Extending product life via digitalization of remanufacturing processes

Tech for Sustainability Challenge

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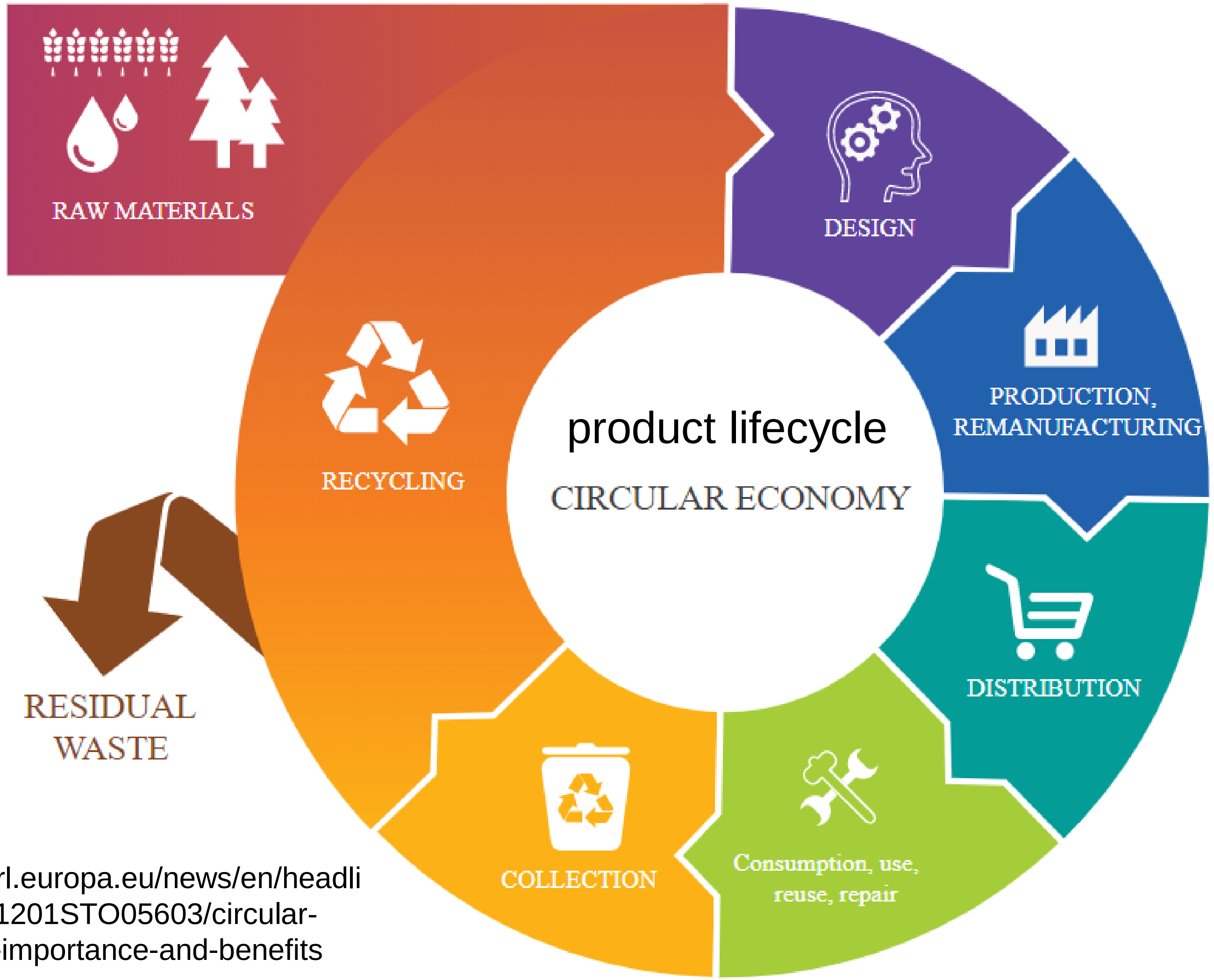
Overview

- Remanufacturing and repair in the context of a circular economy
- Sustainable remanufacturing processes on industrial scale
  - Digital twin of performance
  - Twin paradox of repair and service process
  - Challenges
  - Technological requirements
  - Solutions and approach
- Relation to eco-design
- Siemens DEGREE framework

Remanufacturing and repair as central elements of circular economies and CO2 reduction

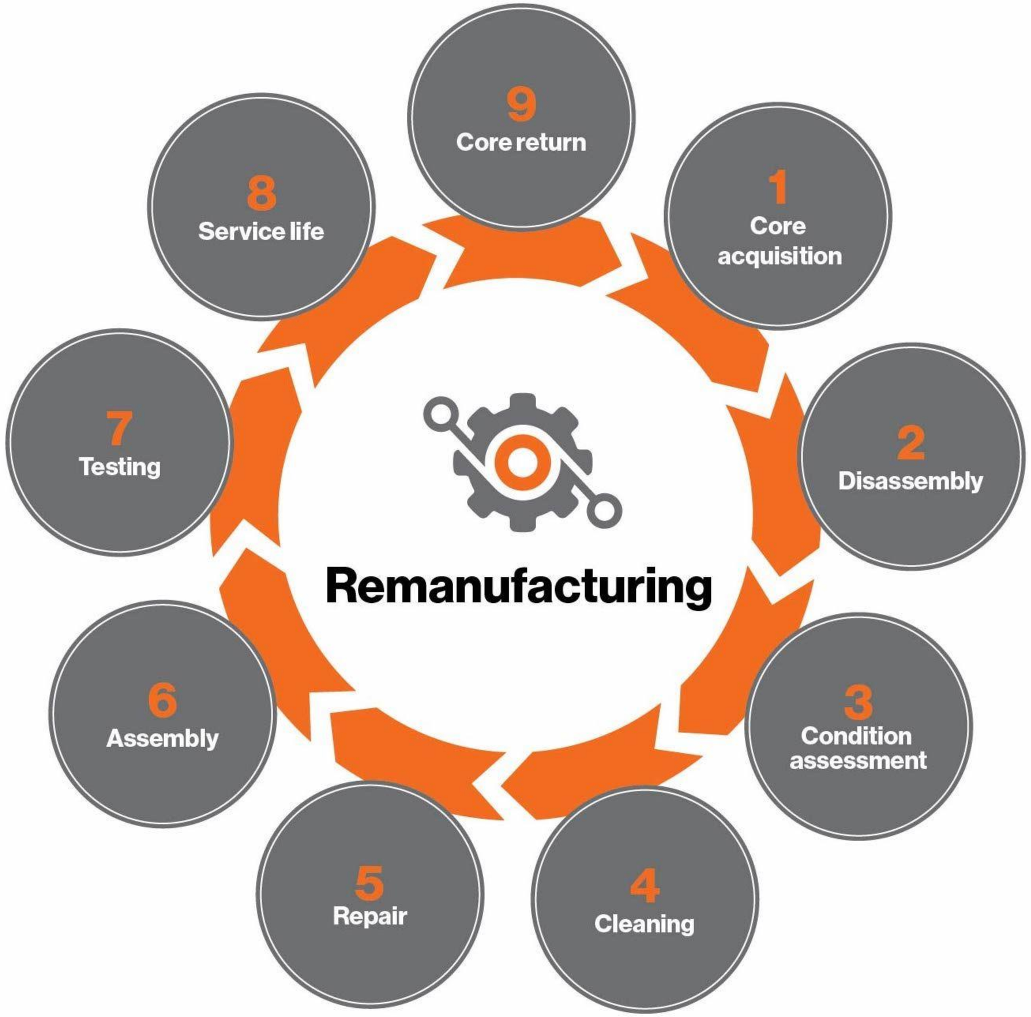


Benefits of remanufacturing

- Cost reduction
- Reduced (raw) material use
- Energy efficiency
- CO_2 reduction
- Reduced waste

source: https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits

Elements of sustainable remanufacturing processes at industrial scale



source: https://www.rit.edu/sustainabilityinstitute/blog/what-remanufacturing

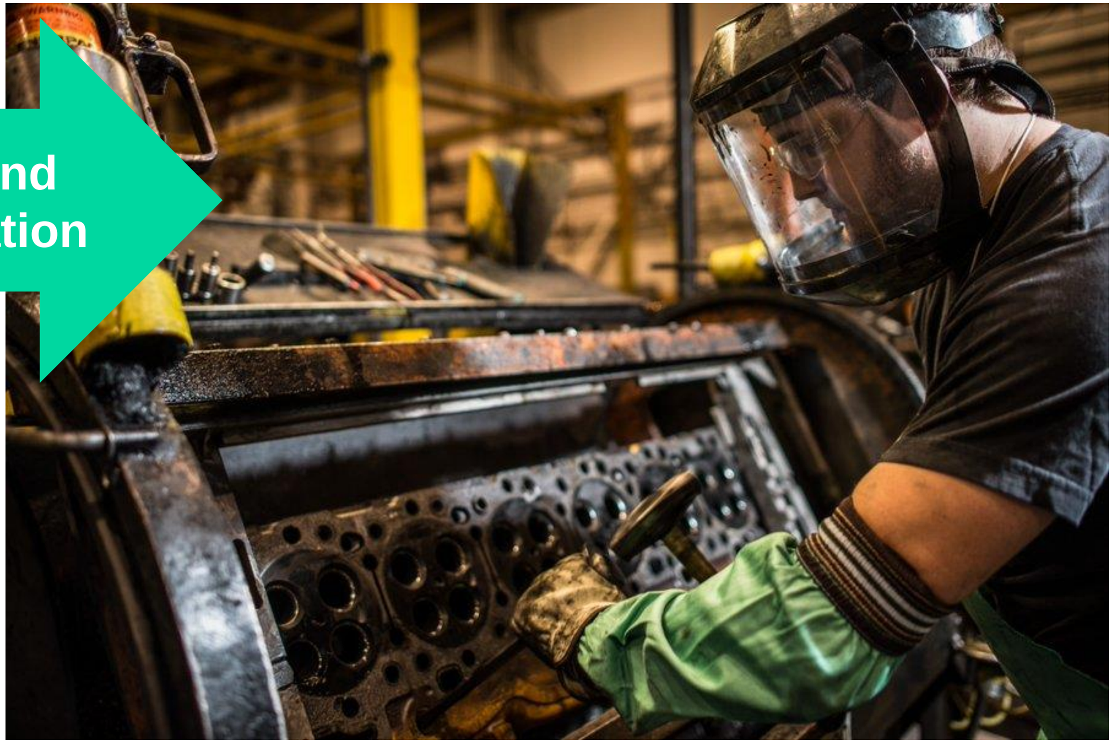
Key remanufacturing process steps

- core collection and logistics
- core assessment and sorting
- disassembly
- cleaning
- inspection
- repair
- assembly and testing
- packaging

Sustainable remanufacturing – where past meets industrial future

modern Siemens Additive Manufacturing facility

data and automation



source: https://twitter.com/CaterpillarInc/status/984520502583709696/photo/1

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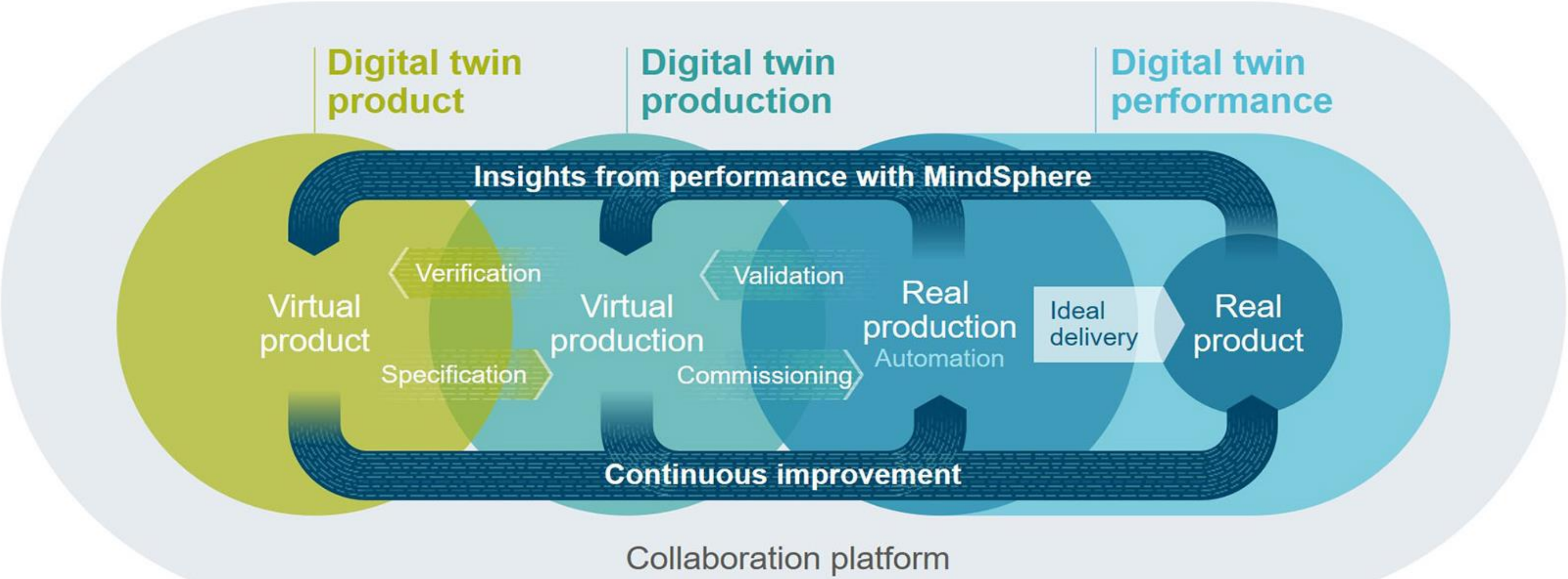
Next step of evolution: Digital Twin of Performance



Siemens PLM, 2020

Data behind established **digital twin of product** and **production** originates from the virtual world is created based on the knowledge of humans

≠

Data behind **digital twin of performance** originates from the real world and is collected by sensors often without any knowledge about its purpose

manufacturing

remanufacturing

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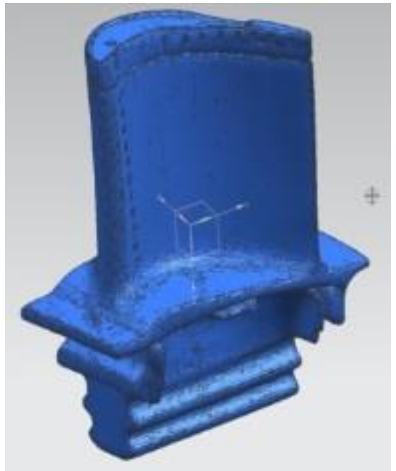
Twin Paradox of repair and service processes

Dilemma: While twin #1 lives and works in the virtual world and knows everything about his creation, it knows nothing about real life. In contrast, twin #2 is born in the real world and knowing everything about real life, except for how it was initially created!

Digitization of repair component

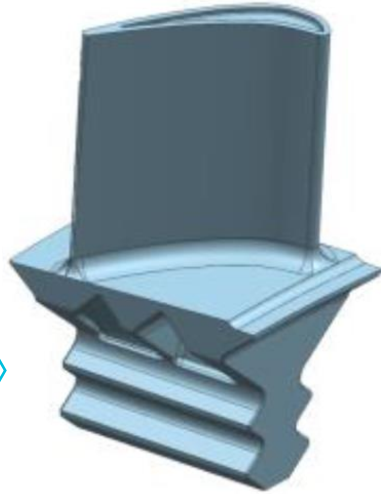
Digital twin #2 created based on the physical component via digitization hardware (e.g. 3D scan)



Quite experienced in life, but not very useful

Difference in DNA prohibits information exchange and coupling

Virtual twin #1 created via human knowledge and the application of design engineering software (CAx solutions)



Quite useful, but knows nothing about real life

How can we make use of the knowledge of the experienced twin with regards to repair execution and planning as we are used to do it with the virtual twin?

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*CAx ≡ Computer Aided Design, Engineering, Manufacturing, Quality Control

Major challenges of remanufacturing and service business

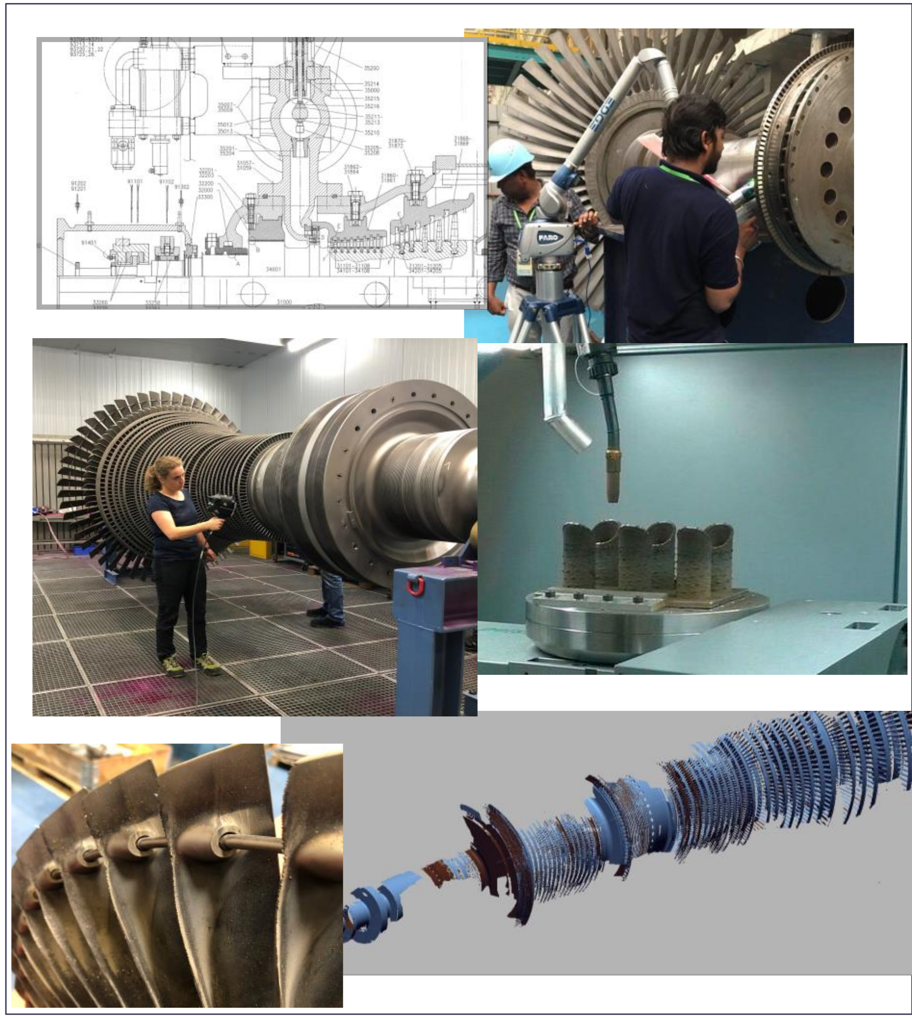
process

- Assessing reparability and remaining useful life
- Coping with legacy and/or missing information
- Defining and retrieving relevant information from repair components
- Component specific unique part properties (material and geometry)
- Individual component specific process sequence including machine setups
- Sophisticated digitization equipment required
- New and advanced manufacturing methods required

infrastructure

- Low degree of automation
- Globally distributed activities and sites (customer and shops)
- Specialized shops and products
- Heterogenous hard- and software landscape
- Scattered data sources and insufficient IT infrastructure
- Several departments with different responsibility involved

Missing scalability hindering circular economy at industrial scale



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Technological requirements behind sustainable remanufacturing

hardware

- Selection and integration of digitization equipment (e.g., 3D scanning)
- Closed-loop processing (adaptive machining, in-process control, etc.)
- Machine interfaces to enable data exchange along process chain

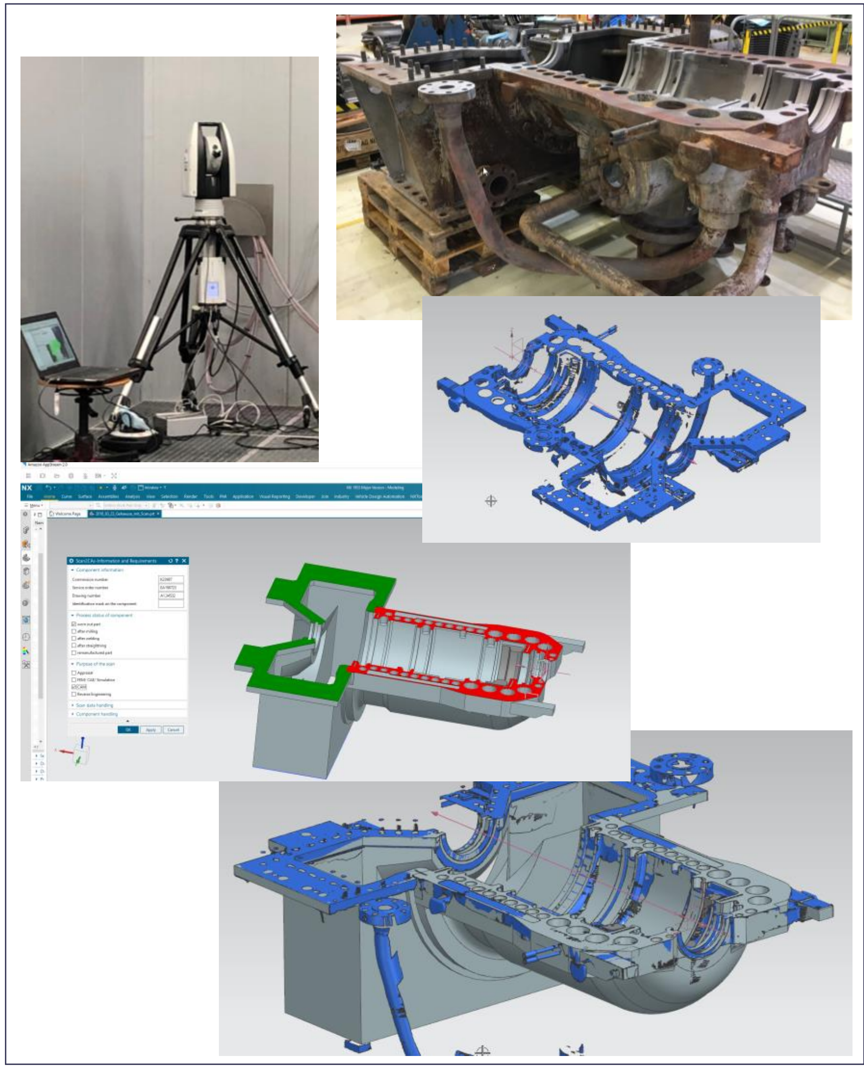
software

- Continuous CAx chains supporting component specific workflows
- Enhanced design functionality to leverage advanced manufacturing methods
- Interfaces to shop floor equipment and automated data processing
- Automated quality control up to virtual qualification

data management

- Knowledge aggregation and collaborative use to enable decision making
- Planning, control, and execution of workflows on shop floor level
- Search and correlation functionality for mixed data sources
- Distributed access and derivation of process specific information
- Traceability (component, time, process, operation)

➡ Digital backbone to leverage domain expertise and enable automation



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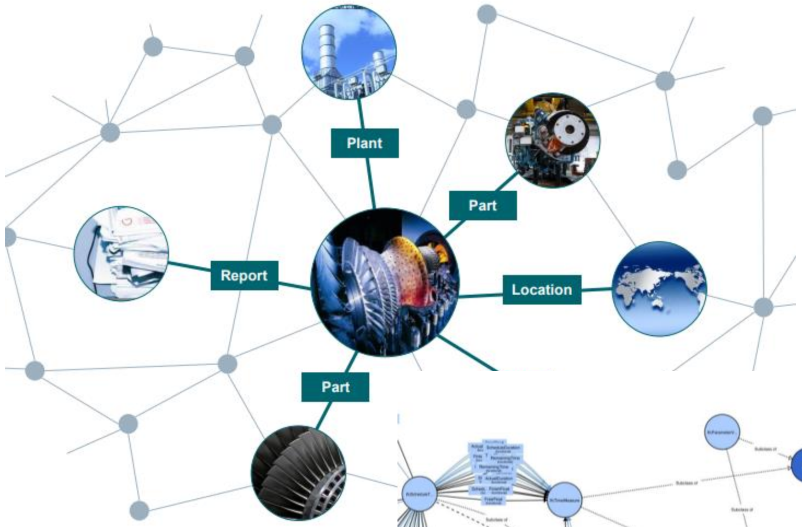
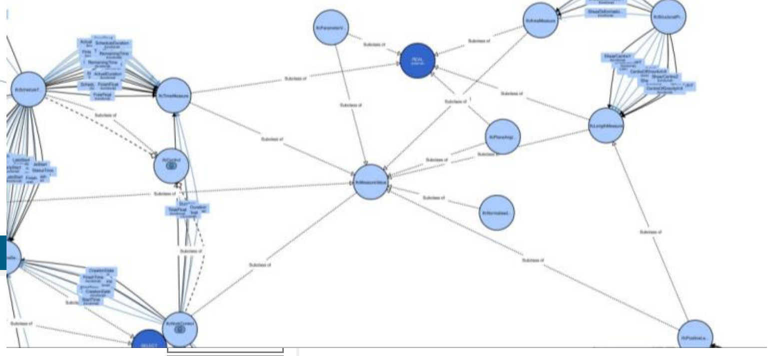
Possible solutions and approach

- Domain expertise modelling and visualization (i.e., ontologies and knowledge graphs)
- Equipment capability modelling and definition of component repair requirements via semantic representation
- Process step specific 3D models augmented with meta data
- Seamless CAx integration based on enhanced physical models incorporating as-is data
- Machine learning methodology to support automated data processing at each level
- Cloud / sever-client based architecture providing customizable solutions and bi-directional data exchange
- Incorporation of operational data into performance evaluation

Digitalization of remanufacturing and service business will boost repair quantities and increase efficiency





Scan2CAx -Requirements

Basic Information

Commission number	
Service order number	EA120 422
Drawing number	Z004170.0
In case of a single component: Identification mark on the component	

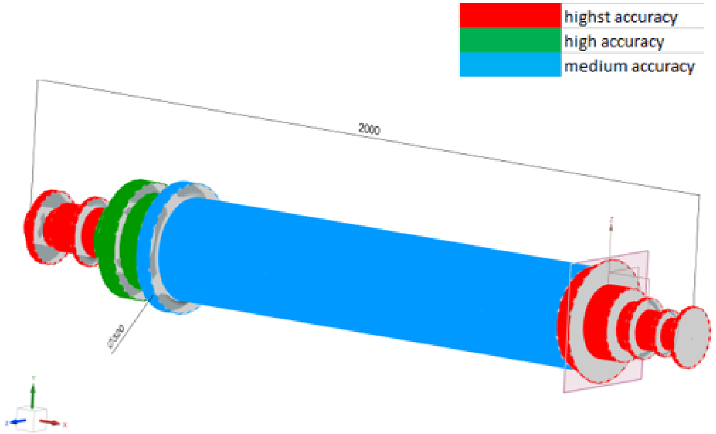
Process status of component

- [x] worn out part
- [ ] after milling
- [ ] after welding
- [ ] after straightening
- [ ] remanufactured part

Purpose of scan

Formal Scan Order

Requirements regarding the scan



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Relation to eco-design

Robust eco-design is an integral part of new product design and development

A digitalized remanufacturing will enable design for remanufacturing

Currently, remanufacturing and repair are still decoupled from new product design (time spans, changing IT systems, data formats, etc.)

How do product performance and reparability correlate?

Which design has proven to be repair friendly?

Which material can be processed most efficiently?

Which areas usually need repair and how can I reflect that in my design?

Which advanced manufacturing processes can I chose from?

What makes this product easy to disassemble and transport?

How can I quickly compare different design options

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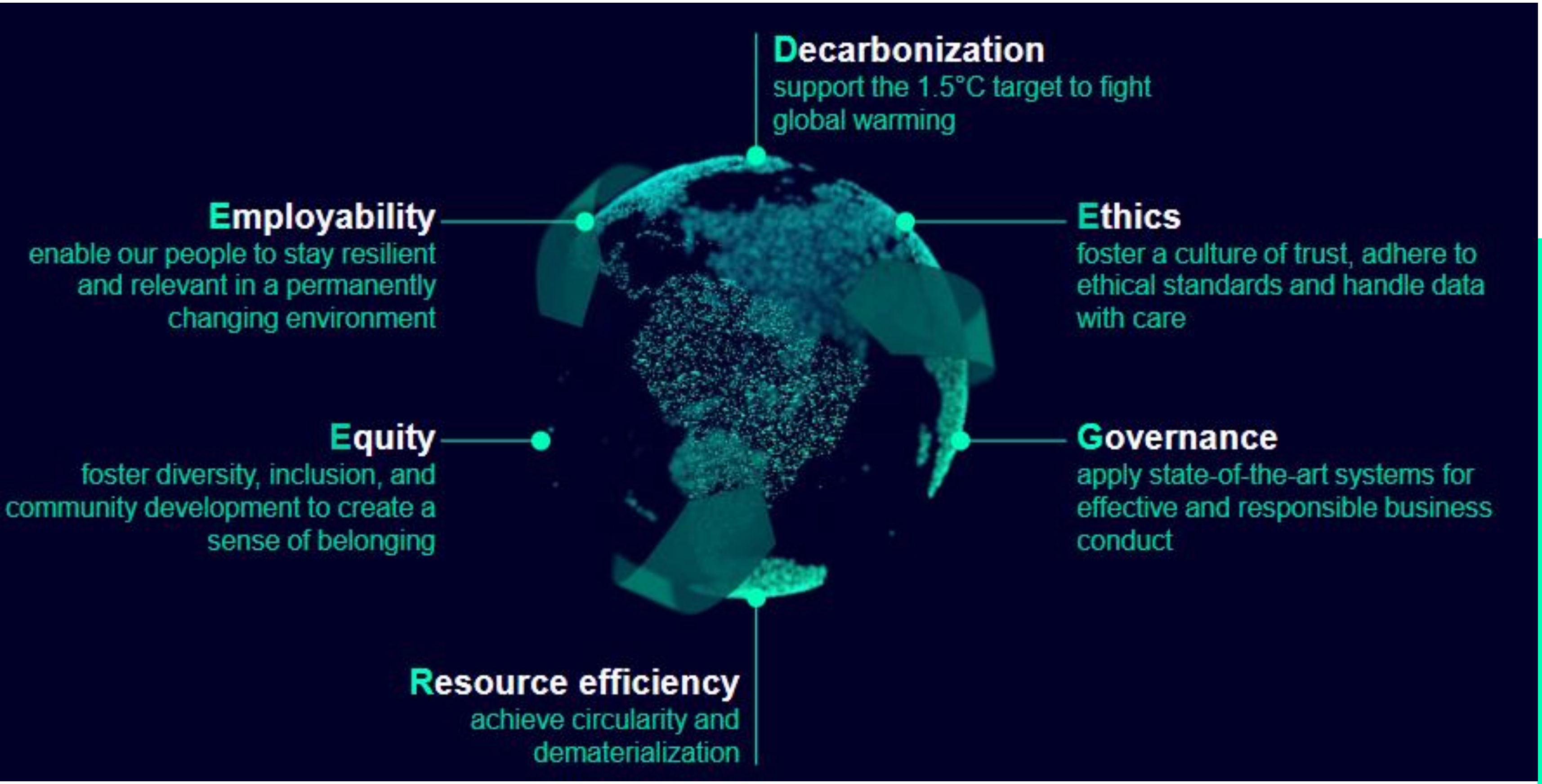
Siemens DEGREE framework



June 2021 Capital Markets day Siemens presentation

- **Decarbonization:** Net zero operations by 2030 and net zero supply chain by 2050
- **Ethics**: Train 100% of employees in business conduct every three years
- **Governance**: Long-term incentives tied to an internal ESG/Sustainability Index including customer Net Promoter Score, CO2 reductions and training hours
- **Resource Efficiency**: Eco-design for products by 2030 and zero landfill waste by 2030
- **Equity:** 30% female share in top management by FY 2025
- **Employability:** By 2025 double-digit learning hours and 30% improvement in lost time injury frequency rate

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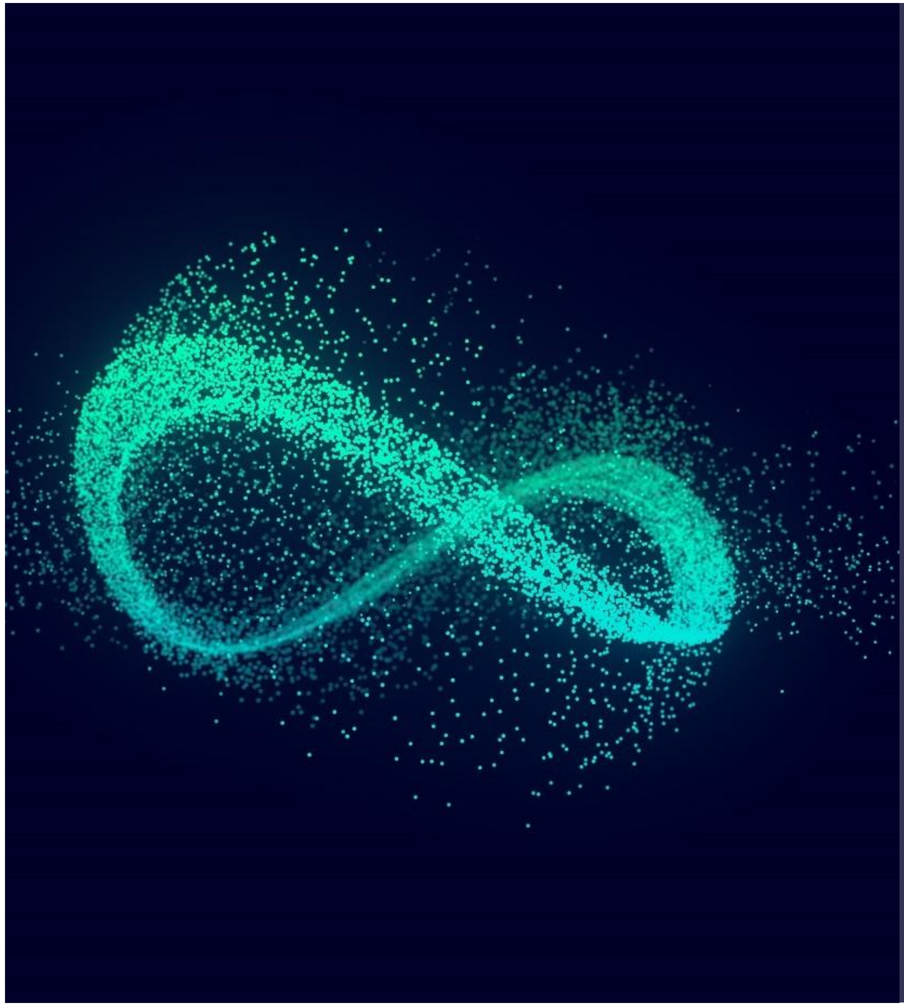
Contact



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Thank you!

Questions?

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