Real-time benefit assessment in production of fiber reinforced polymers (FRPs)

Implementation of Industry 4.0 in benefit assessment

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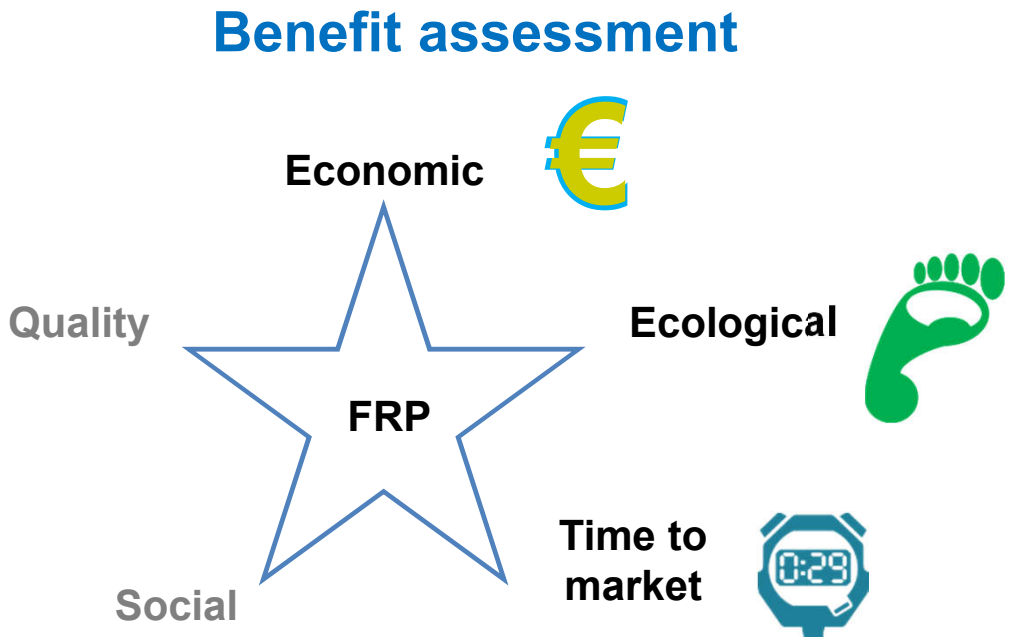
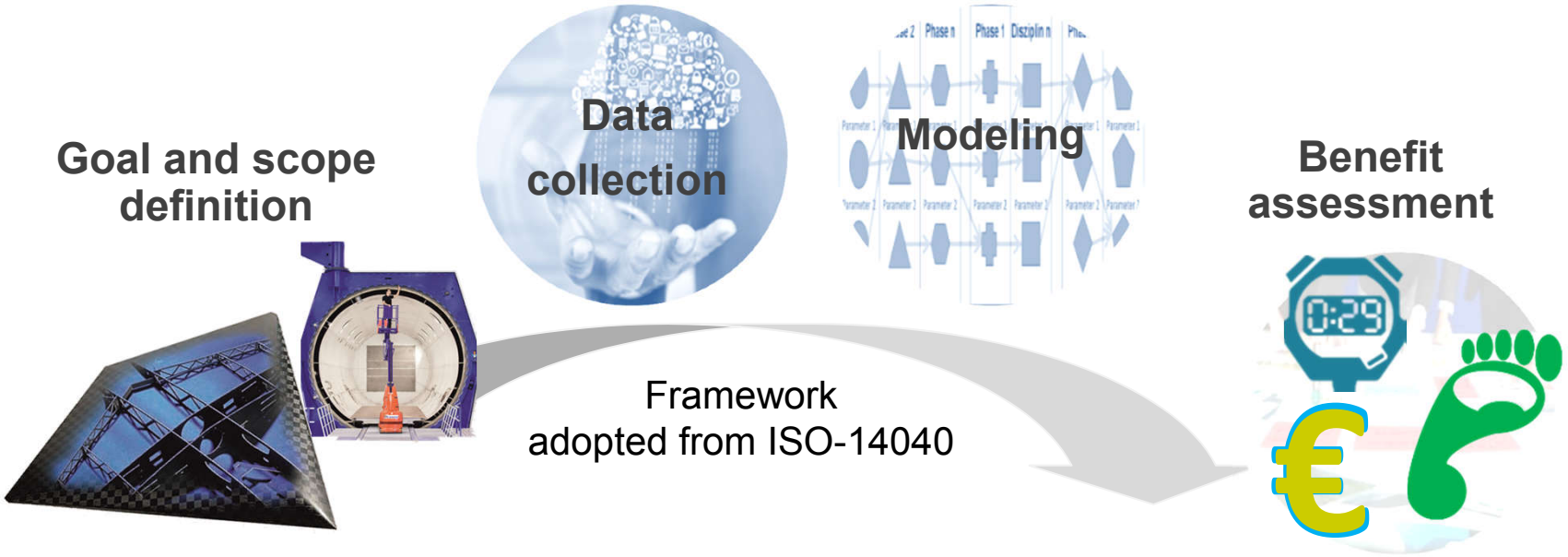
Motivation 1



Motivation 2

Motivation 3

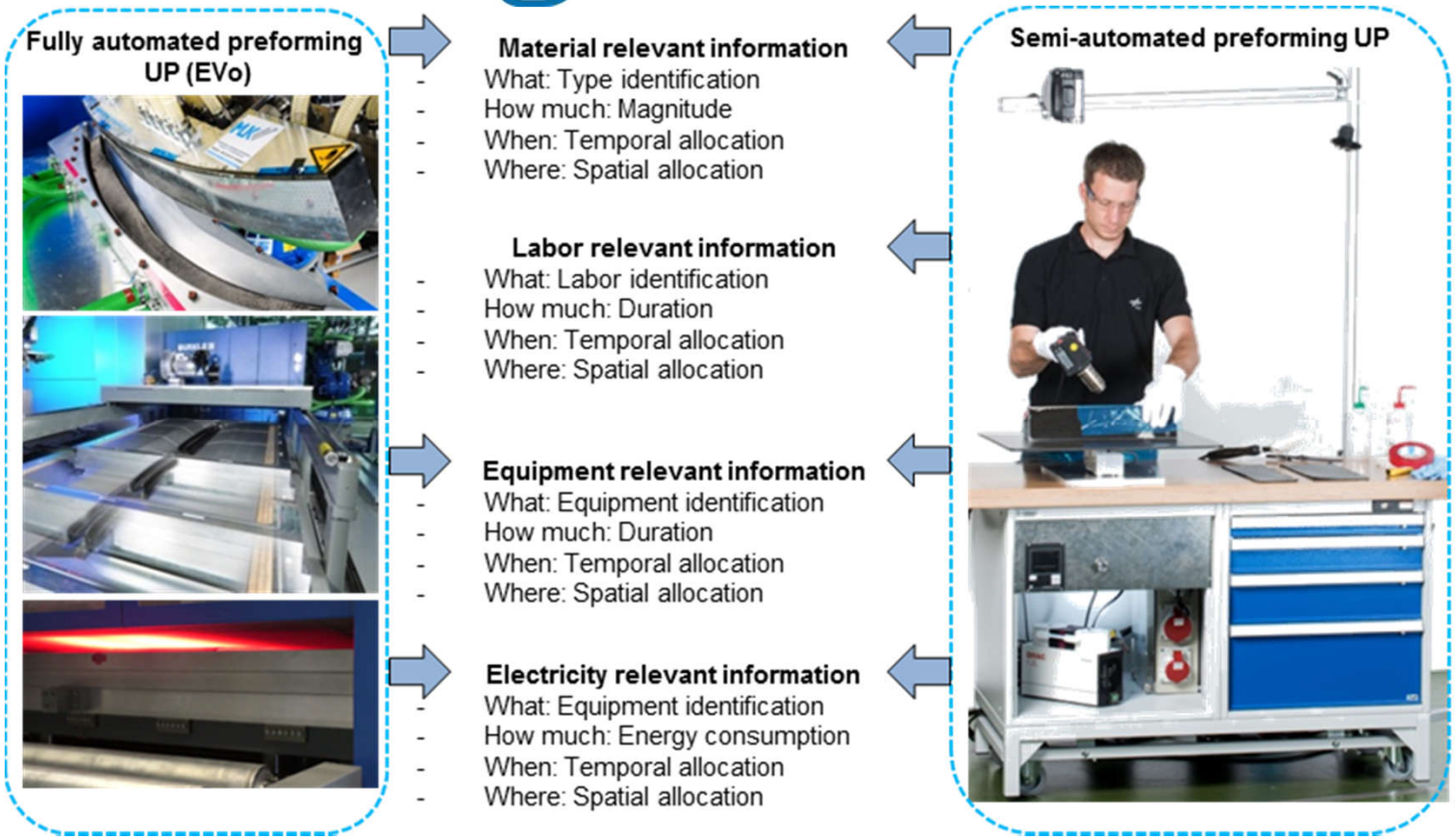


- Conventional data collection
  - Time consuming
  - Offline data processing /assessment
  - Dedicated collector
  - Dependent quality
  - FRP production has in general a low degree of automation (DoA)
  - High DoA is a prerequisite of digitalization in data collection
- SWS
  - Automated, sensor-based
  - Real-time data processing
  - Real-time impact assessment
  - Process automation is not a prerequisite
  - Product and process independent

Concept of the smart-work-station (SWS)

Patent DE 10 2016 120 555 A1
DLR: Ali Al-Lami

- Elementary flow definition
  - Fiber
  - Matrix
  - Core material
  - Ancillaries
  - Labor
  - Electricity
  - Equipment
- Initial data
  - What
  - How much
  - When
  - Where
- Regardless of DoA



Concept of SWS: example of preforming with various DoA

Data collection in SWS

- Sensors
  - Visual recognition
  - Infrared (IR) camera
  - Integrated scales
  - Electricity meter
- Technology independent
- Product independent

5- IR-Camera:
How many workers
How long
Where
When

1- Mold dedicated scale:
Fiber
Where
When

4- Electricity meter:
Which equipment
How long
When
How much energy

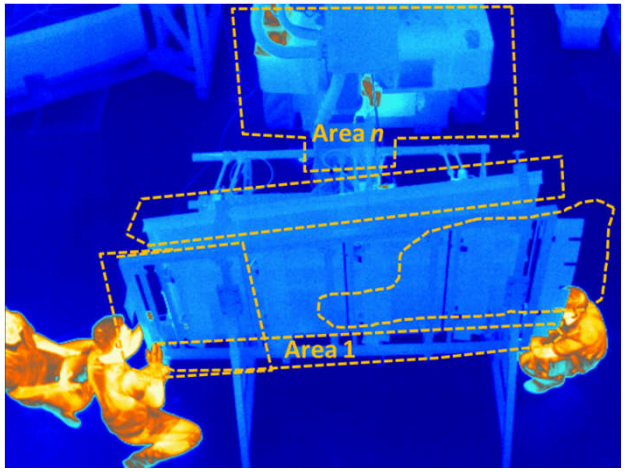
3- Optical detection:
What material
Where
When

2- Integrated digital scales:
How much material
Where
When

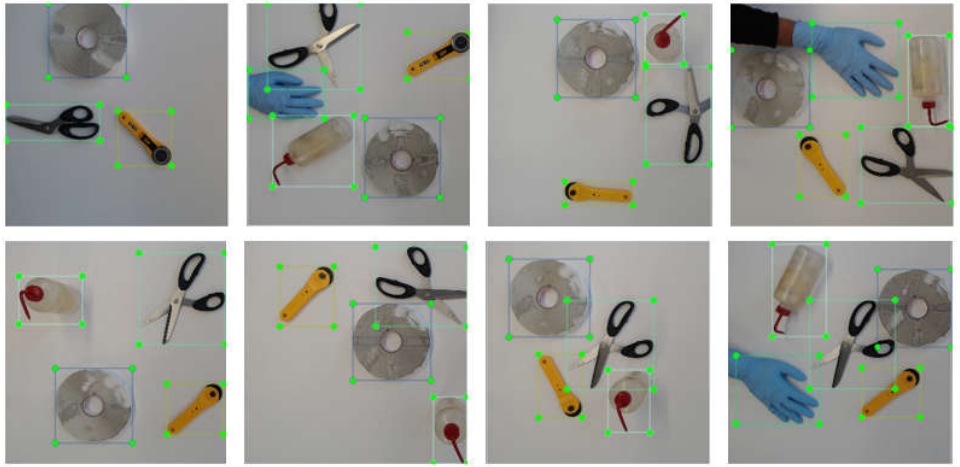
Sensors of SWS: example of preforming with various DoA

Data processing by SWS

- Visual recognition
  - Elementary flows (~350)
  - Pictures
  - QR-Codes
  - Database (DB)
  - Machine learning
  - Recognition
- IR-Camera
  - Work duration
  - Labor count
  - Where
  - Which activity
- Product independent



Work time per activity (NACOR)

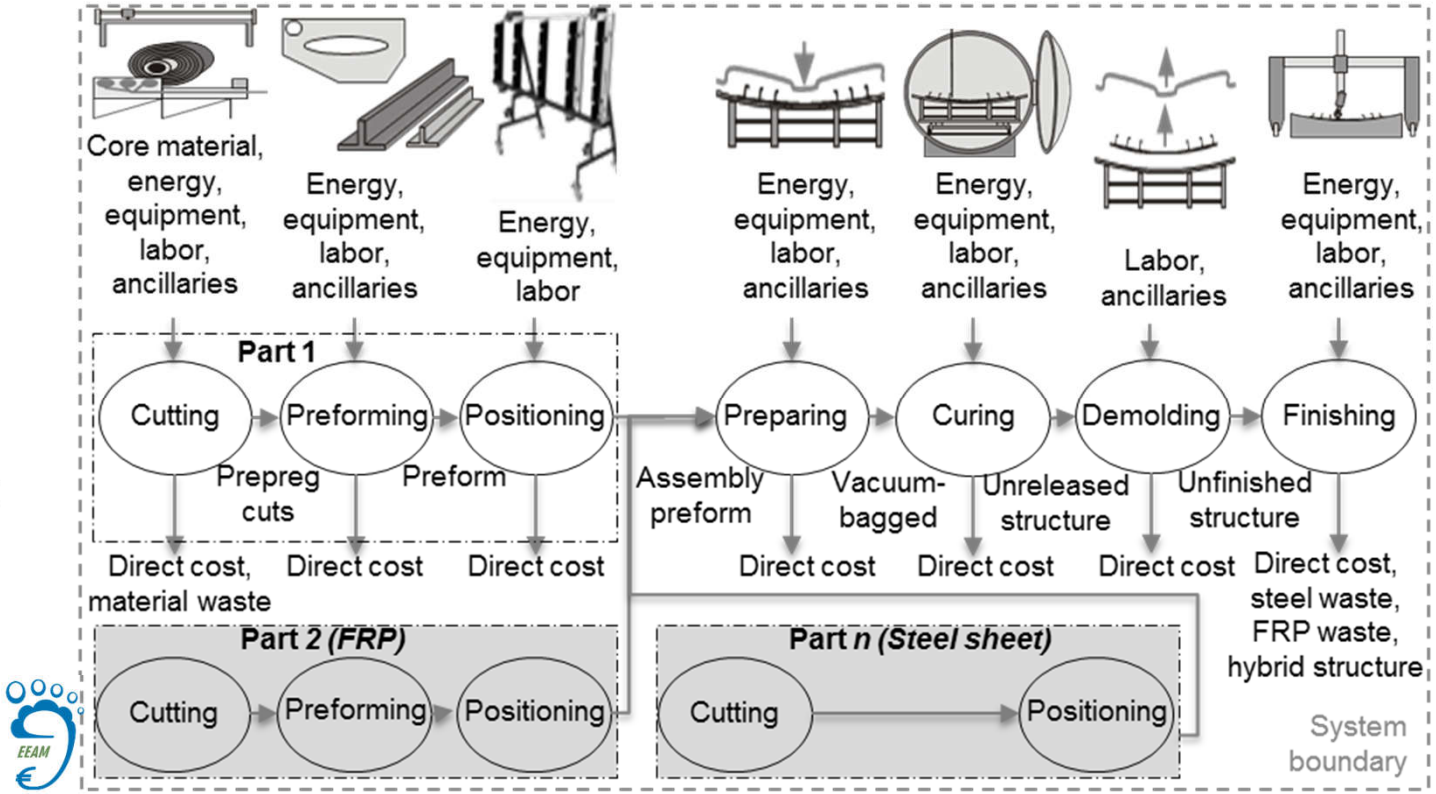


Optical recognition

Process modeling in EEAM

- Production of FRP
  - Manufacturing
  - Assembly
  - Quality assurance
- Process
  - Unit processes
  - Elementary flows
  - Intermediate flows

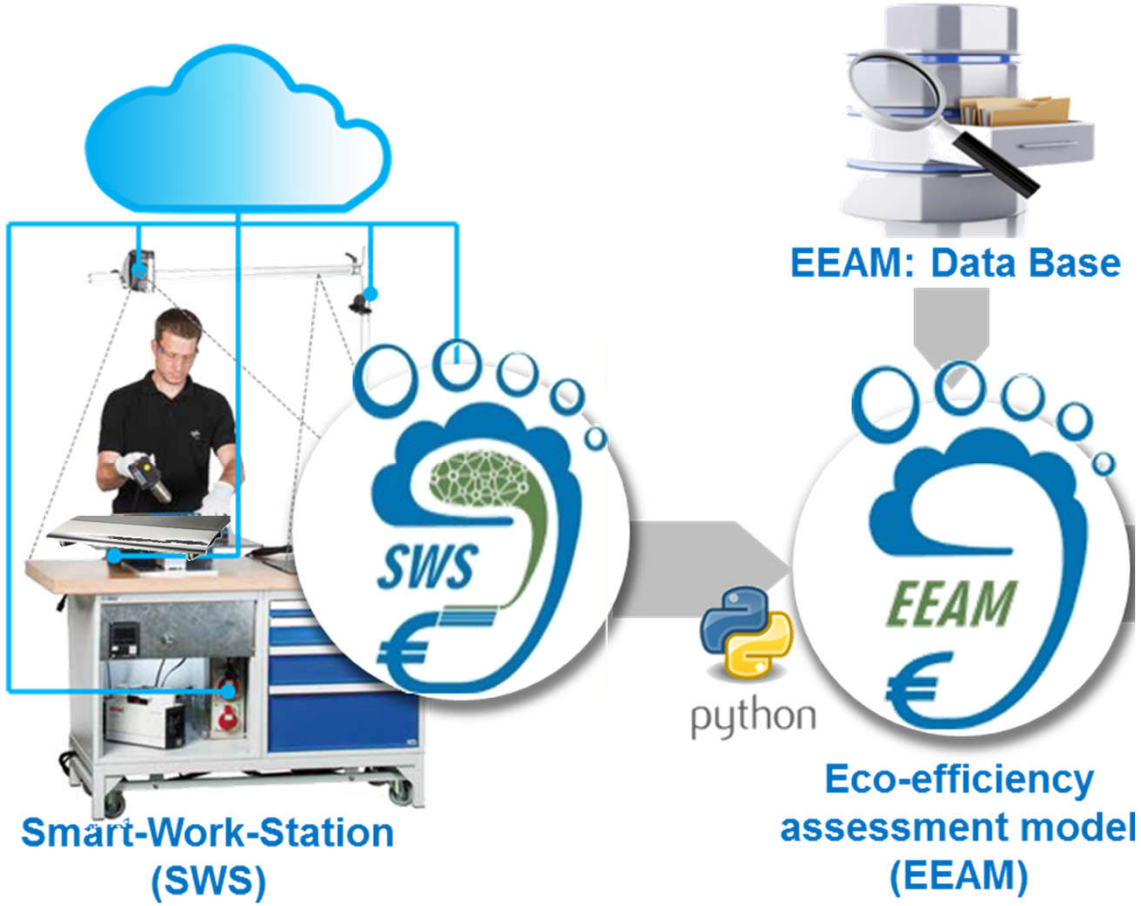
Multi-Material leading edge (LE)



Model example: Multi-material process

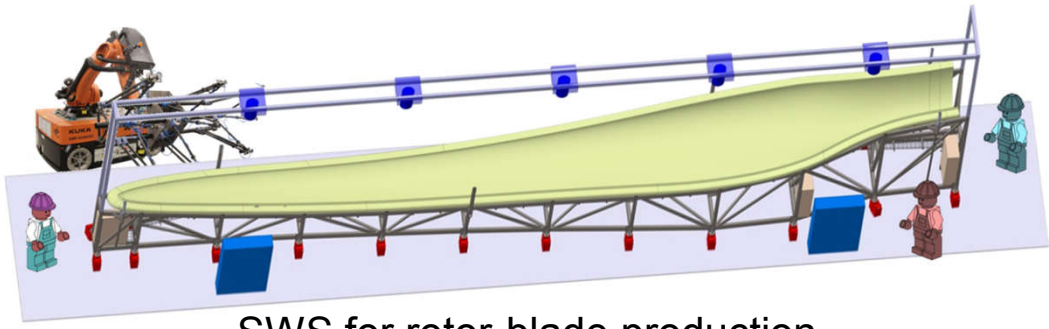
Process assessment by EEAM

- Aspects
  - Economic
  - Ecological
  - Time to market
  - Resources
- Key result indicators (KRI)
  - kg CO_2
  - €
  - hh:mm
  - kg waste/ material
  - kW



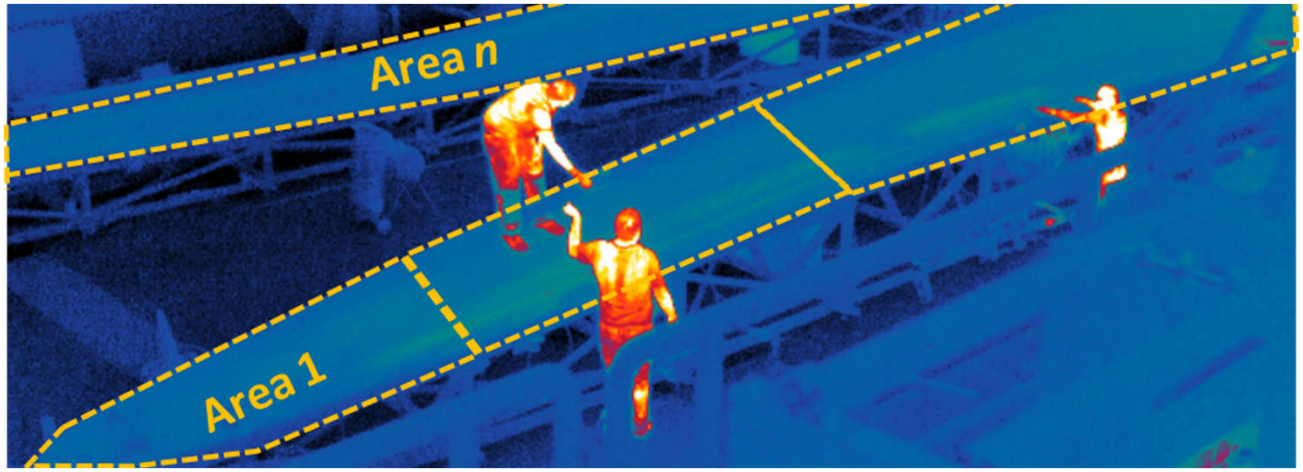
Real-time benefit assessment: SWS & EEAM

Implementation of SWS

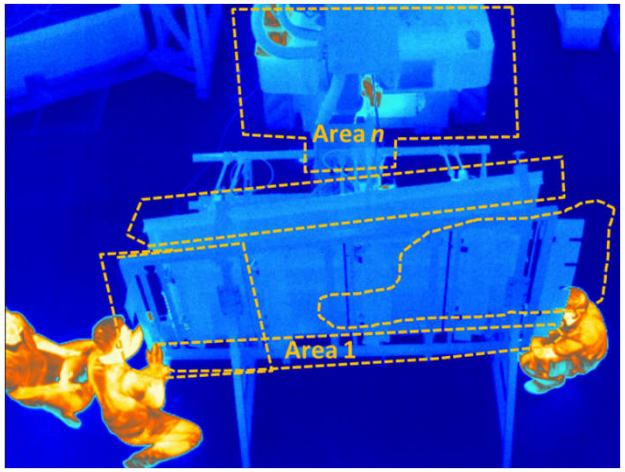


SWS for rotor-blade production

- Aerospace industry
  - Project NACOR: Preforming and Assembly
  - Preforming of spars with high DoA
- Energy
  - Project SmartBlades2: Manufacturing of a 20m rotor-blade



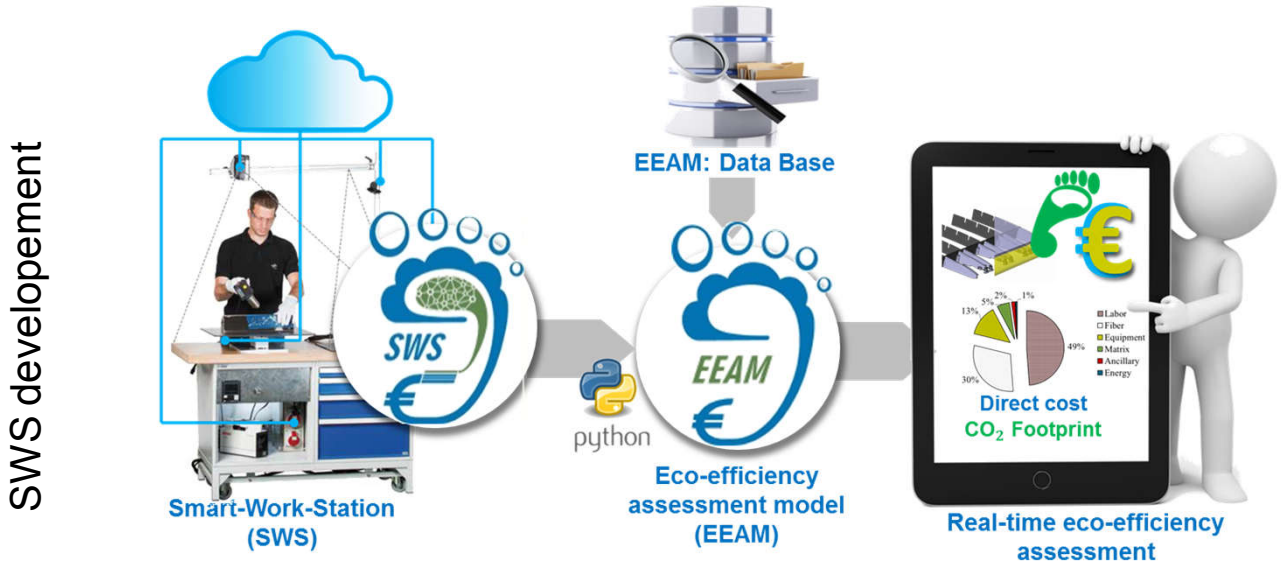
Project: SmartBlades2

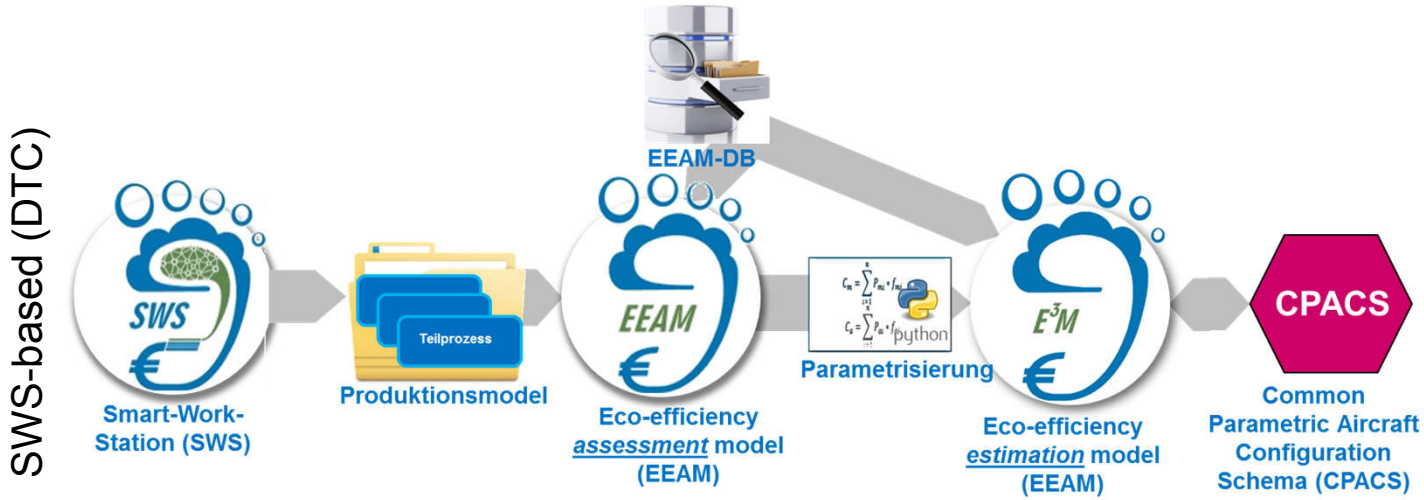


Project: NACOR

Outlook

- SWS development
  - Material DB enhancement
  - Stability
  - User interface
- SWS implementation
  - Further projects: EFFICOMP
  - Further unit processes
  - Other techniques
  - More structures
  - External partners
- SWS-based design to cost (DTC)
  - Parametrization of SWS results
  - Assessment-based estimation
  - Reliable estimation results





DLR

EFFICOMP
Efficient Composite Parts Manufacturing
高生産性複合材成形技術

Thank you for your attention!

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