

Novel applications in assessing manufacturing and assembly of complex composite structures

A pace towards Industry 4.0 in composite manufacturing

11th AIRTEC Congress

Munich, October 27th, 2016

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Institute of Composite Structures and Adaptive Systems

A large, curved image of the Earth from space occupies the bottom right portion of the slide. It shows a blue horizon, white clouds, and green landmasses, including parts of Europe and Africa.

Knowledge for Tomorrow

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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**



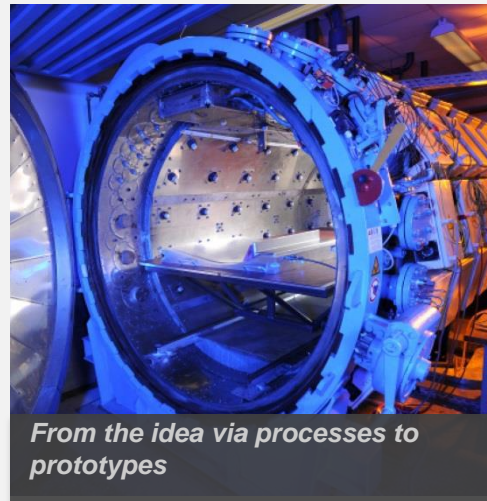
We align our research along the entire process chain for building adaptable, tolerant, efficiently manufactured light weight structures.

For excellent results in the basic research and industrial application.

Department of Composite Technology

Dr. -Ing. M. Kleineberg

Tailored manufacturing concepts

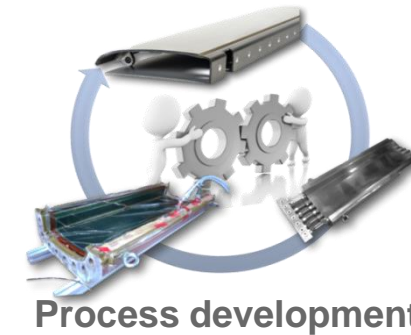


From the idea via processes to prototypes

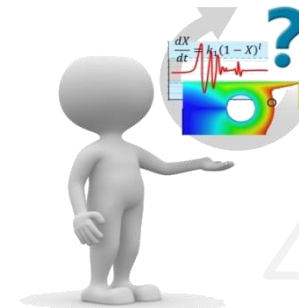
- New technologies for manufacturing
- Hybrid manufacturing
- Assembly
- Repair
- Process automation

Process Assessment

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



Process development

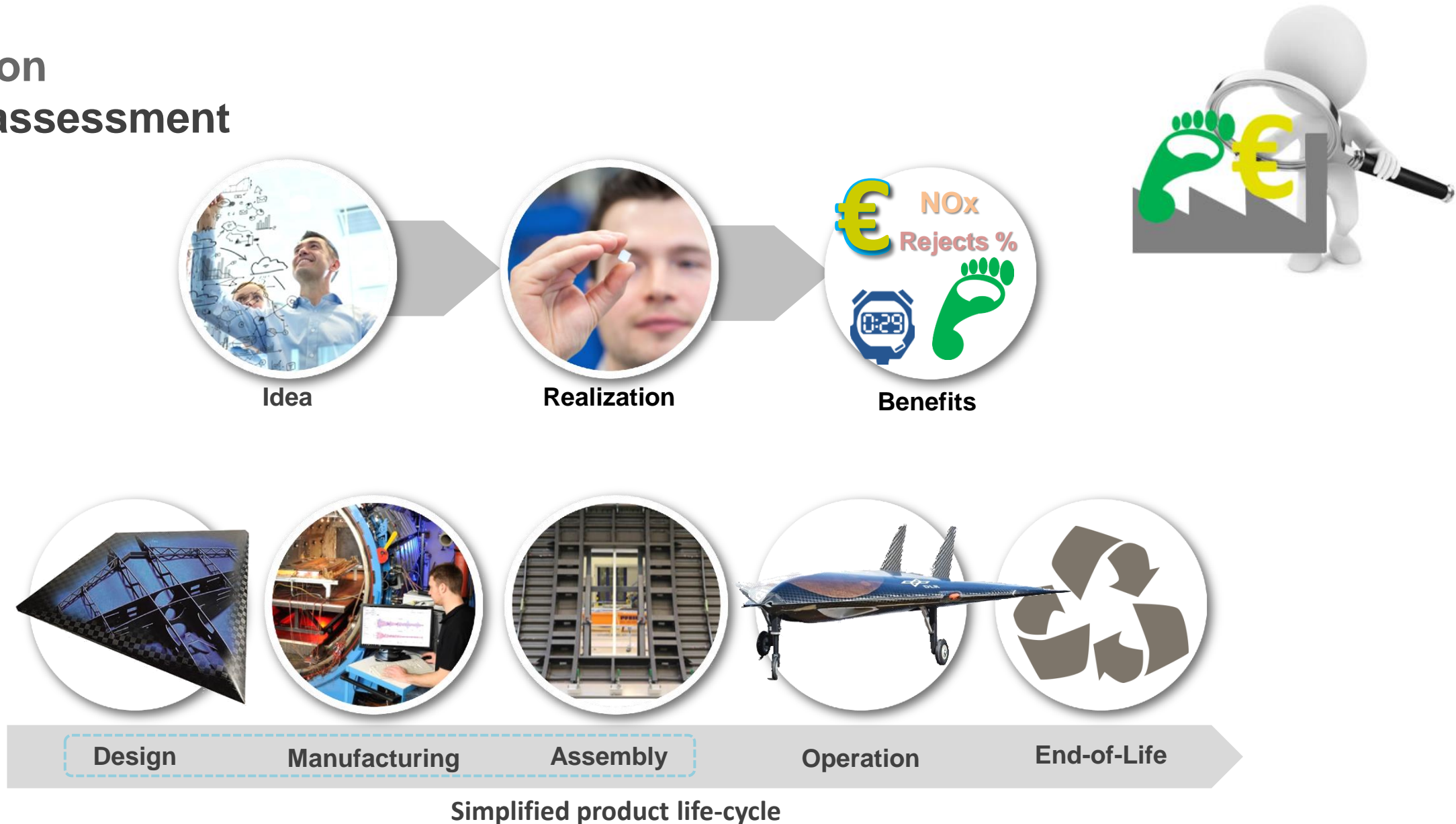


Process analysis



Process assessment

Motivation benefit assessment



Motivation Industry 4.0

The term '**Industry 4.0**' describes the **integration** of **product development**, **production**, logistics and customers within **intelligent networks**.

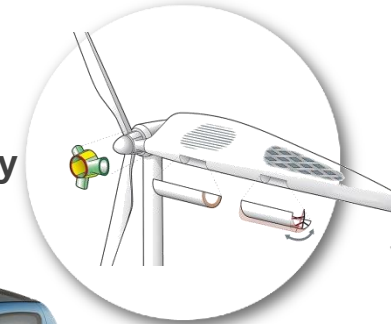
Materials and **precursor products**, **production machines** and consumer products will connect with the digital network and be **modelled in a virtual world**.

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

Automotive



Wind Energy













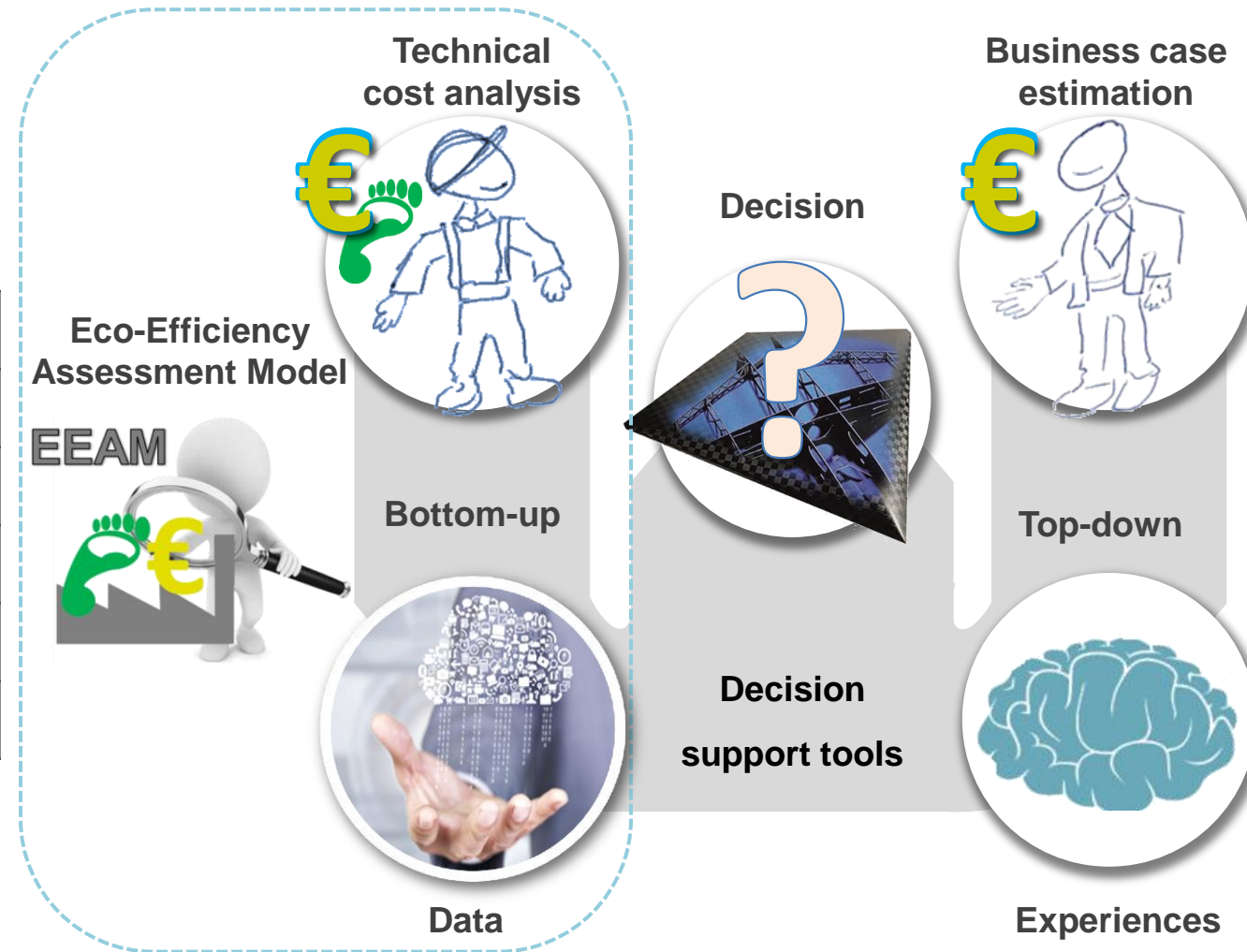
Aeronautic



Source: DLR, Industry 4.0, Industry of the future

Assessment models

Criteria	Bottom-up	Top-down
- Data quality		
- Single technology evaluation		
- Data collection effort		
- Recurring Cost (RC)		
- Non-Recurring Cost (NRC)		

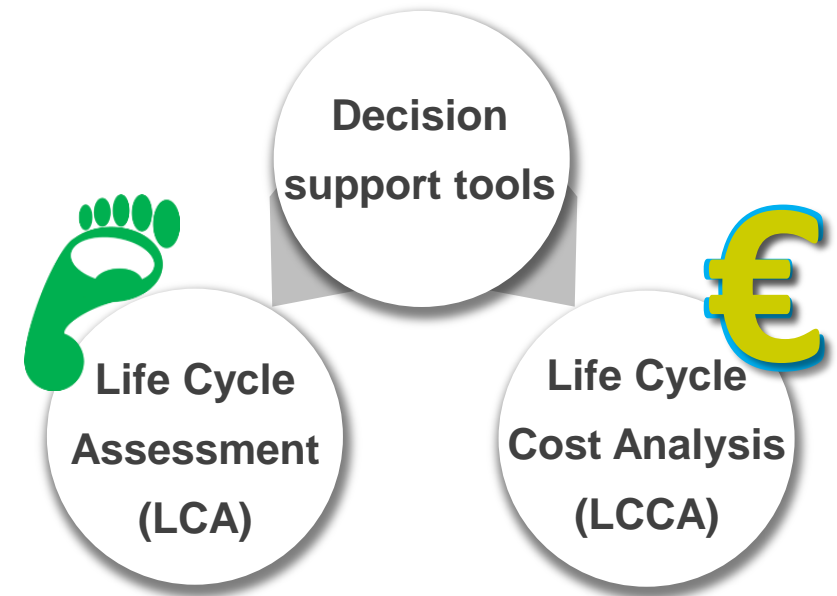


Eco-Efficiency Assessment Model (EEAM) description

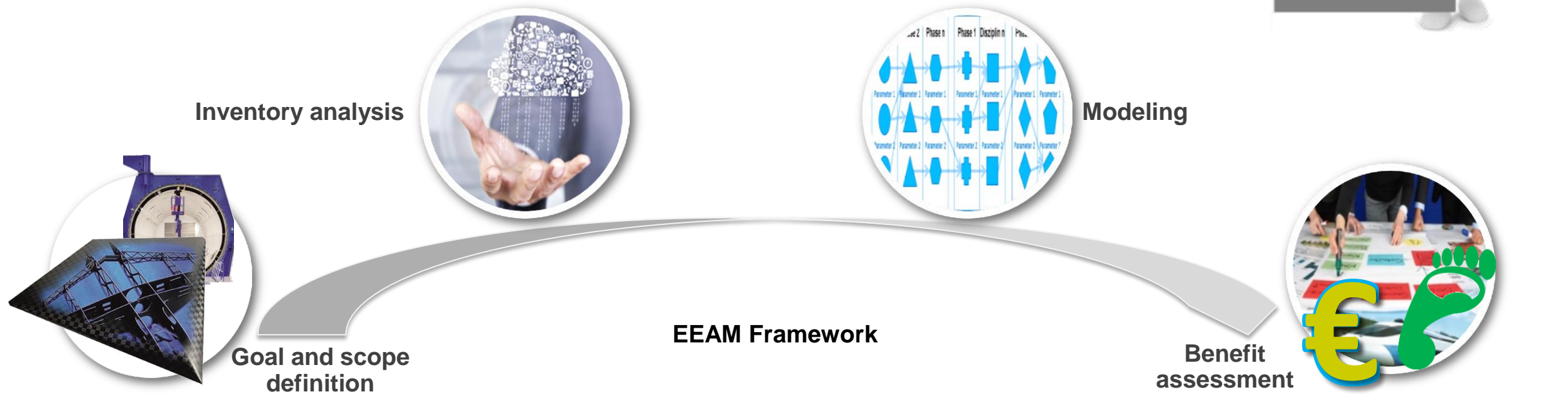


Designed and developed by DLR

- 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

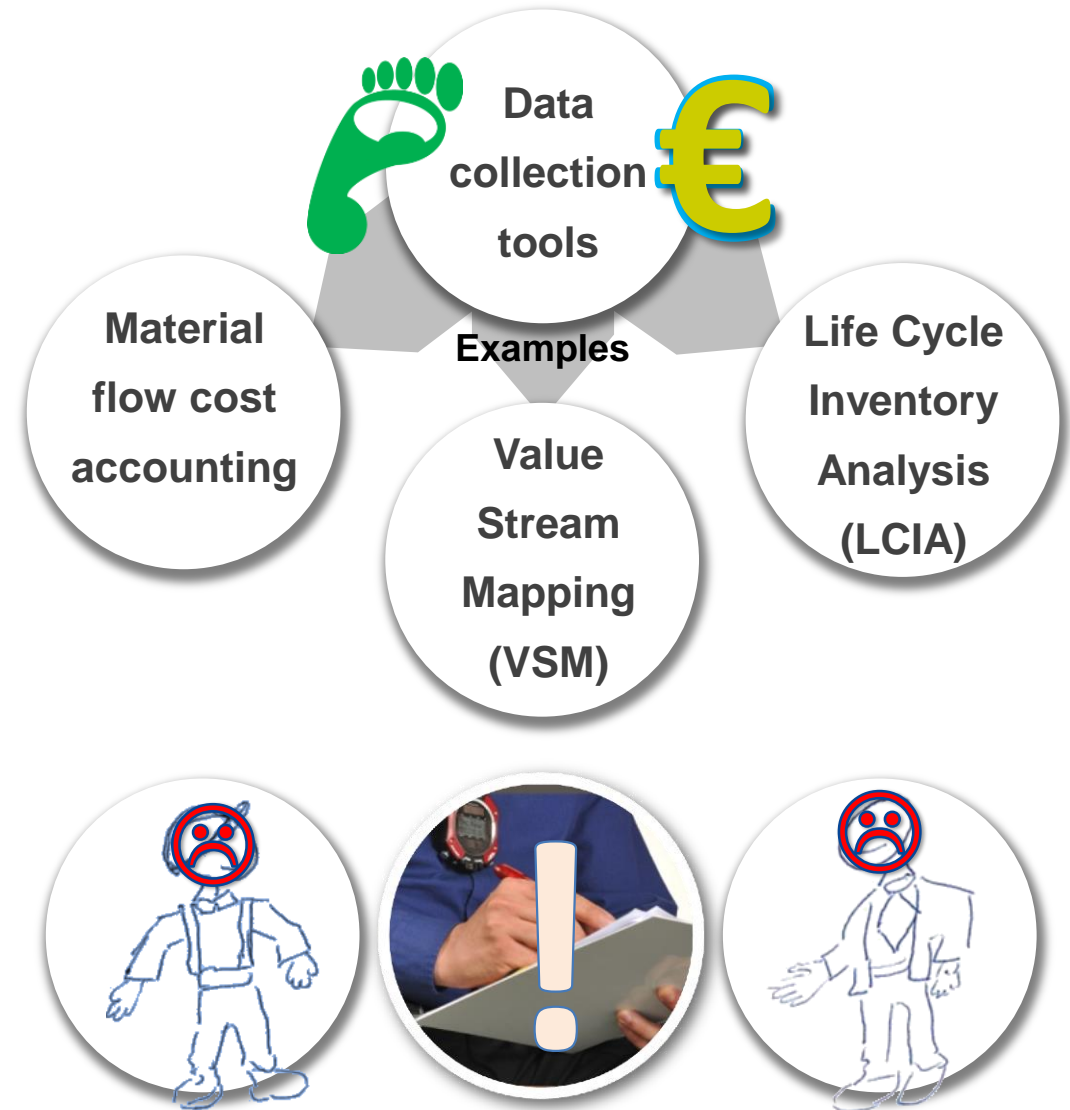


Inventory analysis

Conventional data collection

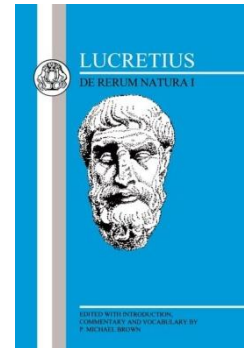
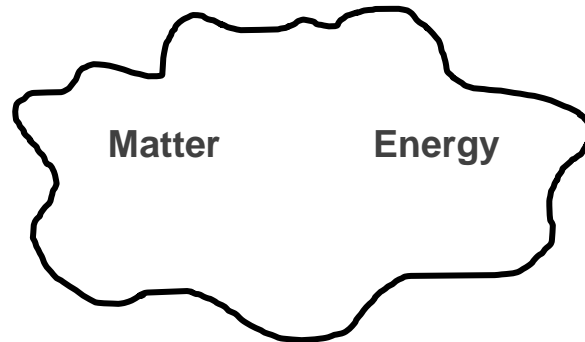


- Dedicated data collector
- Dependent data quality
- Time consuming data collection
- Offline data mining
- Offline assessment
- Automation is required for digitalization



Concept of Smart Work Station (SWS) principles

System boundary

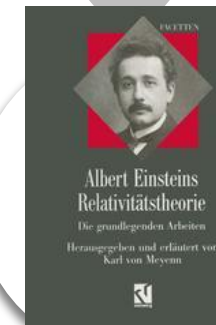


Nothing comes from nothing

Lucretius c. 99 BC –
c. 55 BC

Source: Bloomsbury

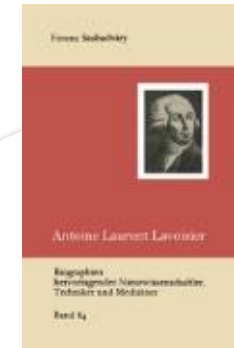
Principles



Mass–energy equivalence

Einstein's 1905

Source: Springer



Law of mass conservation

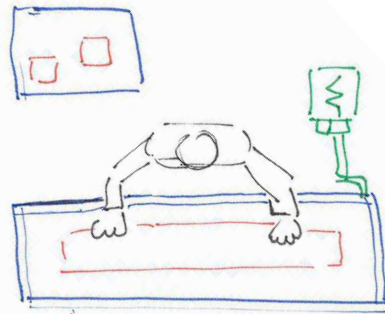
Lavoisier 1774
Lomonosov 1756

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

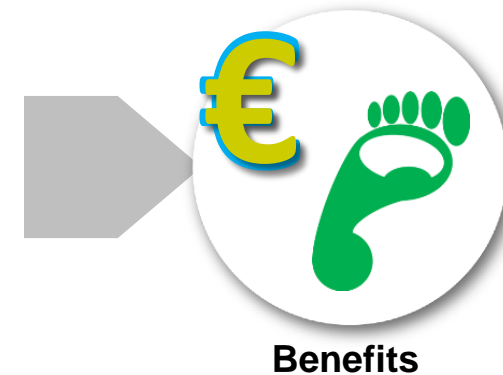
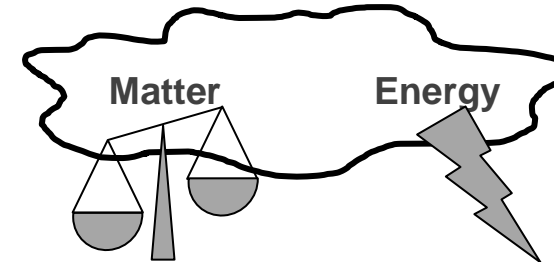
Manufacturing/ Assembly (M&A)

Unit Process (UP) 1

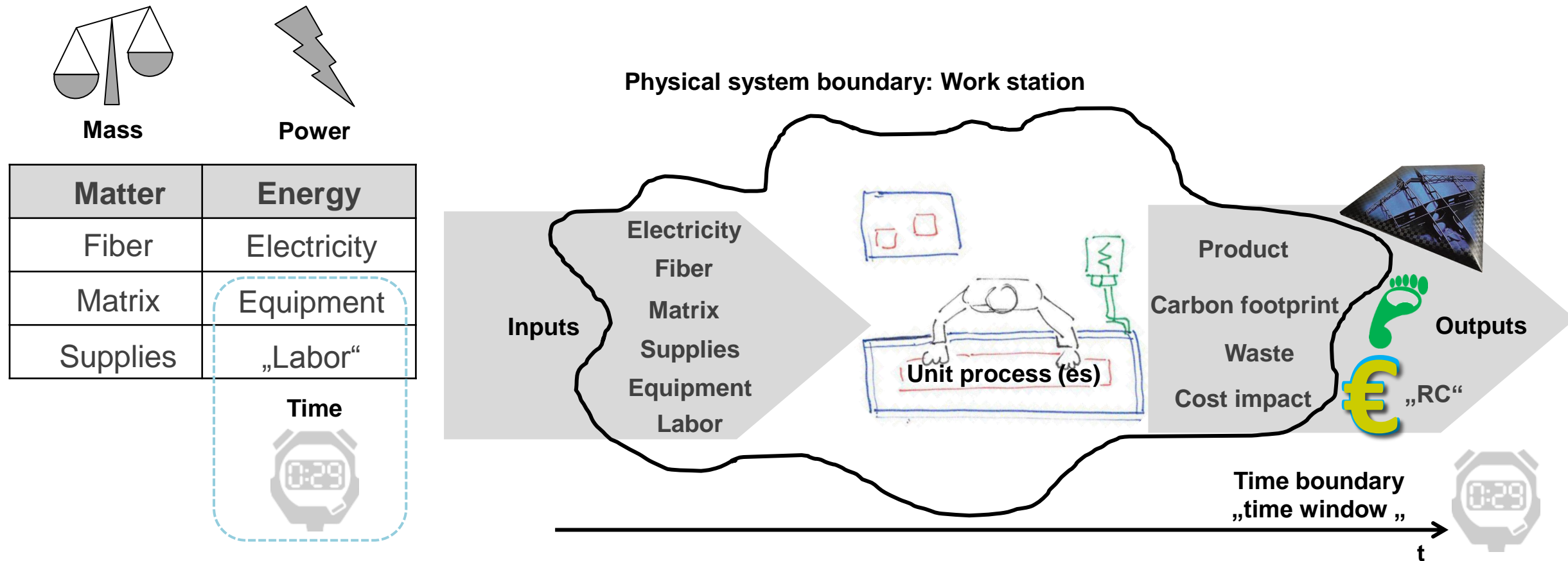
Unit Process (UP) n

Product

System boundary



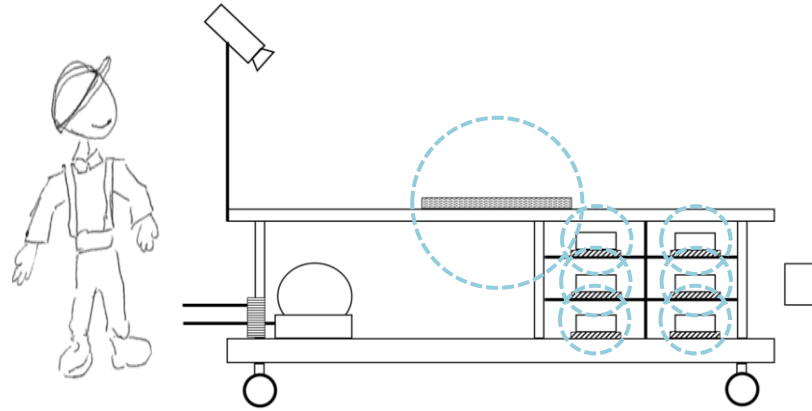
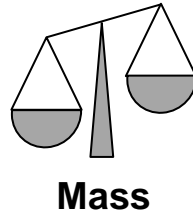
Smart Work Station (SWS) in manufacturing and assembly of composites description



Functionality of Smart Work Station (SWS) matter: materials



Matter
Fiber
Matrix
Supplies

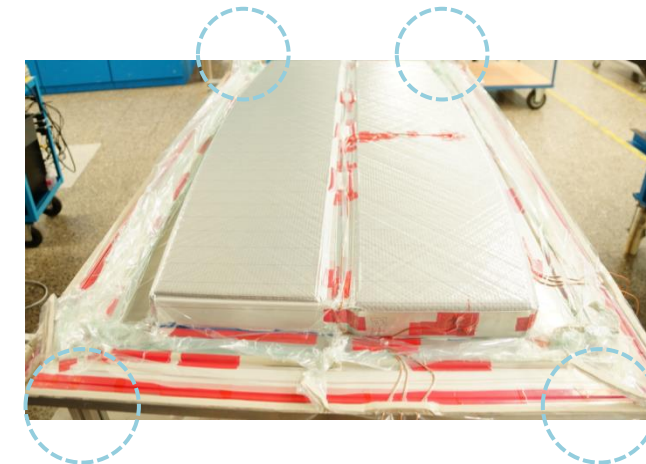


Source: HBM



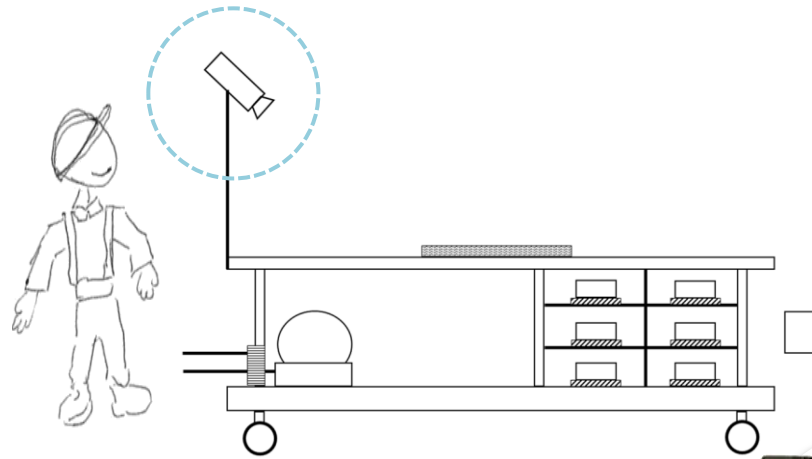
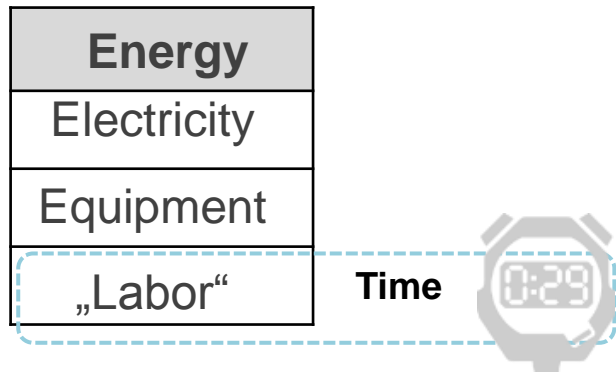
Digital scale system

- 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



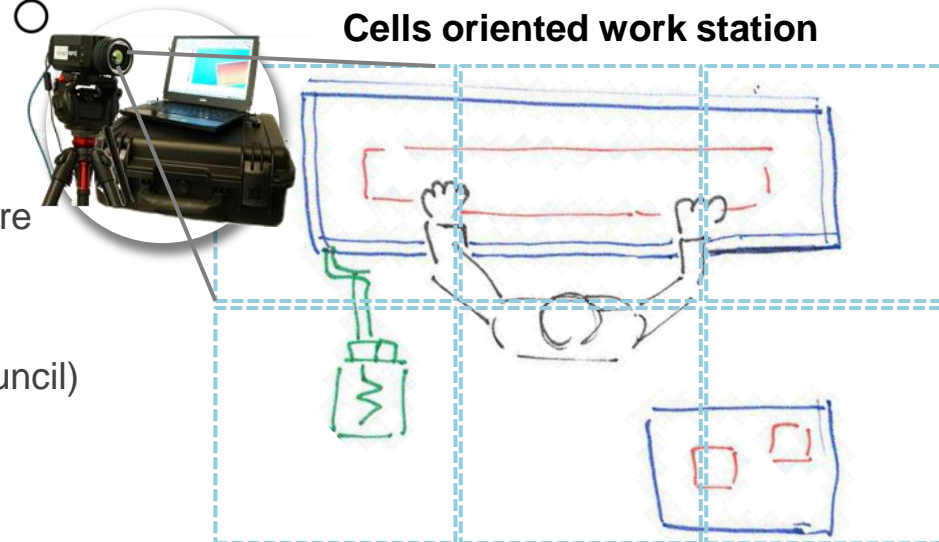
Functionality of Smart Work Station (SWS)

energy: labor work



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



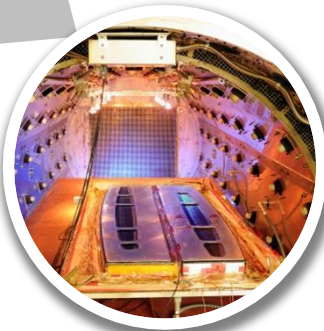
Physical work stations



Cutting

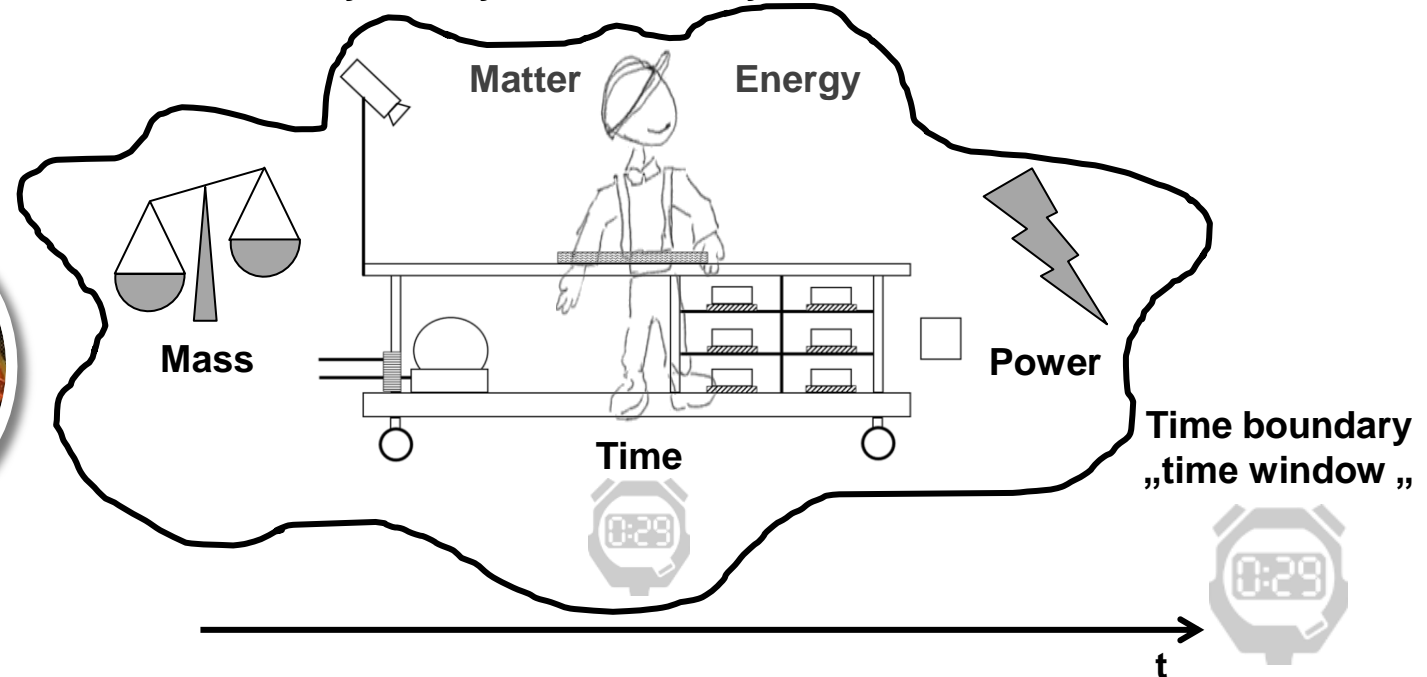


Preforming
Bagging



Infusion
Tempering
Demolding

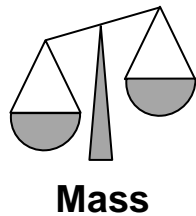
Physical system boundary



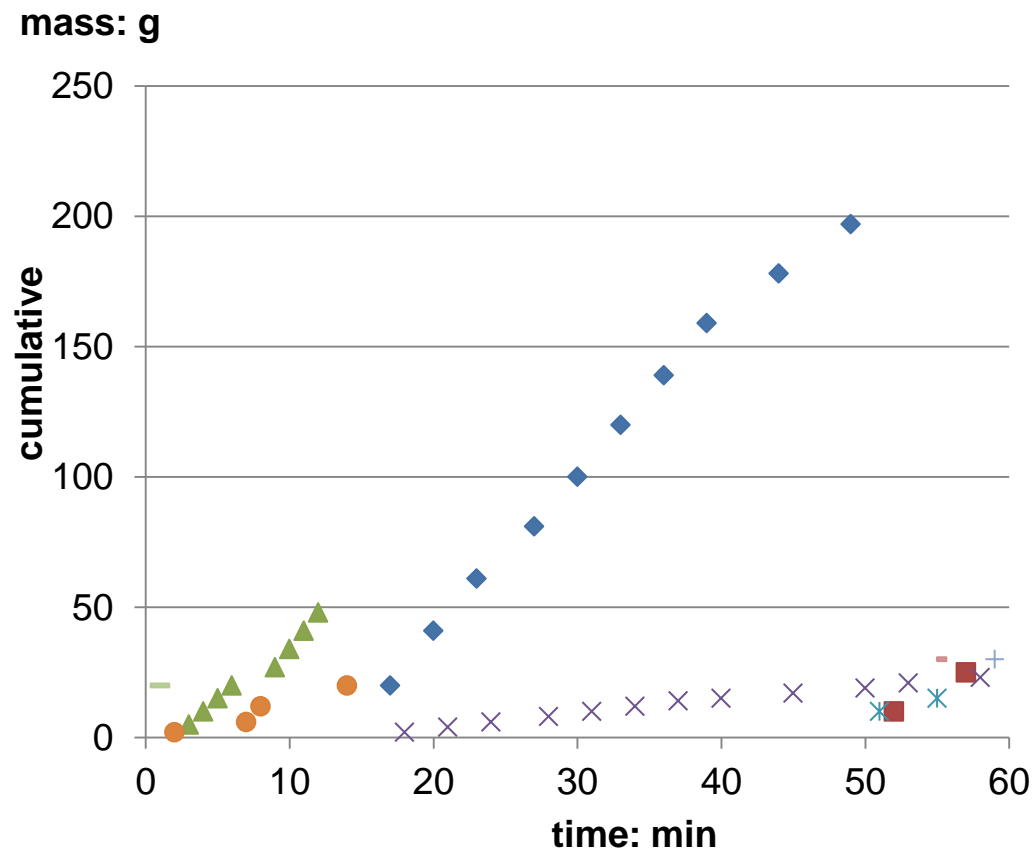
Results of Smart Work Station (SWS) example of materials data



Matter
Fiber
Matrix
Supplies



Preforming
Bagging



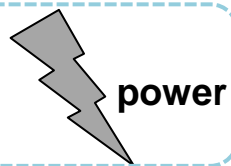
- ◆ Fiber
- Vacuum Bag
- ▲ Tacky-Tape
- × Adhesive tape
- ✱ Breather
- Cleaning tissue
- + Copper pipe
- Vacuum film
- Cotton gloves

these data are estimated and not collected

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

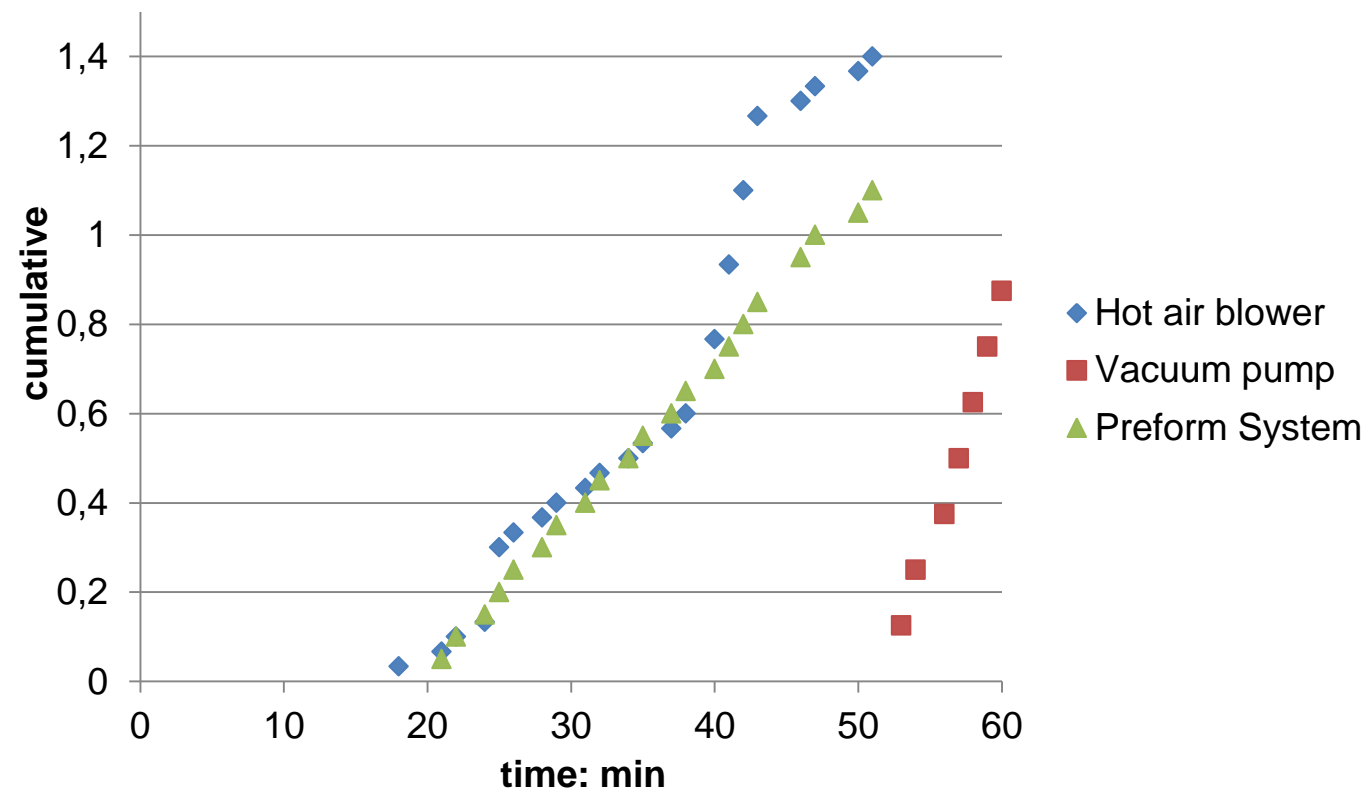


Energy
Electricity
Equipment
„Labor“



Preforming
Bagging

power: kW



these data are estimated and not collected

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



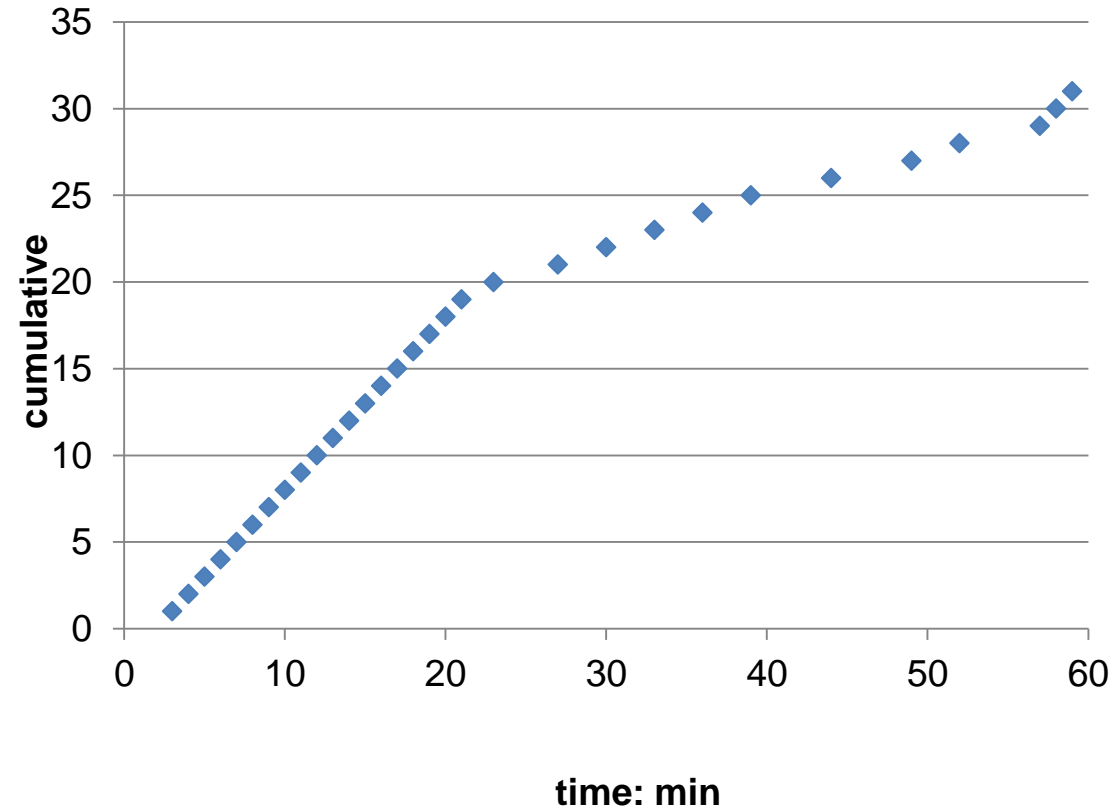
Energy
Electricity
Equipment
„Labor“

Time



Preforming
Bagging

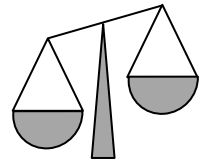
Work time: min



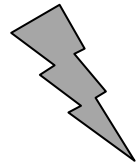
◆ Labor work

these data are estimated and not collected

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



Mass

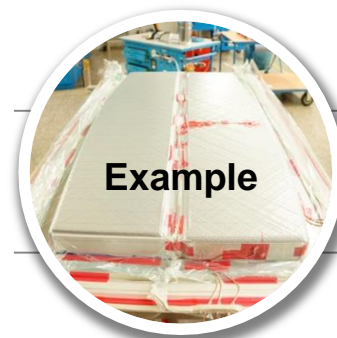


Power

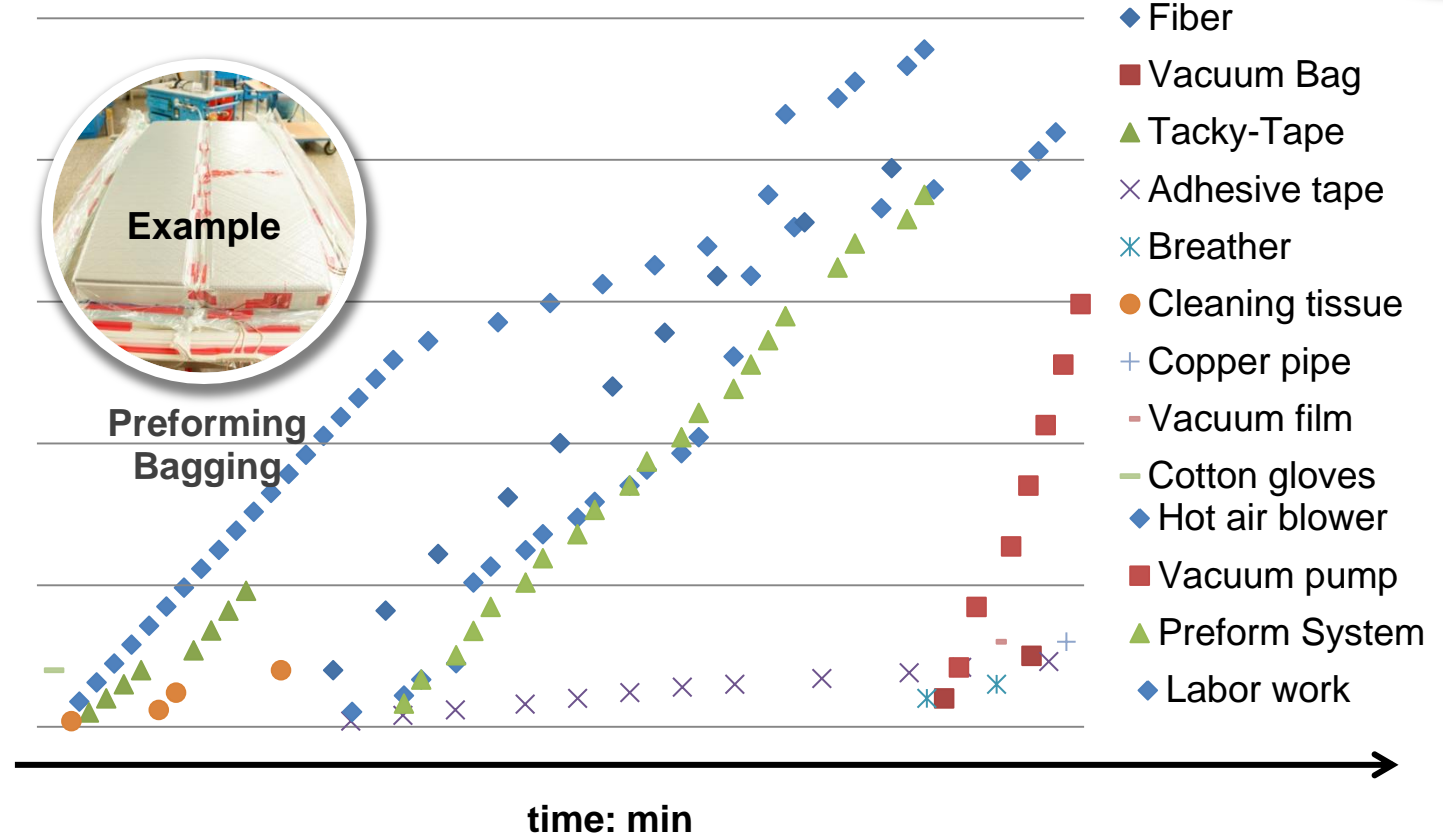
Matter	Energy
Fiber	Electricity
Matrix	Equipment
Supplies	„Labor“



Time



Preforming
Bagging

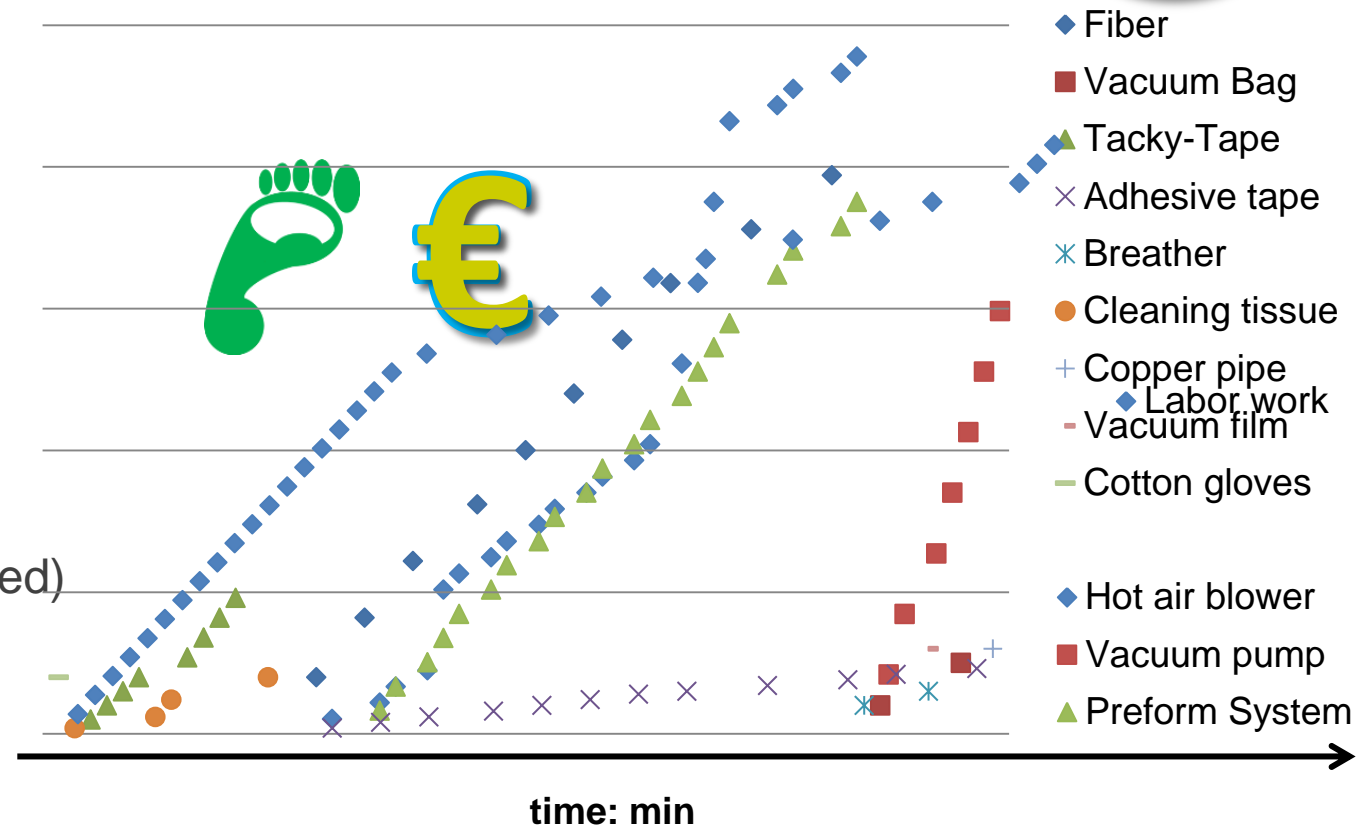


Benefits of Smart Work Station (SWS) benefit assessment & Industry 4.0

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

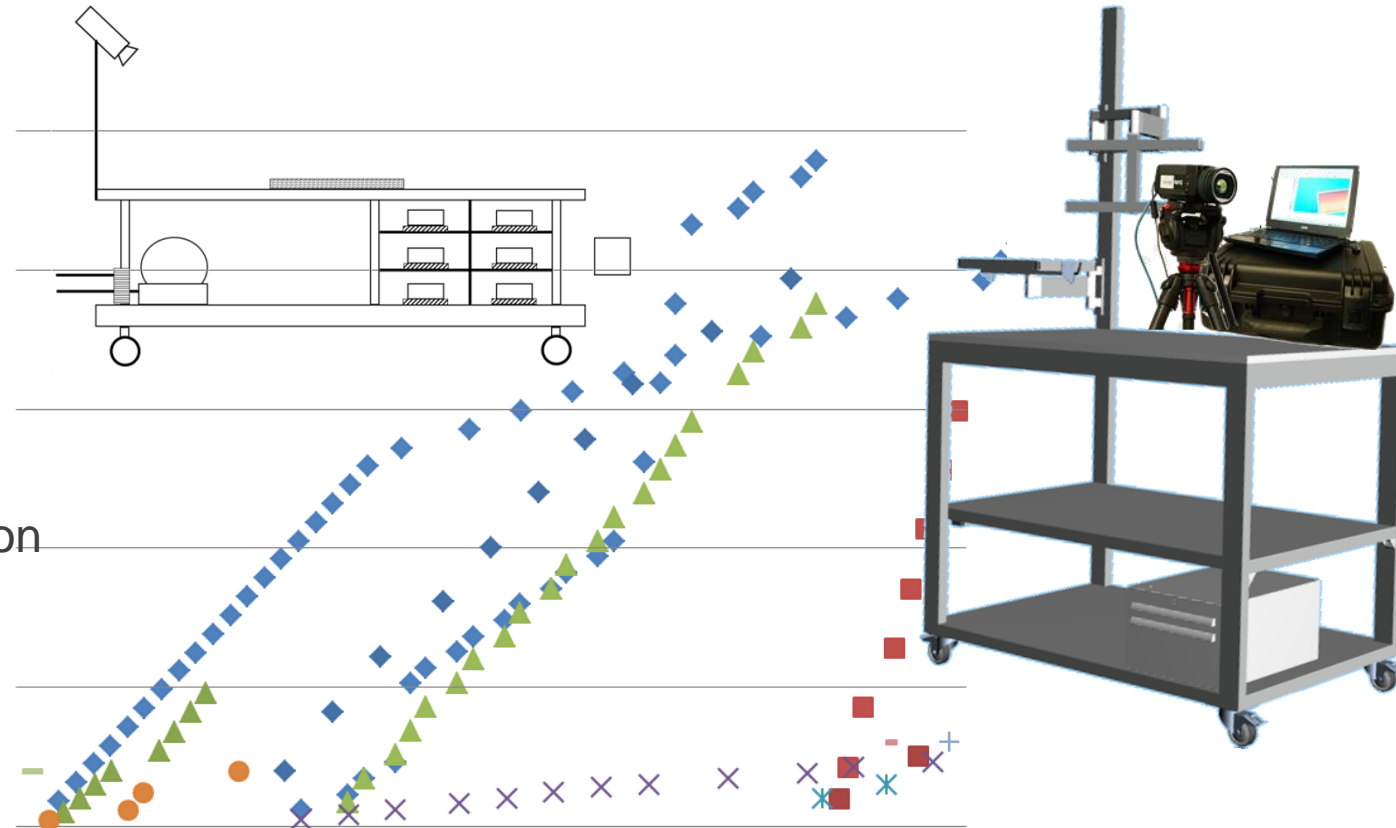
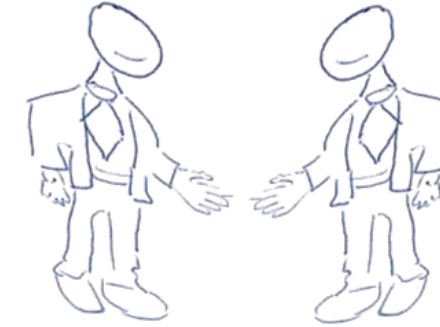
next steps in SWS

Realization

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

Enhancement

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



Outlook next steps in EEAM

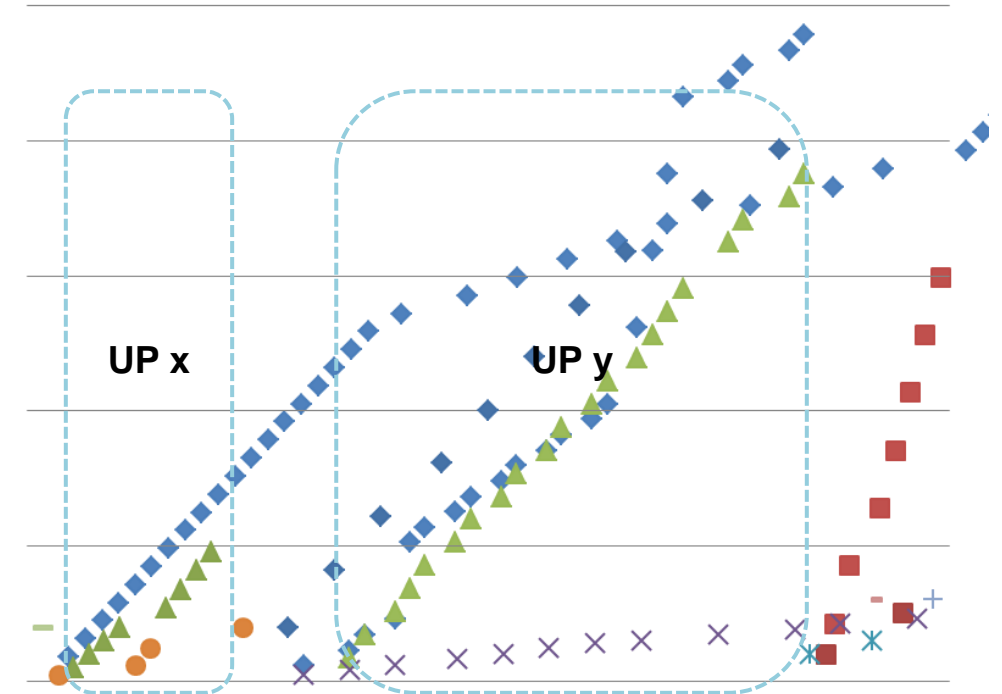
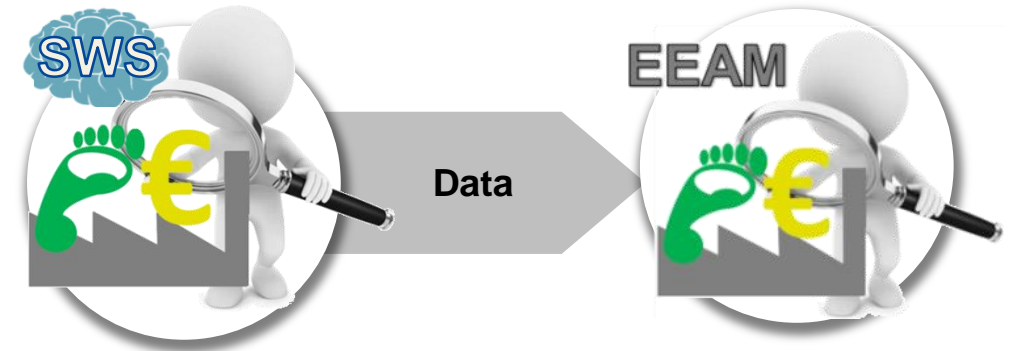
SWS & EEAM

- 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)

Category	Subprocess	ID	Name	AA1 Amount	AA1 Energy	AA1 Time	StandardCosts	StandardBenefits	StandardCosts	StandardBenefits	StandardCosts	StandardBenefits
Equipment	Cutting	4001		0	0	0						
Equipment	Cutting	4002		0	0	0						
Equipment	Cutting	4003		0	0	0						
Equipment	General	4008		0	0	0						
Equipment	General	4010		0	0	0						
Equipment	General	4018		0	0	0						
Equipment	General	4019		0	0	0						
Equipment	General	4020		0	0	0						
Equipment	General	4021		0	0	0						
Equipment	General	4022		0	0	0						
Equipment	General	4023		0	0	0						
Equipment	General	4024		0	0	0						
Equipment	General	4025		0	0	0						
Equipment	General	4026		0	0	0						
Equipment	General	4027		0	0	0						
Equipment	General	4028		0	0	0						
Equipment	General	4029		0	0	0						
Equipment	General	4030		0	0	0						
Equipment	General	4031		0	0	0						
Equipment	General	4032		0	0	0						
Equipment	General	4033		0	0	0						
Equipment	General	4034		0	0	0						
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Equipment	General	4100		0	0	0						



Discussion

Thank you for your attention!



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

Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)

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