PRODUCTION ONTOLOGY - DEVELOPMENT OF A DIGITAL DOCUMENTATION FOR TRACEABLE AND CERTIFIABLE PROCESSES

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Overview

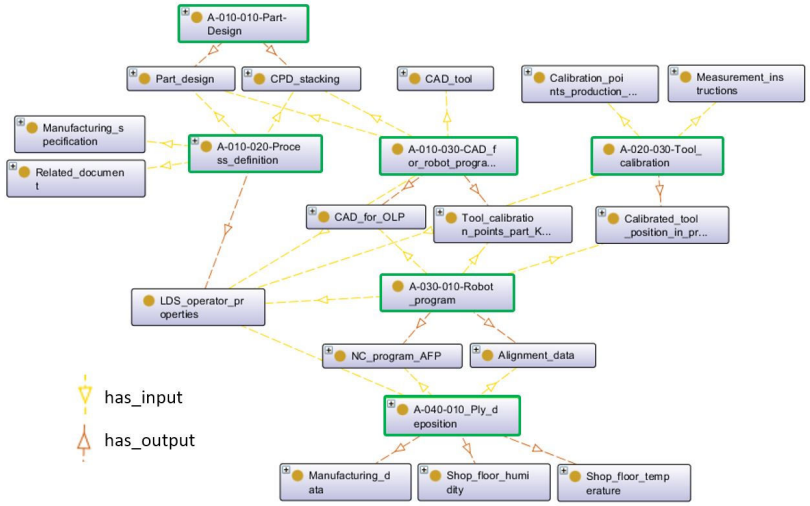
- Motivation
- State of the art (digital life data sheet)
- Methodologies
  - Formalised process description (FPD)
  - Digital life data sheet (LDS) – design and functionalities
- Application on manufacturing of aircraft moveable
- Evaluation of applied FPD and LDS
- Transfer to production ontologies
- Summary and outlook

Motivation

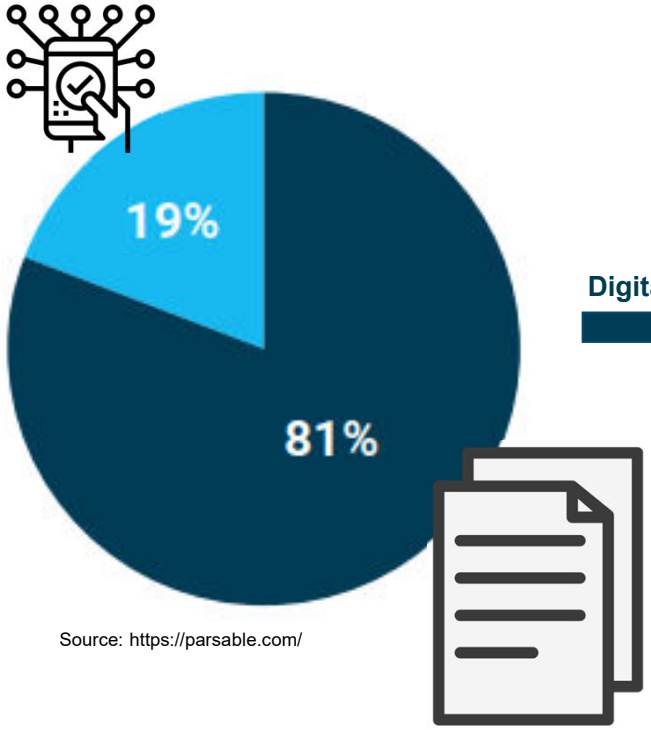
- Software for user-friendly, traceable and automatically analysing of life data sheet (LDS) content
  - Digital LDS ≠ Scan of paper-based LDS

- Formalised process description (FPD) of CFRP processes enables assessment capability (economic, ecological, structural, etc.)
  - Utilisation of data and information (e.g. for certification) for internal and external postprocesses

- Semantic data model provides data consistency and enables AI analysis
  - Sematic data model plus functionalities are essential parts of a “digital twin”



State of the art (LDS)



Source: https://parsable.com/

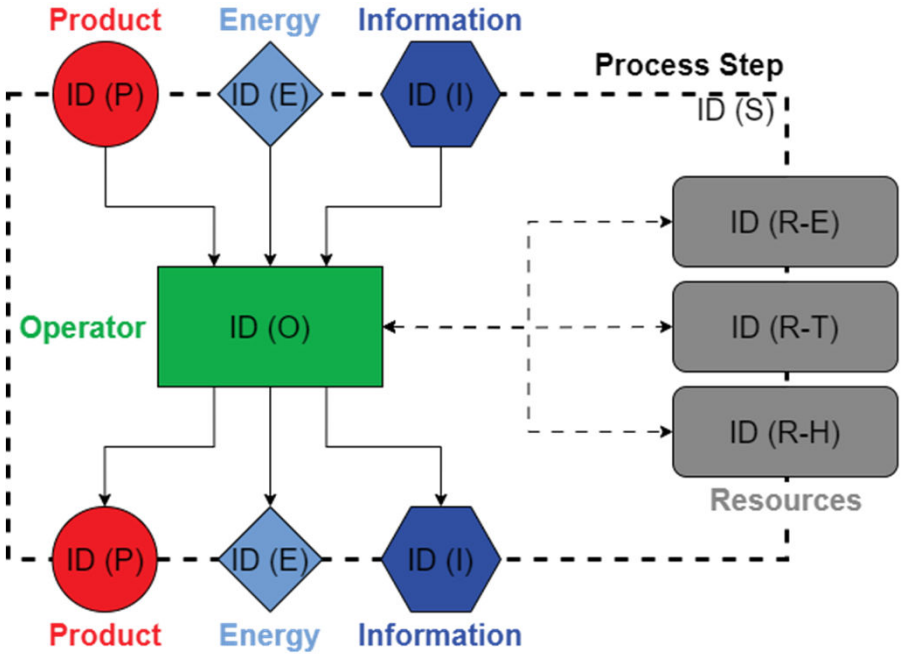
Digital Transformation / IIOT

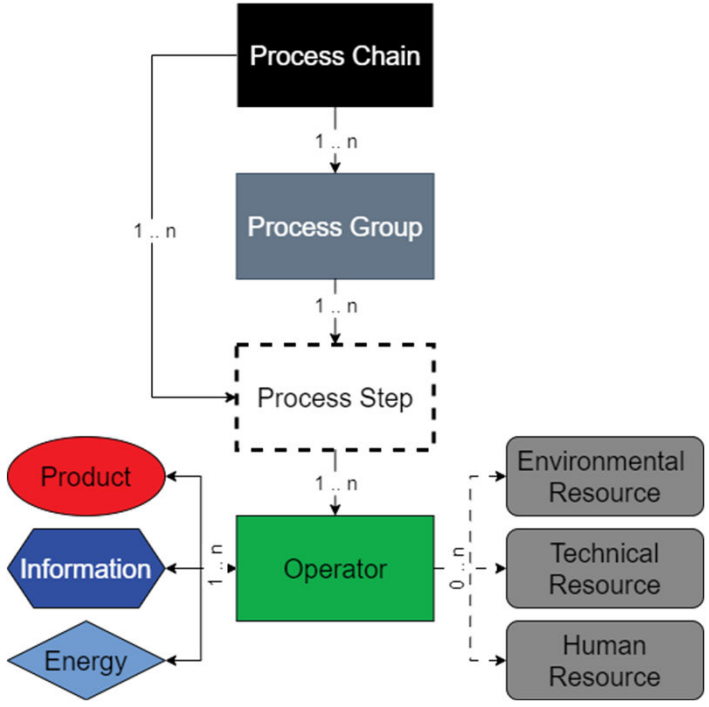
→ Specific solutions (process, machine)

→ No semantic data model for the general description of composite manufacturing processes

Methodology -
Formalised description of manufacturing processes

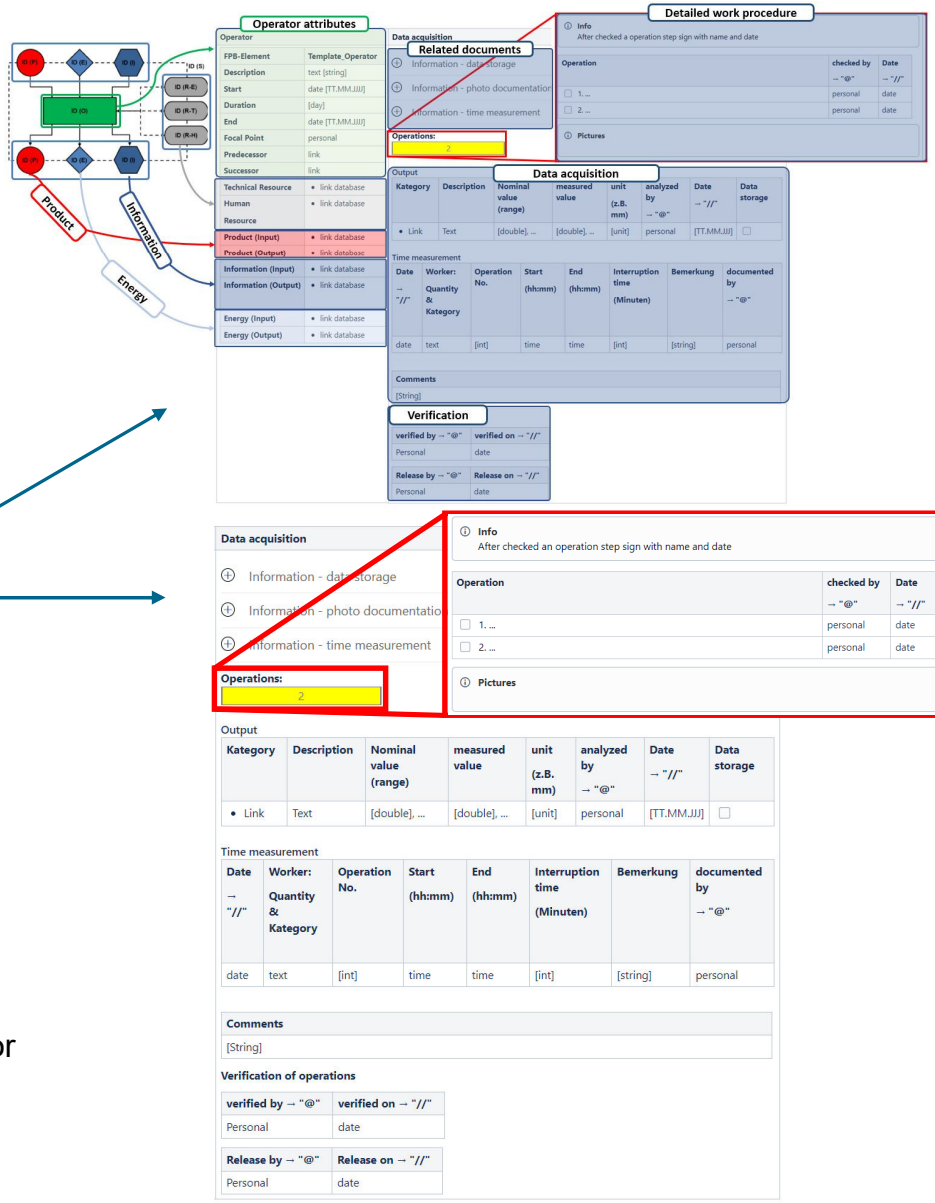
- Processes step granularity with explicit definition of types for information, resources, materials & parts and energy (based on / inspired by VDI/VDE 3682 – “Formalised process descriptions”)





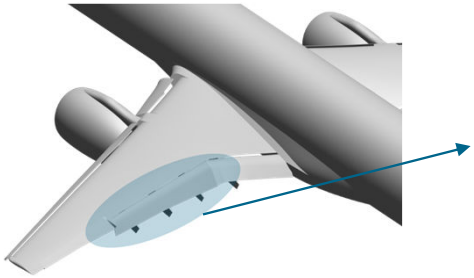
Methodology - Concept of the digital LDS

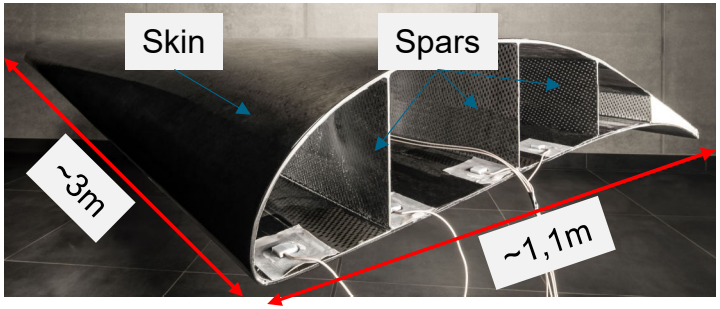
- Structure of LDS
  - Cover sheet, project and part information, data bases of FPD elements, FPD visualisation, detailed description of manufacturing process (→ operator sides)
- Realised in software Atlassian Confluence
- Based on FPD elements and their attributes
- Operator side consists of front end and back end
  - Front end
    - FPD elements with data base links
    - Expanding boxes with additional information
    - Process progress visualisation
  - Back end
    - Functionalities of individual sections
      - Process planning (start, end, resources)
      - Summarising of information, e.g. outputs and comments for postprocesses
    - Checkbox of working steps + sign

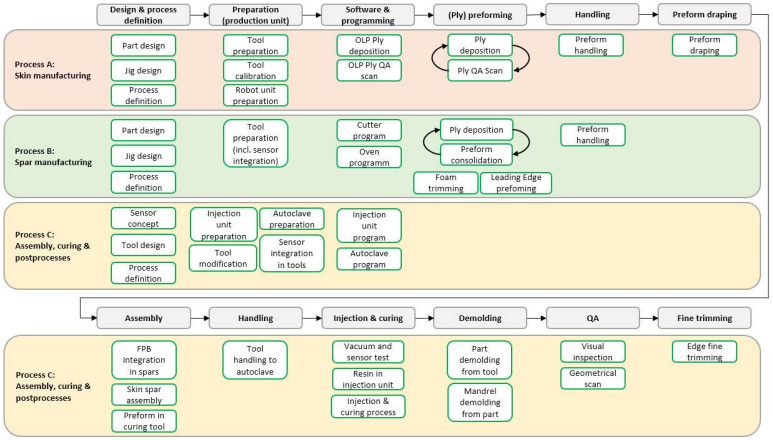


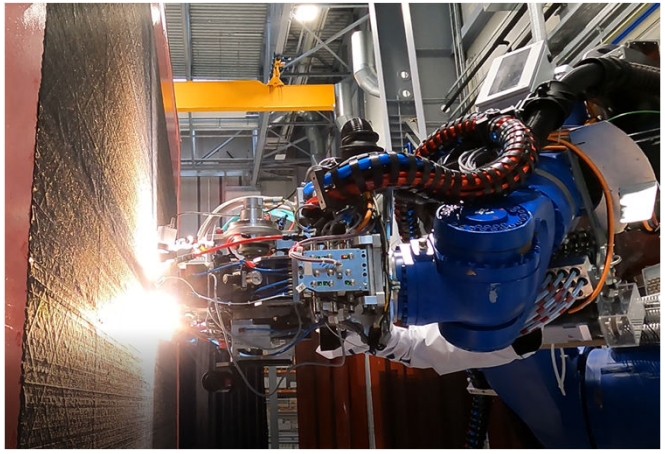
Application on manufacturing of aircraft moveable

- Manufacturing of aircraft moveable

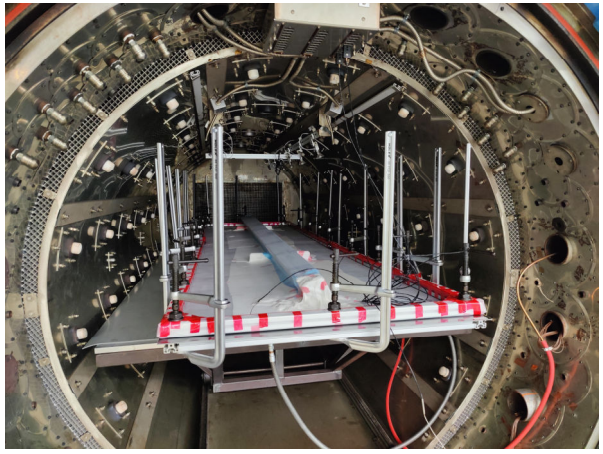




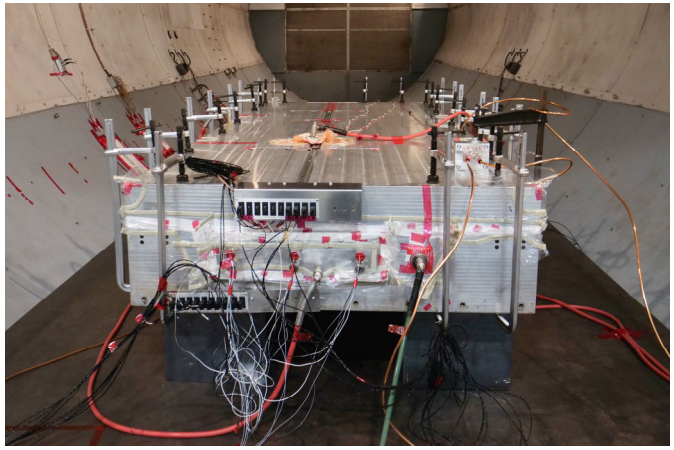




Skin manufacturing (A)

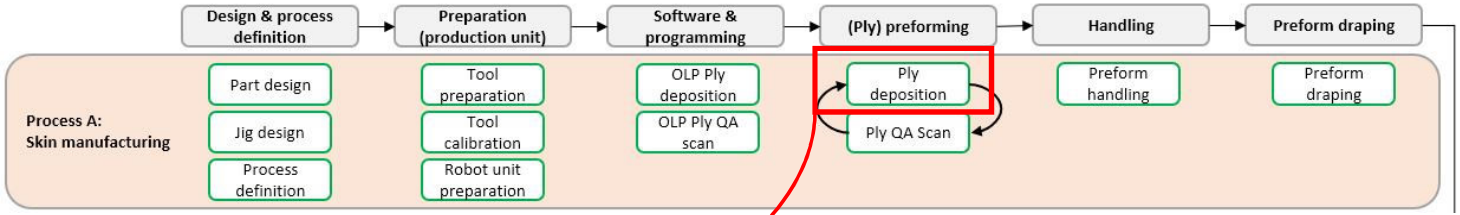


Spar manufacturing (B)



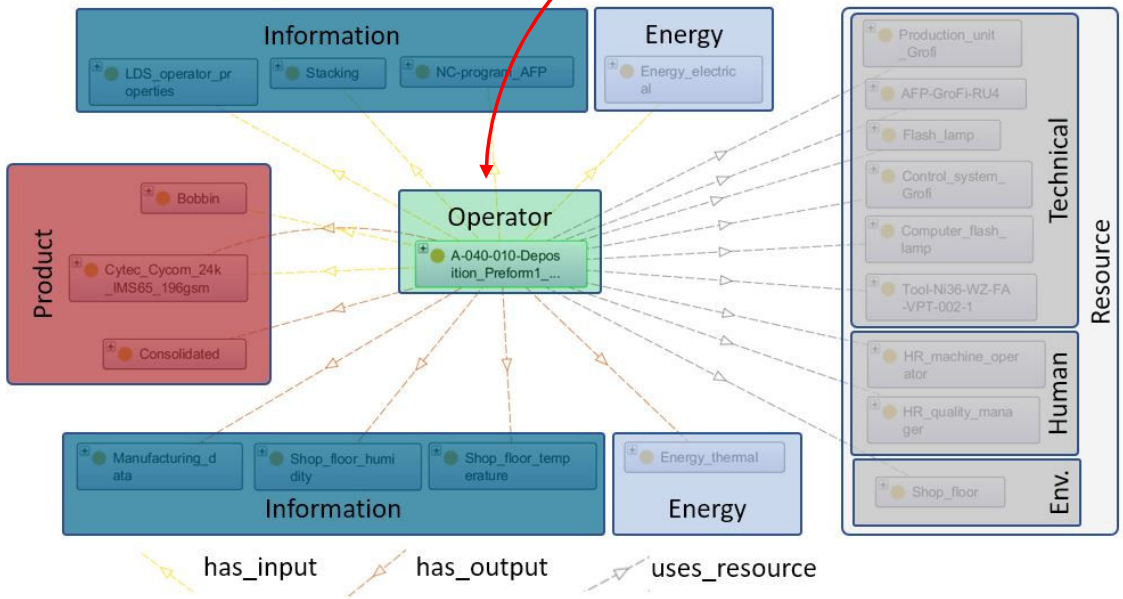
Assembly, curing & postprocesses (C)

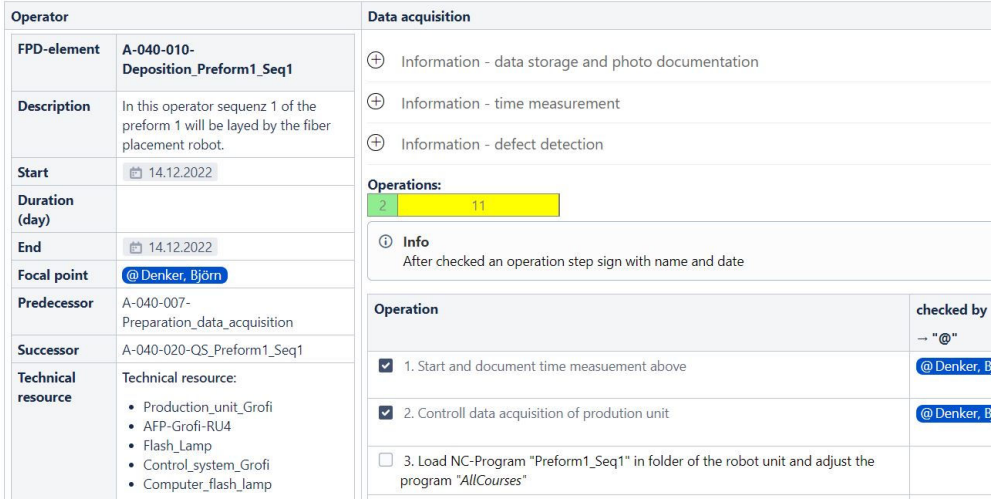
Application on manufacturing of aircraft moveable



FPD elements and links on operator level

FPD elements + process step descriptions





Operator	
FPD-element	A-040-010-Deposition_Preform1_Seq1
Description	In this operator sequenz 1 of the preform 1 will be layed by the fiber placement robot.
Start	14.12.2022
Duration (day)	
End	14.12.2022
Focal point	@Denker, Björn
Predecessor	A-040-007-Preparation_data_acquisition
Successor	A-040-020-QS_Preform1_Seq1
Technical resource	Technical resource: • Production_unit_Grofi • AFP-Grofi-RU4 • Flash_Lamp • Control_system_Grofi • Computer_flash_lamp

Data acquisition

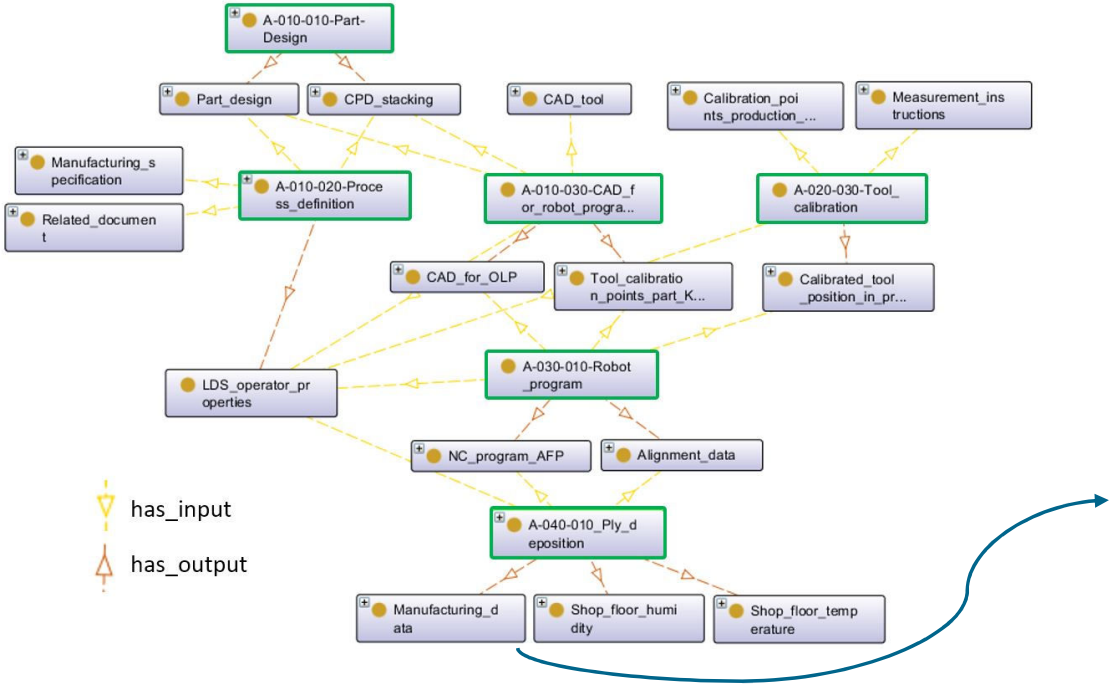
- Information - data storage and photo documentation
- Information - time measurement
- Information - defect detection

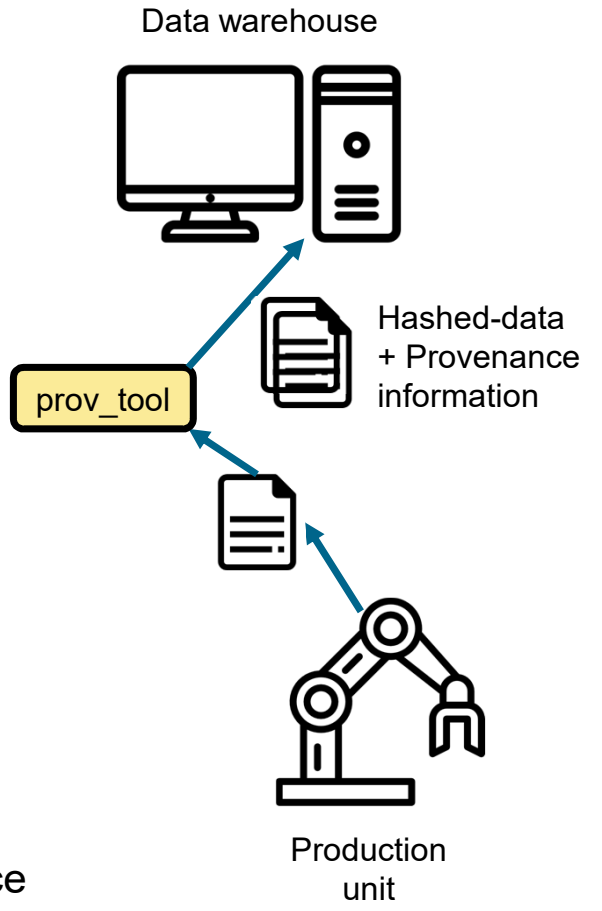
Operations: 2 11

Info
After checked an operation step sign with name and date

Operation	checked by → "@"
☑ 1. Start and document time measuement above	@Denker, B
☑ 2. Controll data acquisition of prodution unit	@Denker, B
☐ 3. Load NC-Program "Preform1_Seq1" in folder of the robot unit and adjust the program *"AllCourses"*	

Application on manufacturing of aircraft moveable





- Interactions of FPD element „Information“
- Application of provenance-tool on measured data
  → Traceable information flow for data generate by technical resource

Evaluation of applied FPD and LDS

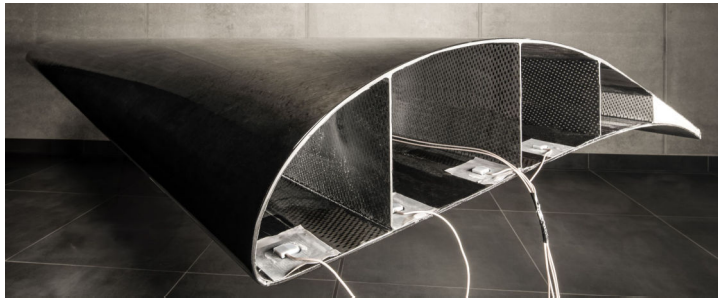
- High data complexity, especially due to many operators and their linkage to each other and their FPD elements
- 26 information at process C (based on measured data object (not on sensor level))
  - Operator “Injection & curing” generates 8 information outputs, although
    - 36x thermocouples
    - 24x ultrasonic sensors
    - 1x gelnorm sensor
    - 1x pressure sensor
    - 4 dielectric sensors and
    - 8x4 fibre bragg gratings
    - Data log autoclave
    - Data log injection unit

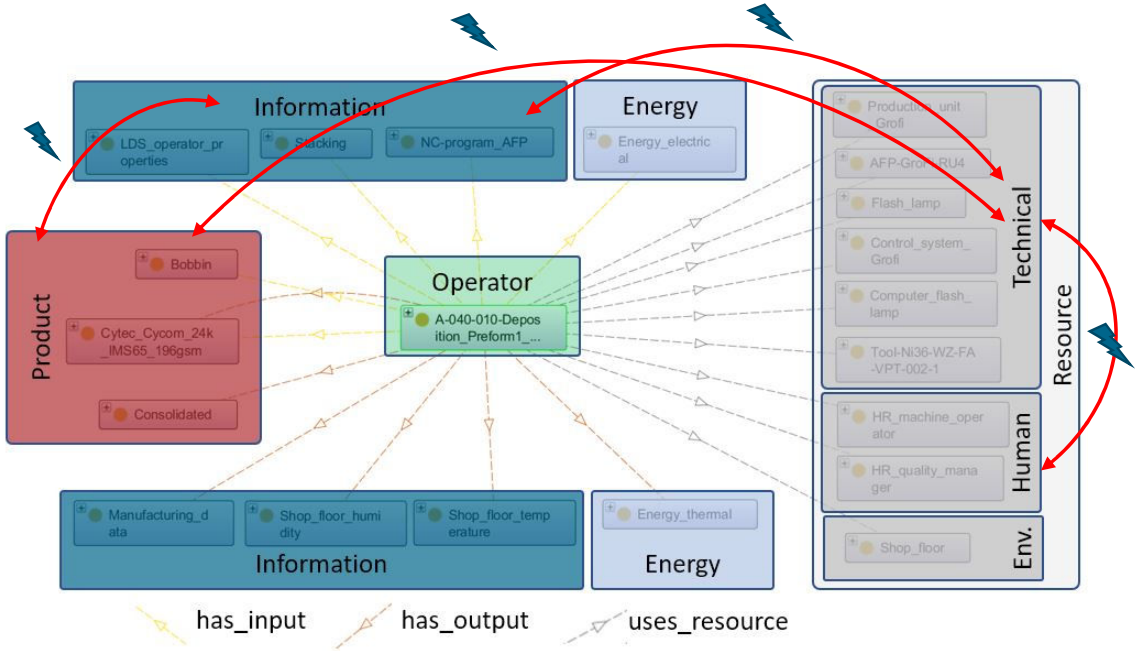
FPD element	Process A : Skin manufac-turing	Process B: Spar manufac-turing	Process C: Assembly, curing & postprocesses	Sum (A+B+C)
Process operator	226	33	56	**316**
Working steps	1695	281	512	**2488**
Technical resource	56	53	165	**274**
Information (input & output)	49	7	26	**70 (doublings)**
Product (input & output)	36	49	19	**104**

Evaluation of applied FPD and LDS

- Pro:
  - Linkage of all planned and measured data is visualised on one operator side
  - Linkage of FPD elements to operator and between operators enabled semantic analysis
  - Improved data analysis due to summarised content of all operators (outputs, comments, defects, ..) incl. data export

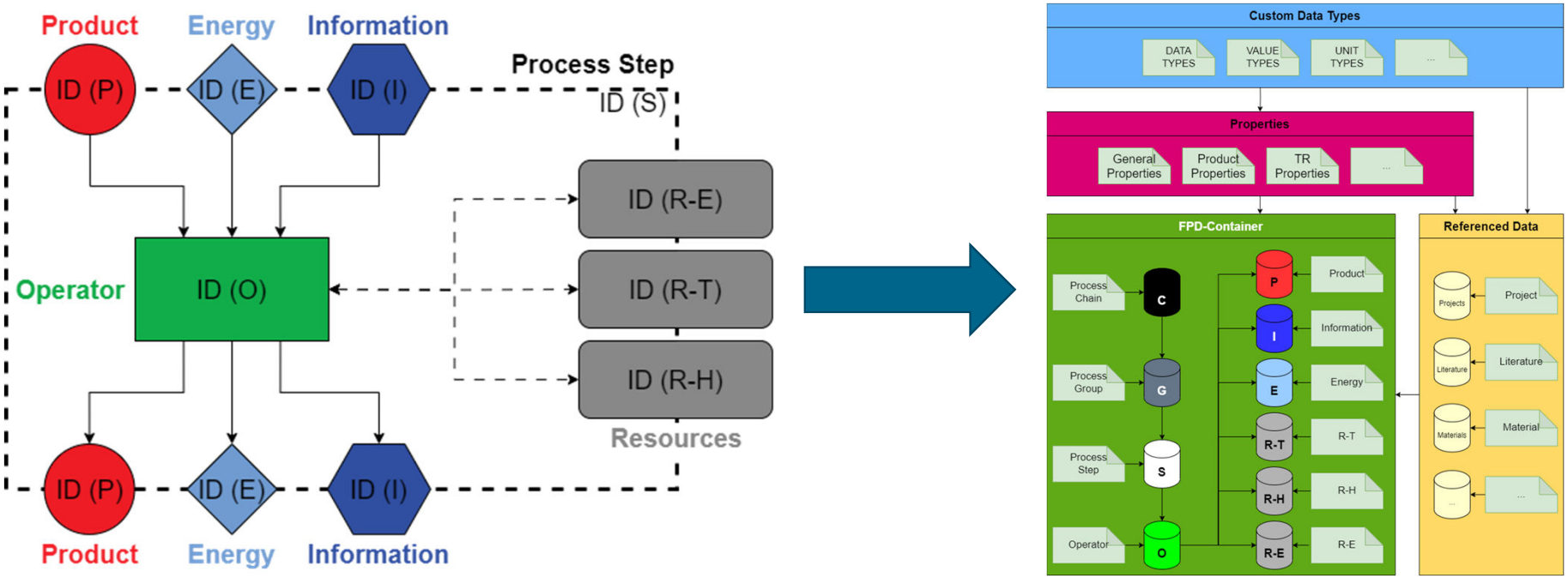
- Contra:
  - Software for FPD creation is not available yet that led to an actual manual transfer in the LDS
  - LDS software has no possibility to define cross dependencies between input and output as well as resource elements of an operator
    - Part design *effects* material
    - Material *effects* process parameter (pp)
    - Material or pp *effects* technical resource
    - Technical resource *effects* human resource





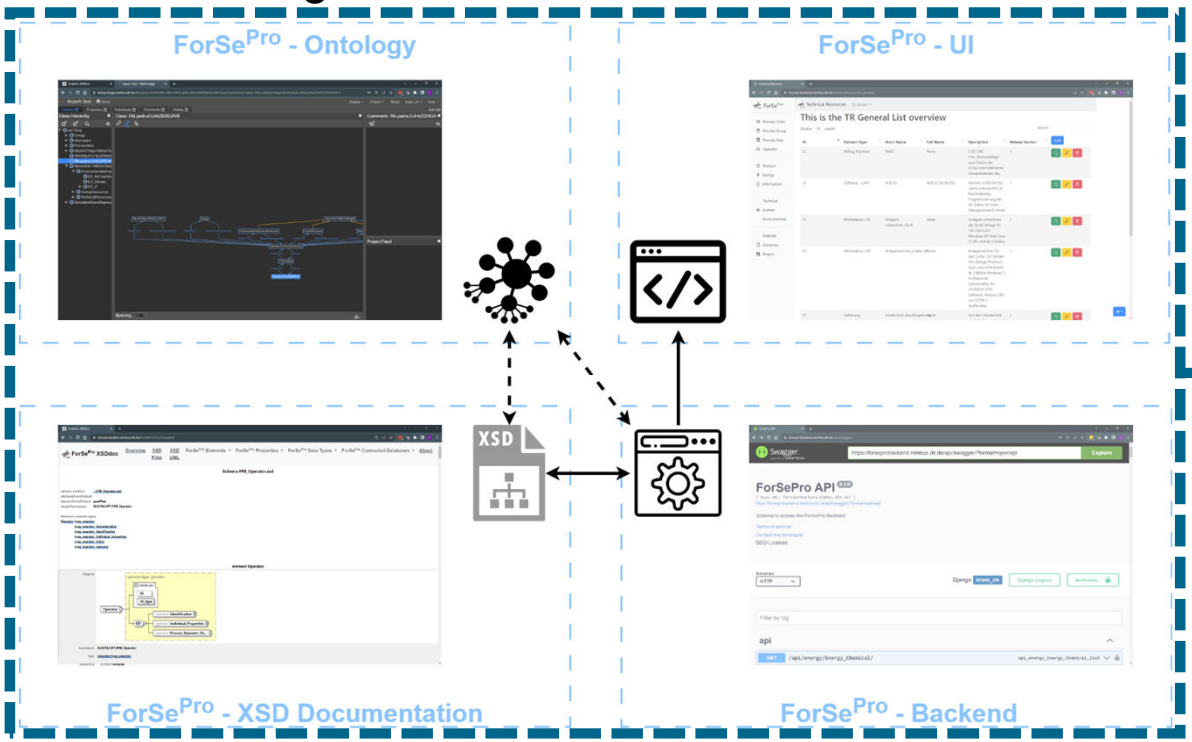
Transfer to production ontologies

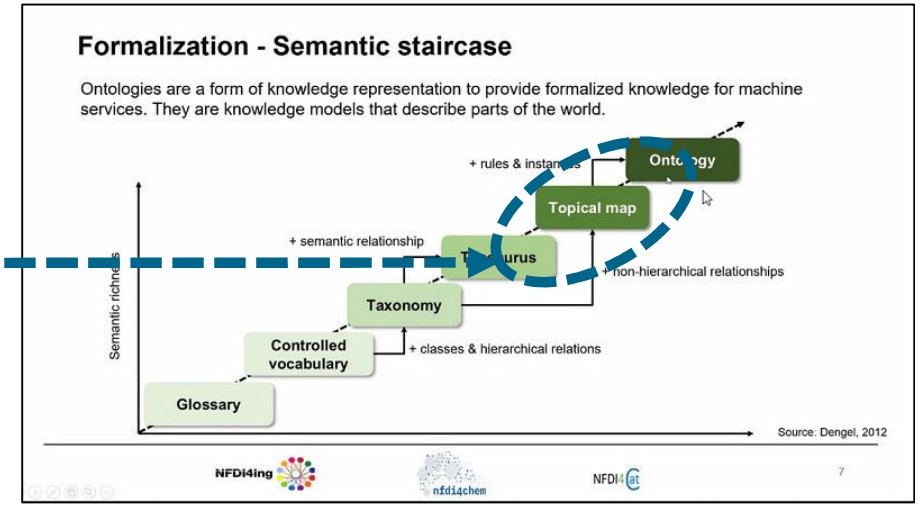
- Transfer of manufacturing related data (virtual and physical) into semantic modelling
- Definition of custom data types, properties, referenced data and FPD elements including relations within XML Schema definition (XSD) language



Transfer to production ontologies

- Development of a DLR Software framework “ForSe^{Pro}” as a web application for definition, use and reuse of FPD data as well as continuous development of semantic modelling





Summary and outlook

- ✓ Approach of a LDS design based on formalised process description was carried out
- ✓ Evaluation of LDS design and digitalisation with a full scale manufacturing of a moveable was performed
- ✓ Internal released framework “ForSe^{Pro}” for semantic modelling

- ➢ Continuous use and further development of the digital LDS
- ➢ Development and implementation of methodologies for semantic and non-hierarchical relationships of FPD elements/assets to enable cross dependencies
- ➢ Implementation of methods for automatic assessment of processes (technical, economical, ecological, etc.)

Acknowledgement

- Presented work was carried out in the project "*Virtual Product House im ECOMAT 2.0: Virtuelle Produktenwicklung für klimafreundliche Flugzeuge*" *(grant number LURAFO4001A)*

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Thanks for your attention

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