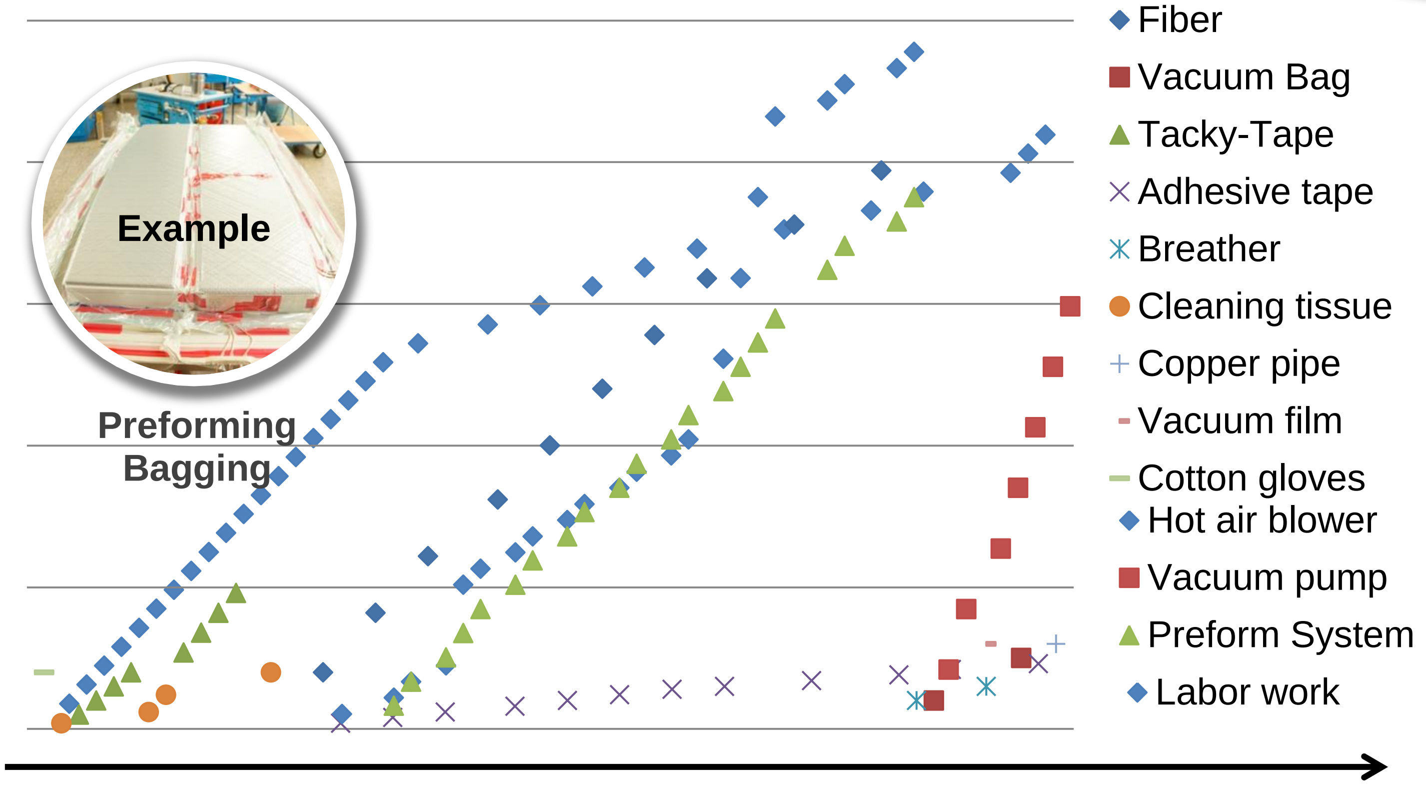
Mass



Power

Matter	Energy
Fiber	Electricity
Matrix	Equipment
Supplies	„Labor“

Time

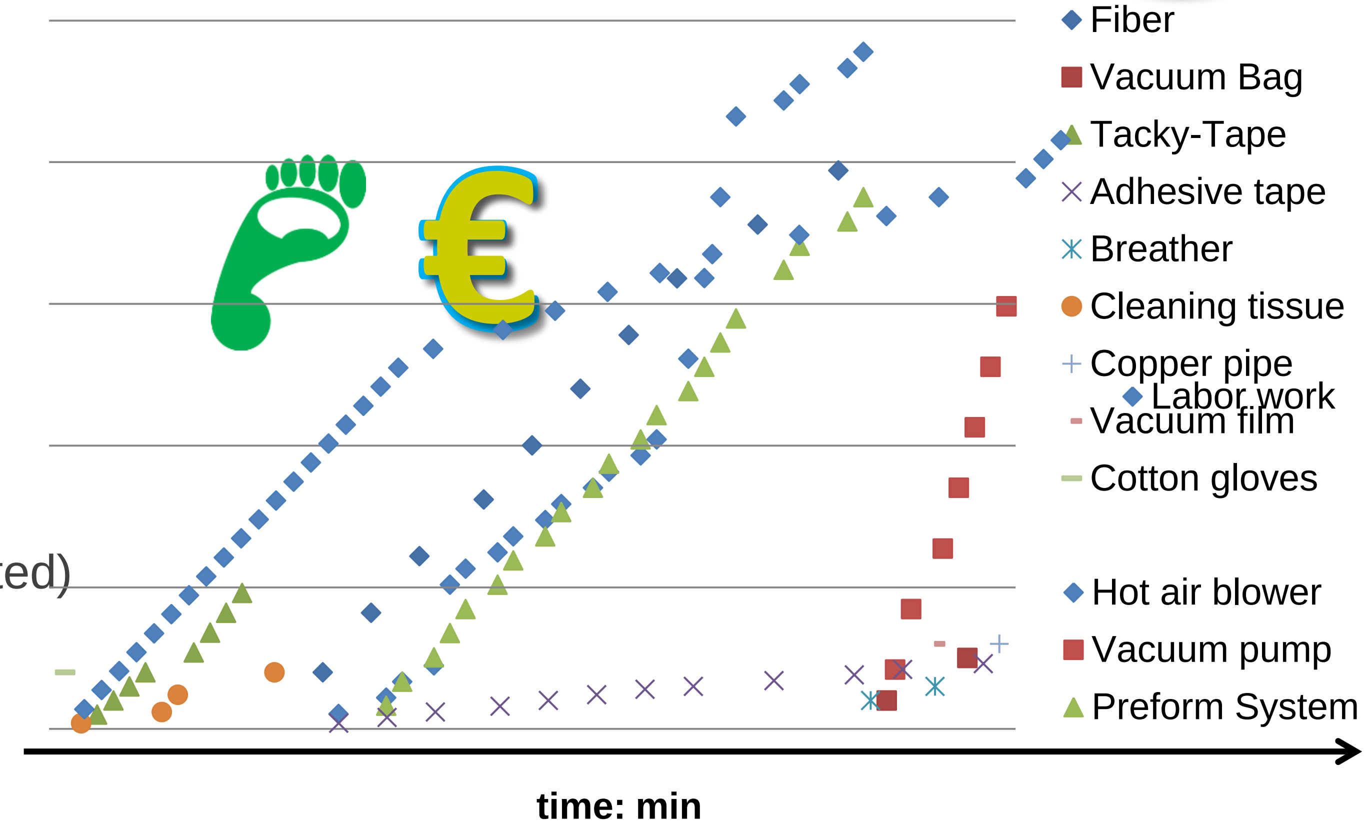


time: min

Benefits of Smart Work Station (SWS)
benefit assessment & Industry 4.0

Industry 4.0

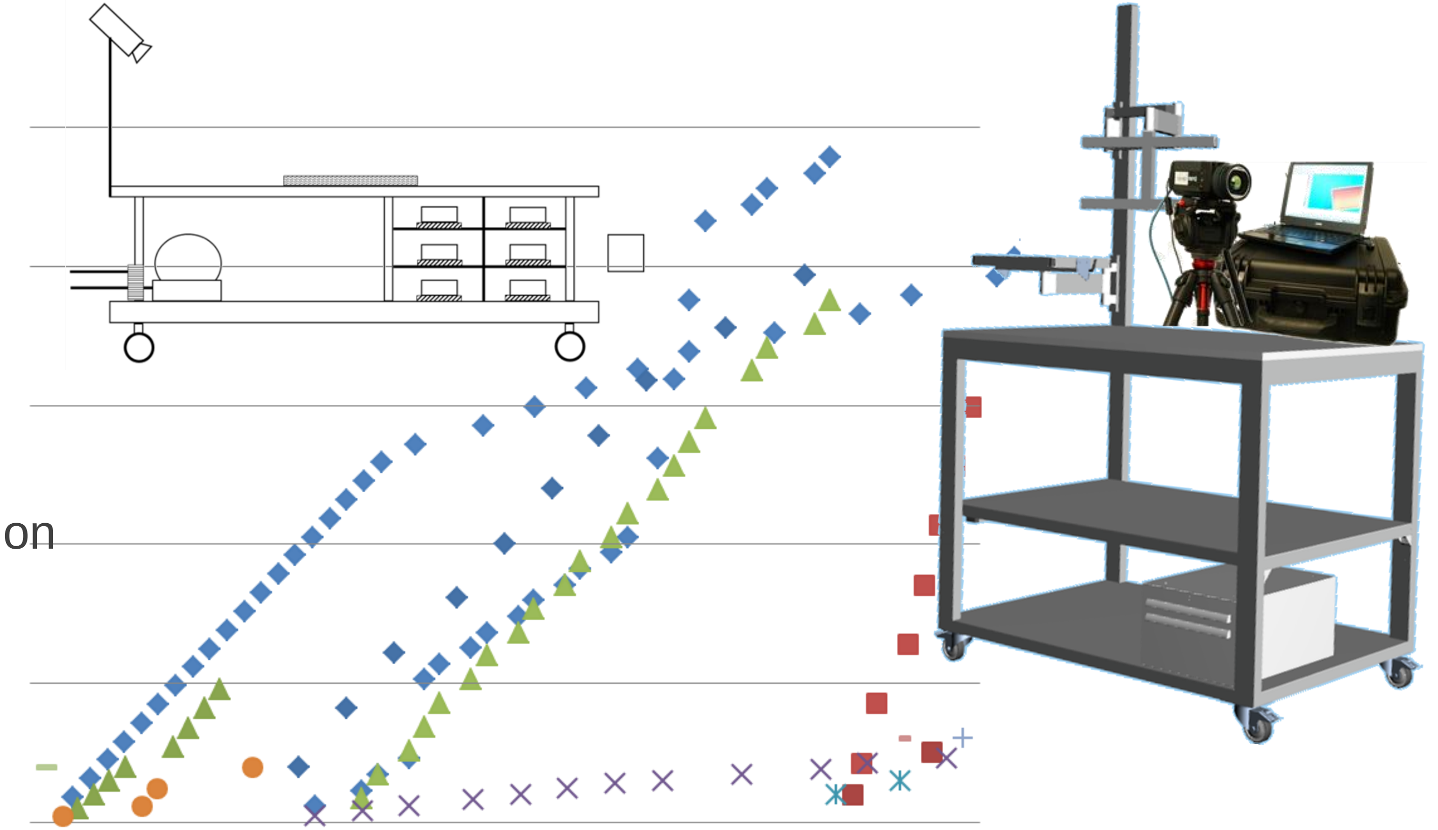
SWS data collection
- No data collector is required
- Independent & repeatable data quality
- „0“ time consuming data collection (automated)
- Online data mining
- Online assessment
- Process automation is not a prerequisite
- Universal: process associated



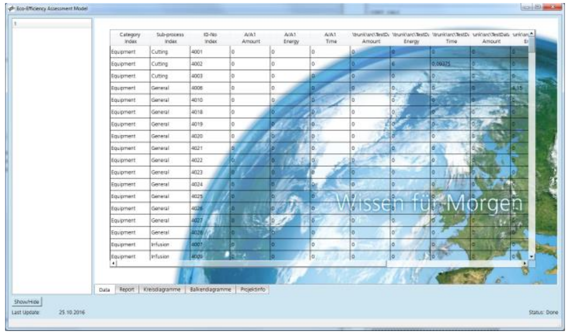
Outlook
next steps in SWS

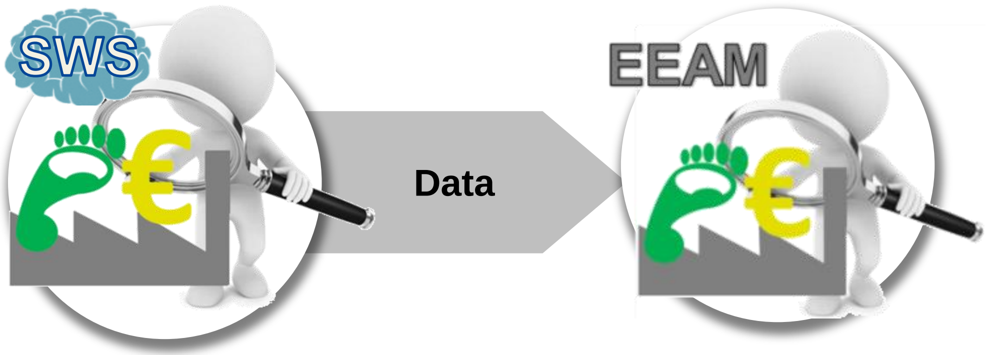
Realization
- Construction
- Development of digital interfaces
- Development of data collection software
- Validation intern
- Validation with partners

Enhancement
- Size extention: scale limitation
- Connection of work stations
- Developement of accurate camera detection
- Data dual-use: product quality assurance
(as designed vs. as manufactured)

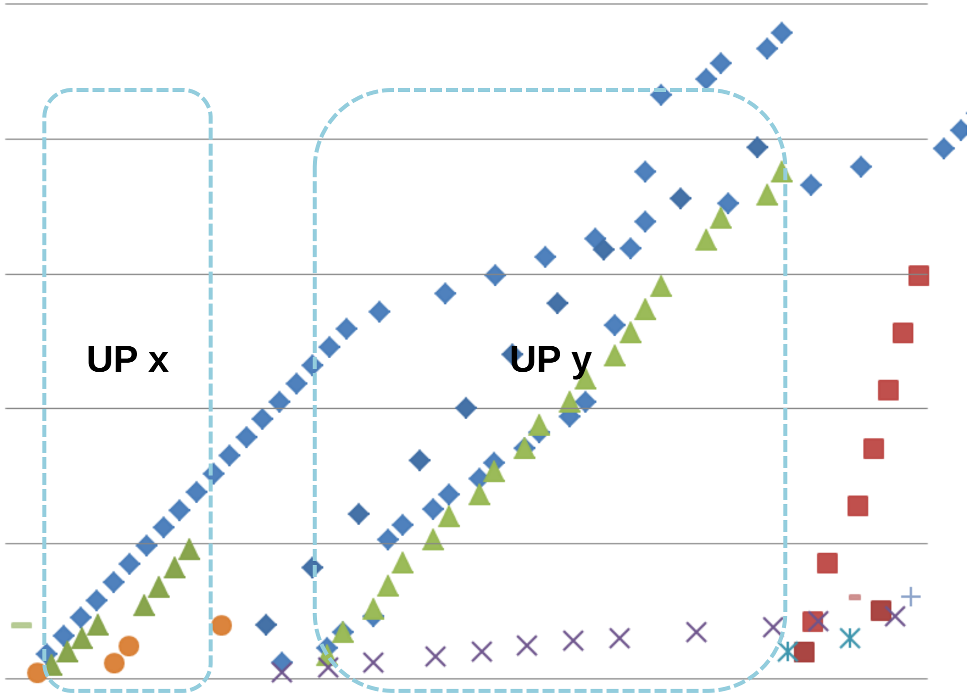


Outlook
next steps in EEAM





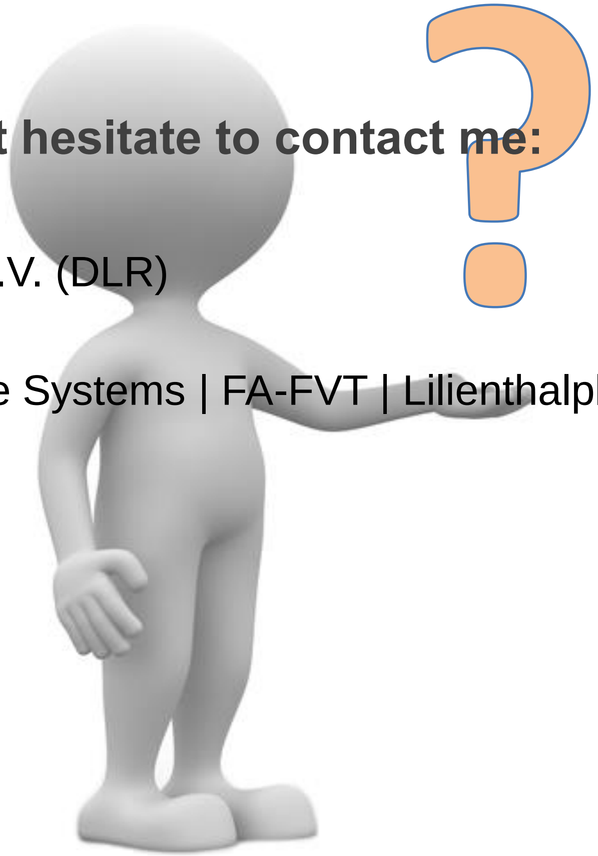
SWS & EEAM
- Correlation of SWS & EEAM
- Online benefit assessment
- Parameterization
- Independent process definition based on parameterization



Eco-Efficiency Estimation Model (EEEM)
- Based on EEAM & parameterization
- Combining bottom-up (RC) with top-down (NRC)
- Benefit estimation in early design phase
- Design-to-Cost (DTC)
- Top-down based on bottom-up
- Design for Manufacturing and Assembly (DFMA)

Discussion

Thank you for your attention!



For any further questions please don’t hesitate to contact me:

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