LIT Factory

Möglichkeiten der Digitalisierung in der Bauteilauslegung

Zoltan Major, Institute of Polymer Product Engineering

LIT Factory & Smart Systems Engineering

unique production systems, additional 2000 m²

Smart Processing with Digitization

Smart Composite Extrusion; Company LEISTRITZ

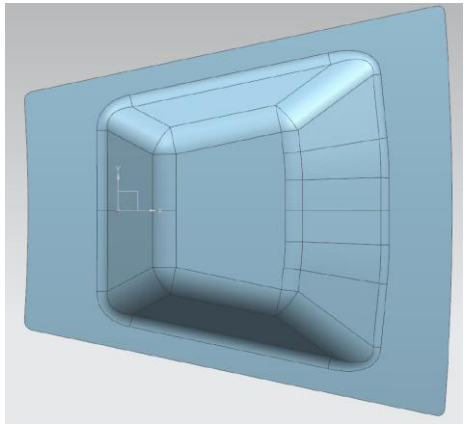
Smart Composite Injection Molding; Company ENGEL

Smart Recycling; Company EREMA

Smart System Engineering

Design of smart polymeric components for industrial applications (industrial components)

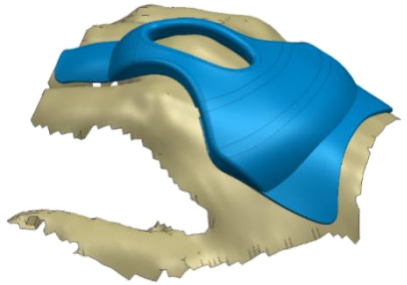
- Automotive parts
- Aircraft components



Locomotion Engineering & Personalized Technologies Lab

Design of smart polymeric components for medical and personal assistance systems

- Medical support systems
- Bicycle concepts, micromobility

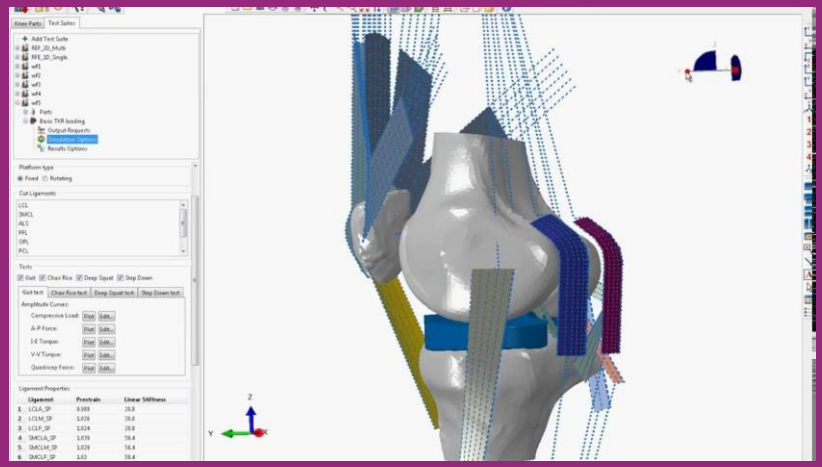


LIT Factory IPPE LABS

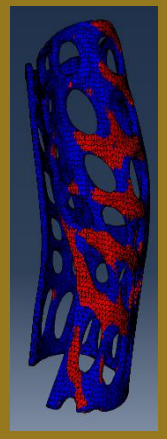
Smart Systems Engineering Lab
(Umut D Cakmak)

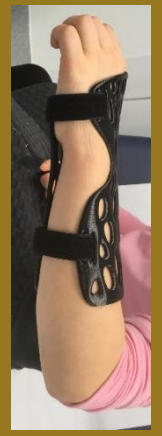
Experimental Mechanics

Modeling and Simulation



Additive Manufacturing





Design, CAD and PDM/PLM/LCA

Locomotion Lab and
Personalized Technologies
(Martin Reiter)

JKU LIT Factory

LIT Factory: Smart System Engineering

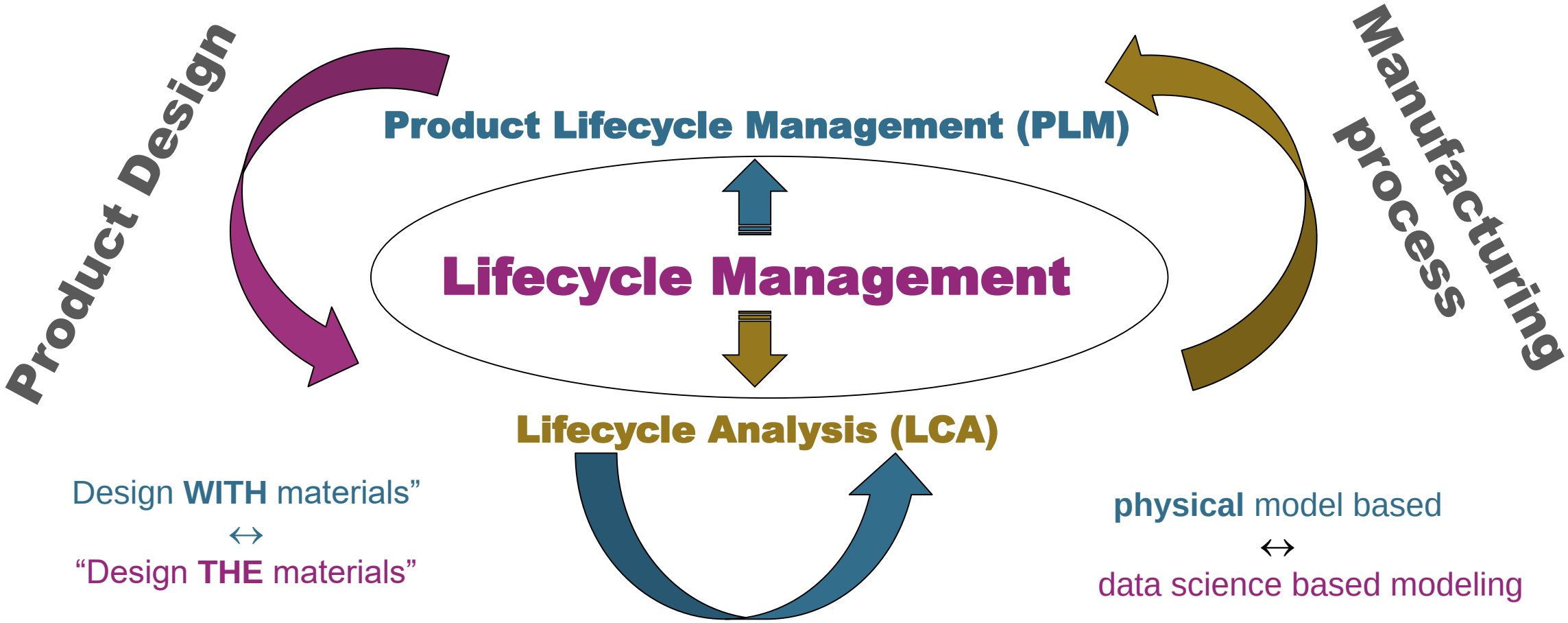
- The main activity of the **Smart System Engineering Lab (SSEL)** is the adaptation and implementation of various modules of the methodology "Integrated Computational Materials Engineering (**ICME**)".

- **Methodology:**
  - Design **WITH** materials" combined "design **THE** materials"
  - Engineering molecular dynamics – processing – micromechanics – macroscopic component performance and life time/reliability assessment simulation

- These modules involve both **physical model** based and **data science** based modeling and simulations tools for descriptive, predictive and perspective simulation models.

- To support the advance of sustainable development by proper digitization, **quantitative life cycle analysis** (**LCA**) models have been elaborated of in various software tools and are combined with above engineering tools within a comprehensive product life cycle management (**PLM**) software environment.

Smart System Engineering



Design **WITH** materials”
↔
“Design **THE** materials”

physical model based
↔
data science based modeling

“Integrated Computational Materials Engineering (ICME)”.

LIT Factory: Smart System Engineering

The SSEL group is supported by **various software partners**.

Main Goal: Implementation and support the industrial application of a full-scale Integrated Computational Materials Engineering (ICME) methodology

Software Licences

- **Siemens Austria** (A), LIT Factory partner, in-kind contribution, various industry licenses for the LITFactory partners (see next slide)
- **hbk Prenscia** (D, A) LIT Factory partner, in-kind contribution, nCode (fatigue and life time analysis) and ReliaSoft (reliability analysis) licences
- PRIMEaerostructures (A), Abaqus, special agreement for LIT Factory industry licences
- eXstream engineering (Hexagon Group, B), interested for partnership; Digimat, special agreement for LIT Factory industry licences
- CoreTech (Taiwan), Moldex3D research licences, individual agreement for industry use
- J-SOL (J, Tokyo), research licences of J-OCTA (molecular dynamics) and J-Composites (forming and compression molding), individual agreement for research

LIT Factory: Smart System Engineering

➢ Multiscale Package 1 (LIT Factory partners, Siemens, hbk)

SIEMENS
Ingenuity for life

NX
CAD

Culgi
Molecular dynamics simulation

Heeds
Optimization

Star CCM Plus
Processing simulation, injection molding

SimCenter3D Materials Engineering
Micromechanics, ICME

SimCenter3D
Component Simulation

FiberSim
Processing simulation, draping, forming

SimCenter3D
for Durability Simulation

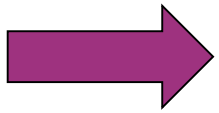
SimCenter1D
automation

nCode (hbk)
For experimental mechanics and durability simulation

TeamCenter
Product life cycle management

Reliasoft
Reliability and FMEA

Puzzle with software tools …



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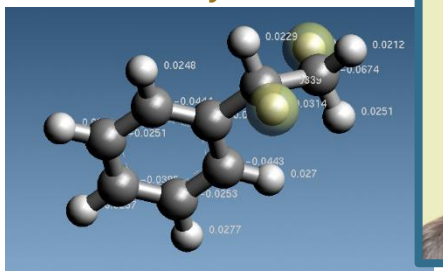
INTEGRATED COMPUTATIONAL MATERIALS ENGINEERING (ICME)

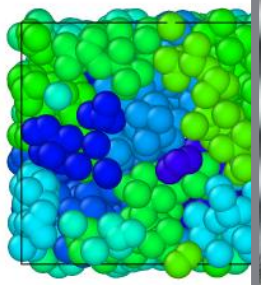
- Virtual realization of the structure-property-performance relationships
- Structure prediction by process simulations – basic method
  - Digital Continuity
- Structure prediction by experimental techniques – hybrid method

INTEGRATIVE SIMULATION
MATERIAL, PROCESS, MICROSTRUCTURE- AND COMPONENT

Molecular Dynamics (CG)
- Rheology, Viscoelasticity
- Fiber/matrix interface
- Diffusivity



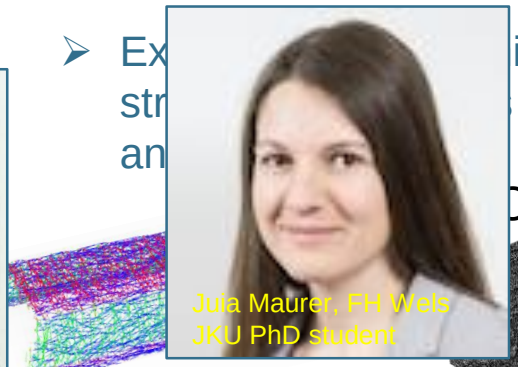
➢ To predict rheological behavior



➢ To predict mechanical behavior (stiffness, strength)

➢ Experimental determination of all input date necessary for IM/CM/AM simulations

➢ Ex ination of str (CT-FOD) an

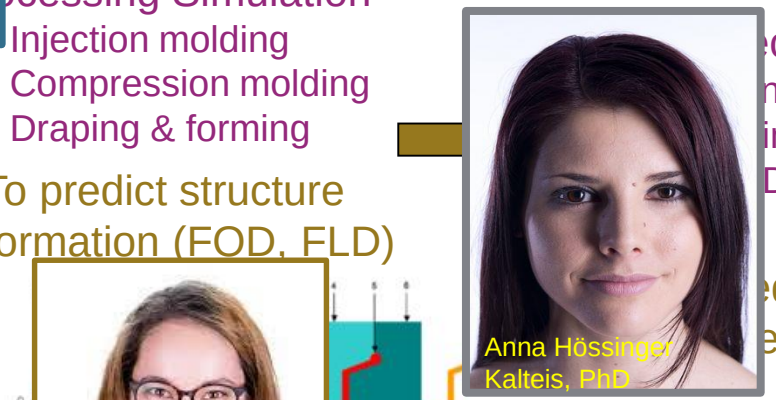


CT m

mponent
acterization
mulation
periment

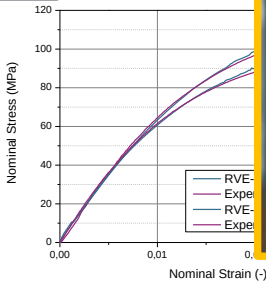
ocessing Simulation
- Injection molding
- Compression molding
- Draping & forming

➢ To predict structure formation (FOD, FLD)



echanics Simulation
ntinuous fibers (sfrp, cf-smc)
ing (cells)
D

edict mecha ess, streng



Life Time Analysis
PLM integration
LCA analysis

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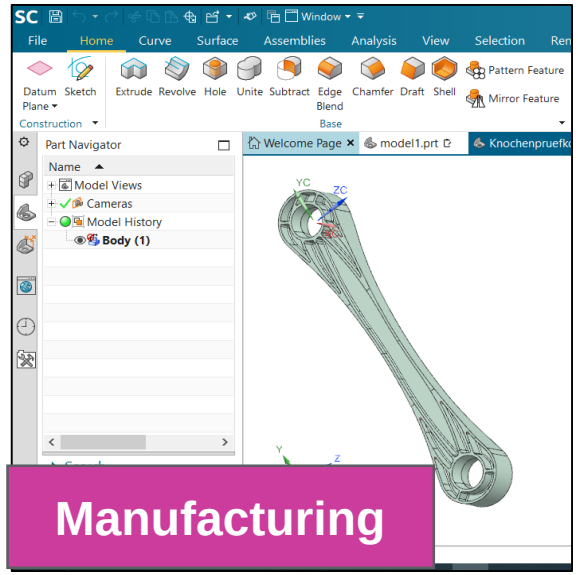
Design of Composite Components

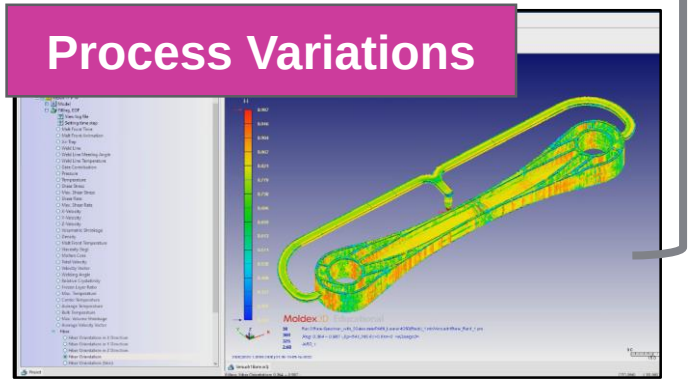
SFRP Injection Molding Workflow – *Simcenter 3D integration*



Manufacturing

From CAD…*Siemens NX*

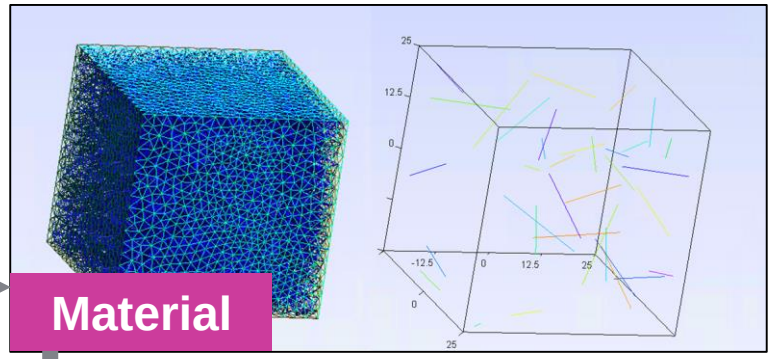
Process Variations



Automatically map Manufacturing Simulation results to structural mesh

Structural mesh and loading condition

Simcenter3D

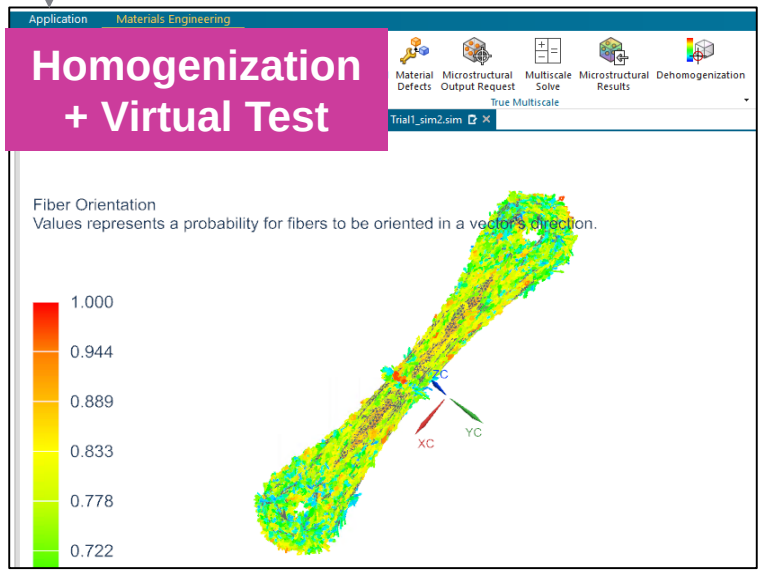


Material

Microstructure Definition

Simcenter – Multimechanics

Homogenization + Virtual Test



Multi-Scale Simulation

Simcenter - Multimechanics

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Injection Molding Simulation

Moldex3D

(Study of Disha Tupe and Erik Fabian

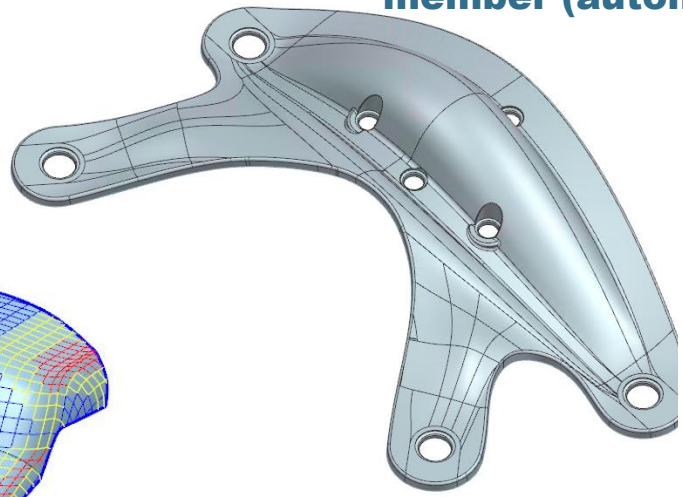
Design of Composite Components

Draping and forming simulation studies

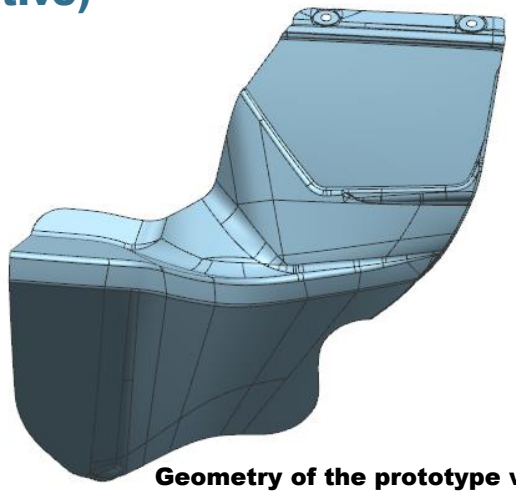
Kinematic modeling

- **Determination of shear angle**

Transmission cross member (automotive)

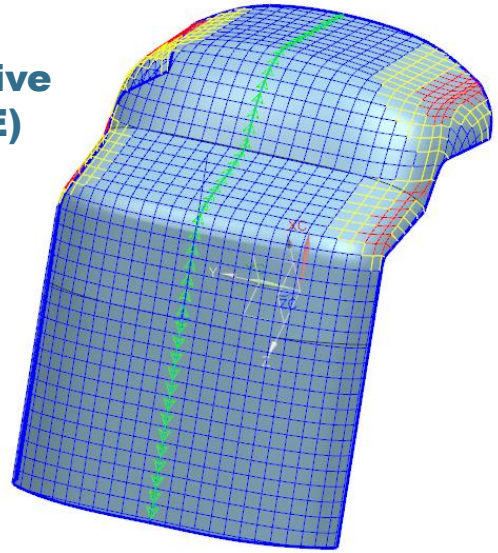


Aircraft component

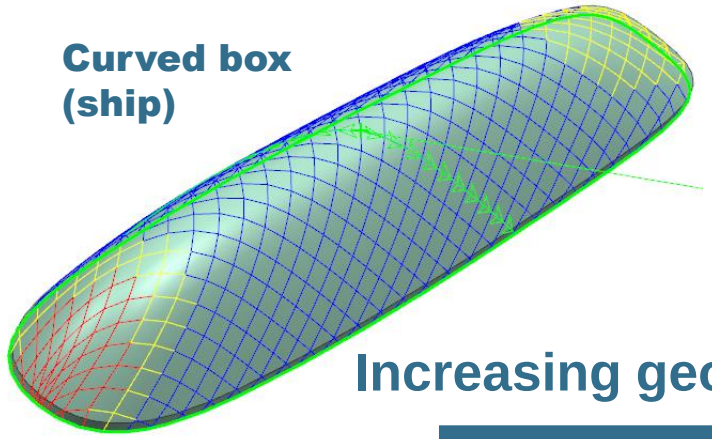


Geometry of the prototype was received by Carbon-Solutions Hintsteiner GmbH.

Nohab locomotive front (RE)



Curved box (ship)



FE Simulation

- **Non-linear, strain rate and temperature dependent material models at forming temperature**

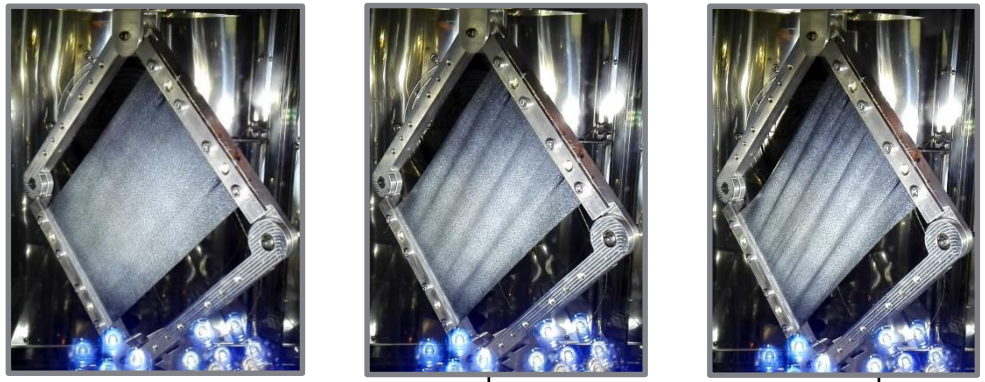
Increasing geometrical complexity (number, grade and sharpness of curvatures

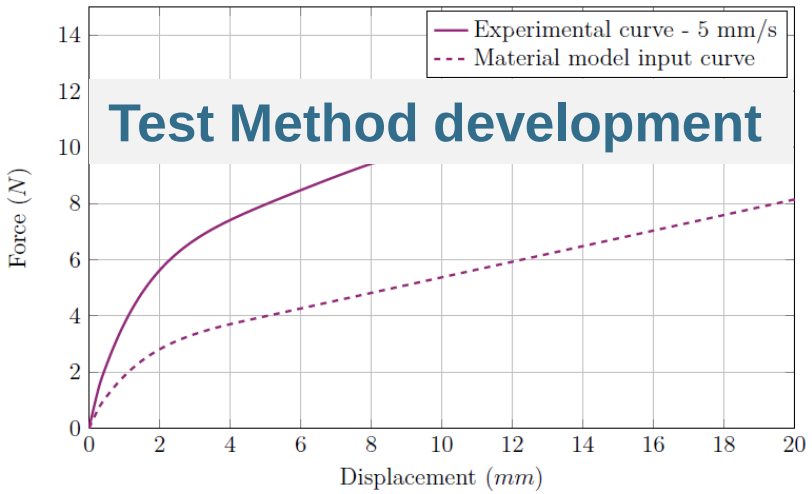
Software tool: Siemens NX, Simcenter3D and FiberSim (Siemens Industry Software GmbH, Linz)

Forming of UD Thermoplastic Composites

Testing and Simulation Methodology

PICTURE FRAME TESTS in-plane deformation





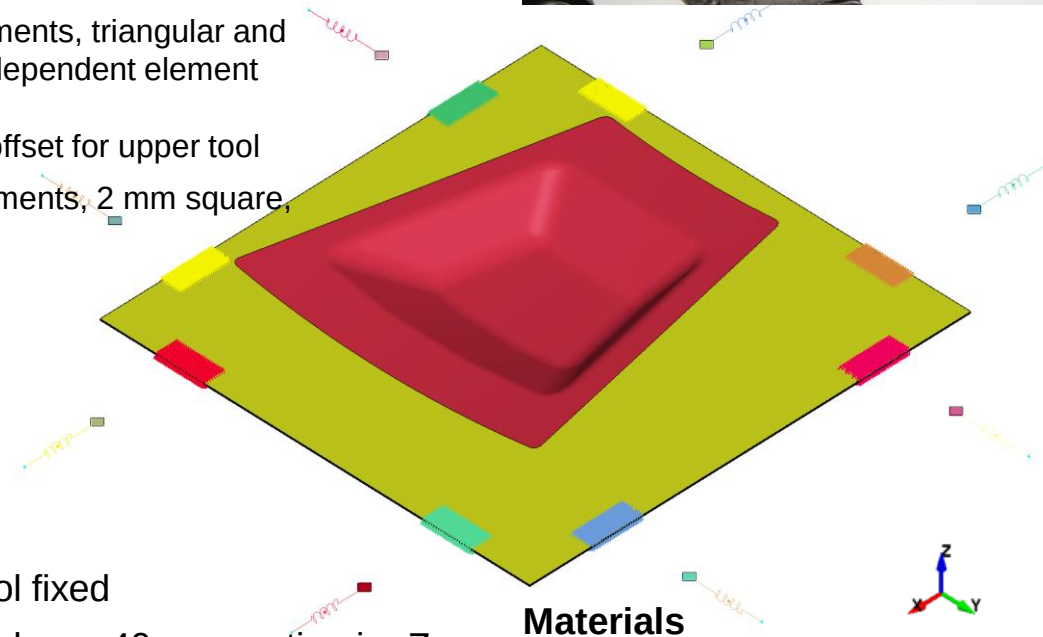
Test Method development

Forming Simulation

Mesh

Tools: 2D shell elements, triangular and square, curvature dependent element size,
1.4 mm geometry offset for upper tool

Blank: 2D shell elements, 2 mm square, uniform distributed



Boundaries

–Lower Tool fixed

–Upper Tool 40 mm motion in -Z (1.4 mm gap), speed 50 mm/s (*x 50*)

–Clamps + Springs

Materials

–Tools: rigid body

–Blank: Shell-Membrane layered (overall 24 layer)

Cooperation with J-SOL (J-Composites)

Software tool: J-Composites (J-Sol, Tokyo, J and LS-Dyna, Dynamore)

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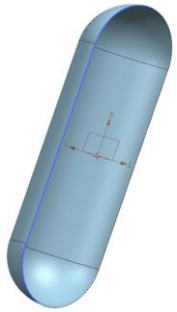
MSc Thesis of Daniel Laresser, IPPE JKU, 2019; CHASE Project 1.3 (Miron, Laresser, Kapshammer), Companies: FACC, Greiner, Borealis

Failure Modeling of Laminates

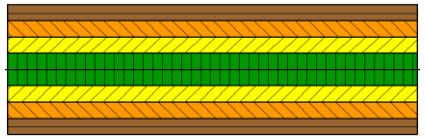
Conventional and Advanced Laminate Models

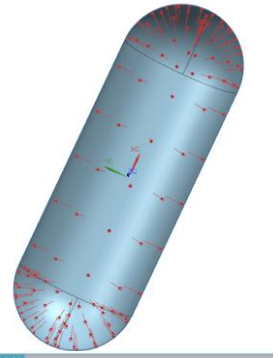
Construct geometry → Meshing → Assign material → Assign loads and constraints → Solve → Evaluate results

.prt-file

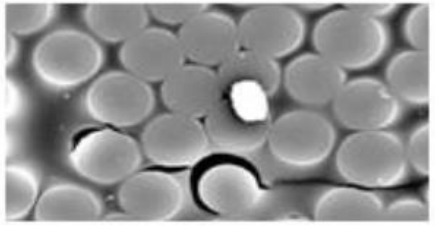


.fem-file

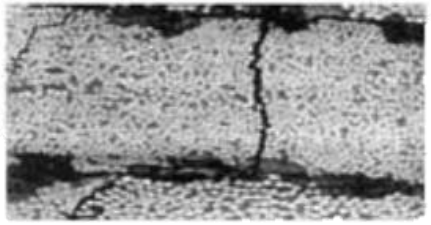


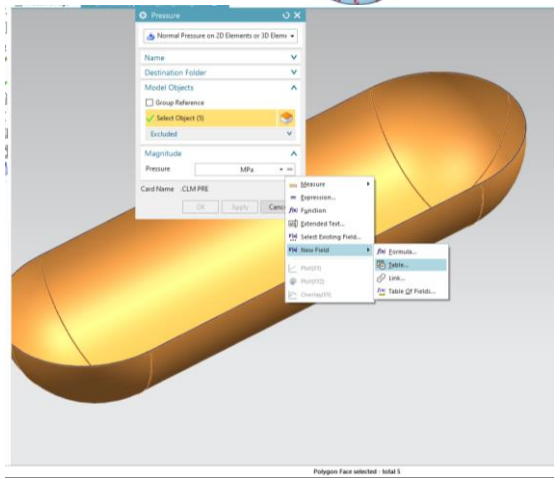


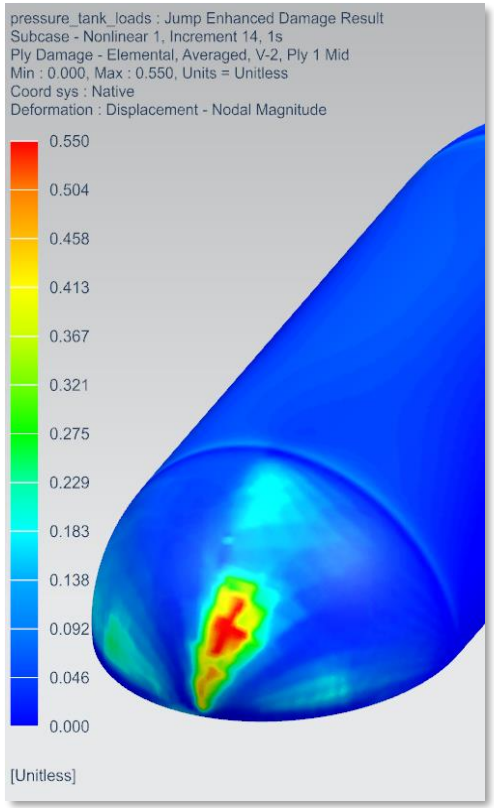
Diffuse damage

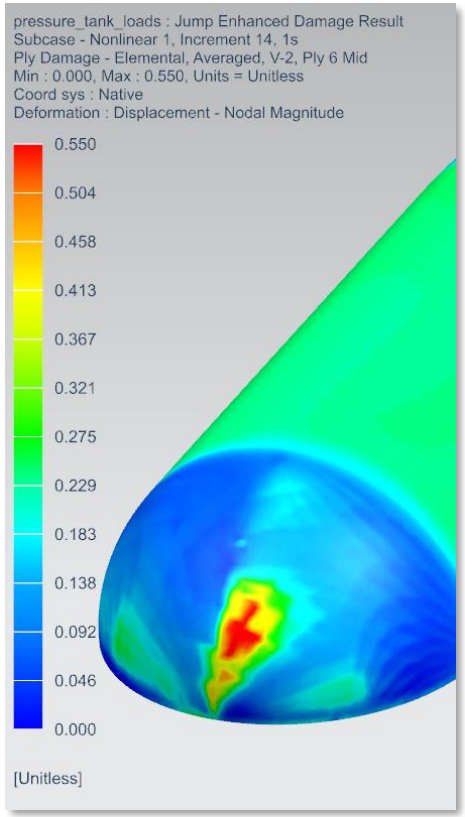


Transverse cracking









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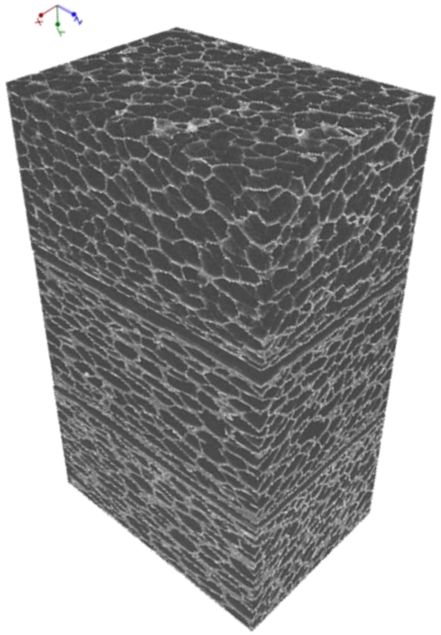
Hebertinger, 2019; G. Seebach, 2020; SimCenter3D

Modeling of Cellular Structures

CT-based Foam Models: Hybrid Integrated Models



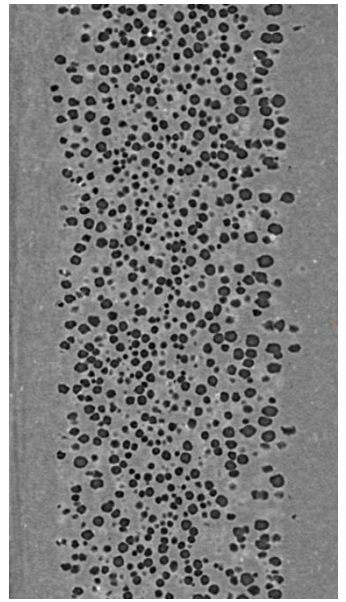
FOAM Modeling

low density foam
=
HMS extrusion foam

low cell wall thickness

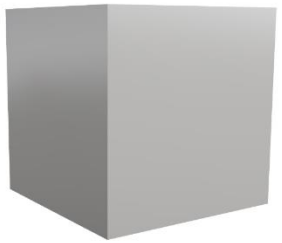
high density foam
=
injection moulding foam

high + varying cell wall thickness
skin layer

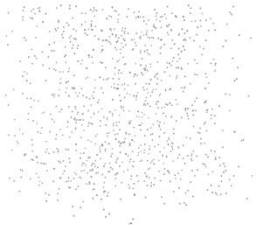


model generation from CT data

construction box



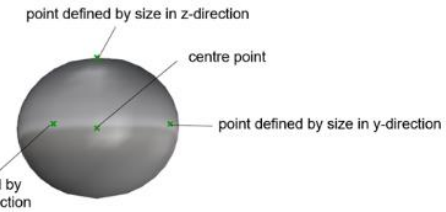
seed points



Voronoi structure

validation

- tensile test
- compression test
- bending test



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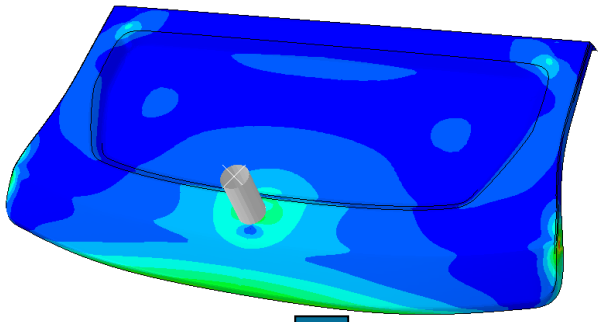
Structural Analysis of Sandwich Components

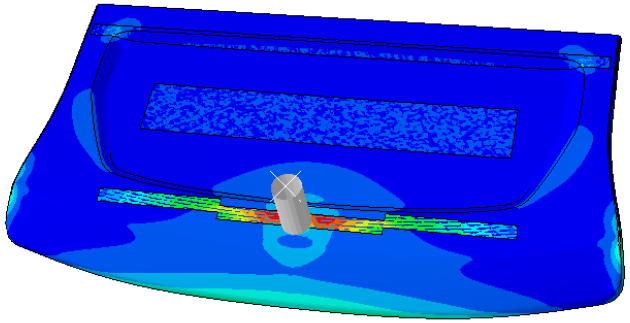
Conventional and Micromechanics Models

Components

Conventional sandwich component

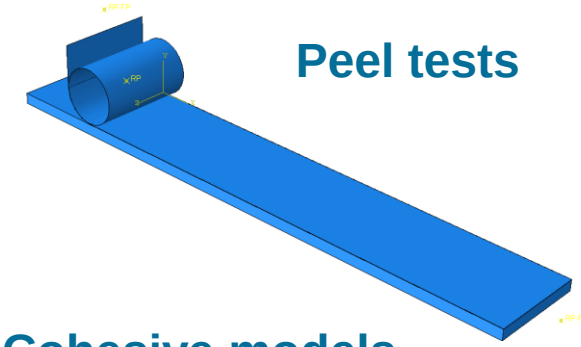


with Local Tape Reinforcement

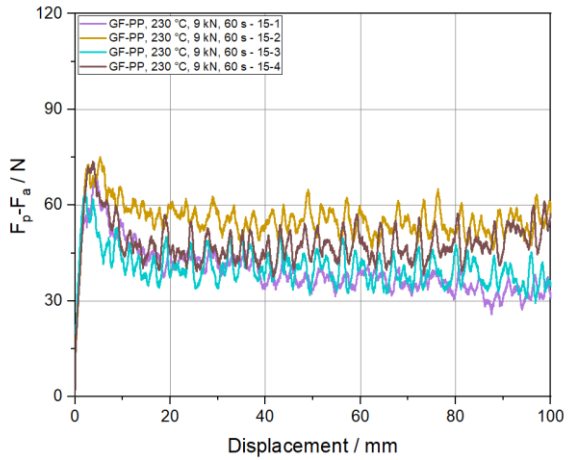


Interface Characterization

Peel tests

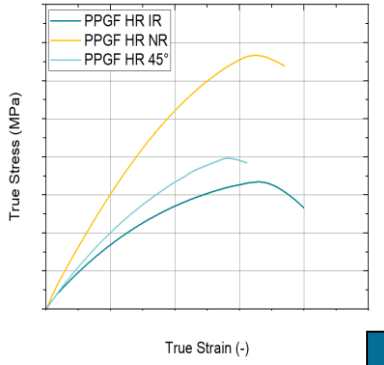


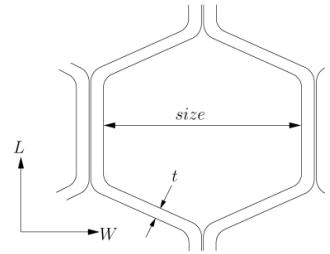
Cohesive models



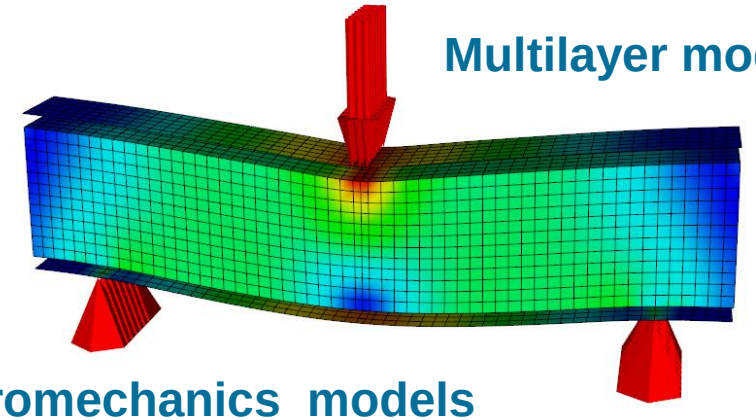
Material Modeling

Characterization of Skin and Core Materials





Multilayer models



Micromechanics models

Data Based Modeling and Simulation

AI for Material Development

AiM GEN

Data Generation

AiM EVA

Data Evaluation

AiM PRO

Property Prediction

AiM CENTER

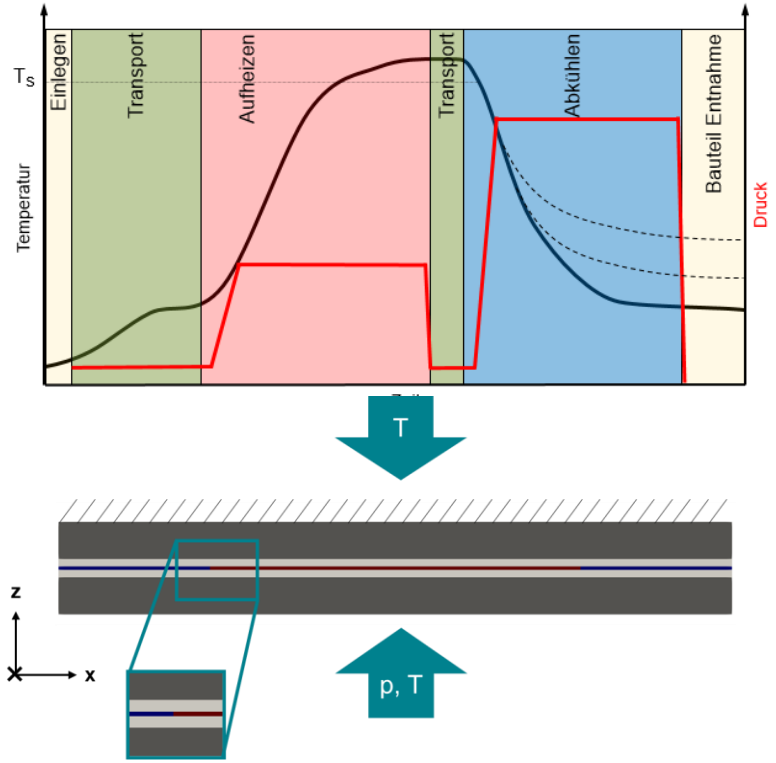
Material Database & Pre-processing

Martin Reiter, Florian Kiehas, cooperation with Borealis

Data Based Modeling and Simulation

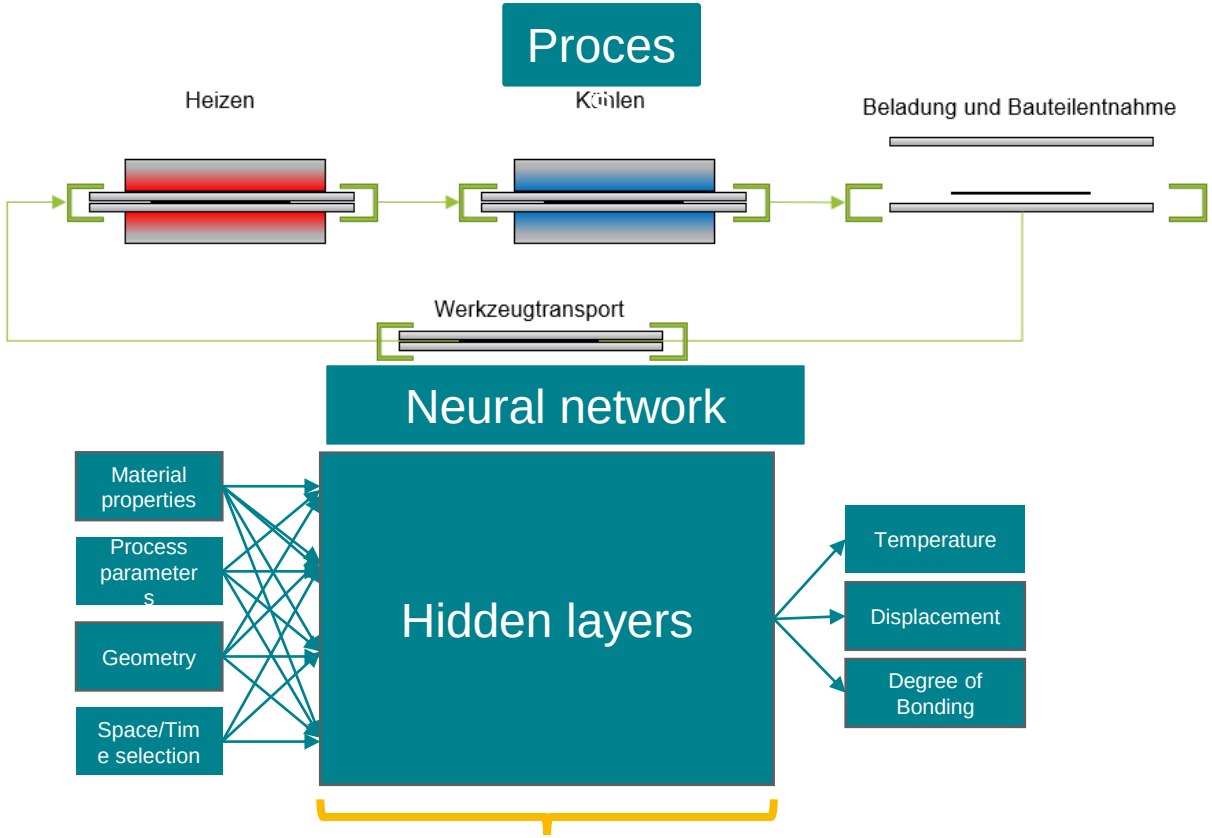
AI for Process and Component Development

Physical Model Based Simulations for Data Generation



PhD, Kobler, Chase-JKU IPIM

Data Based Model Generation



3 layers, 16 nodes each

Prediction of Processing Parameters

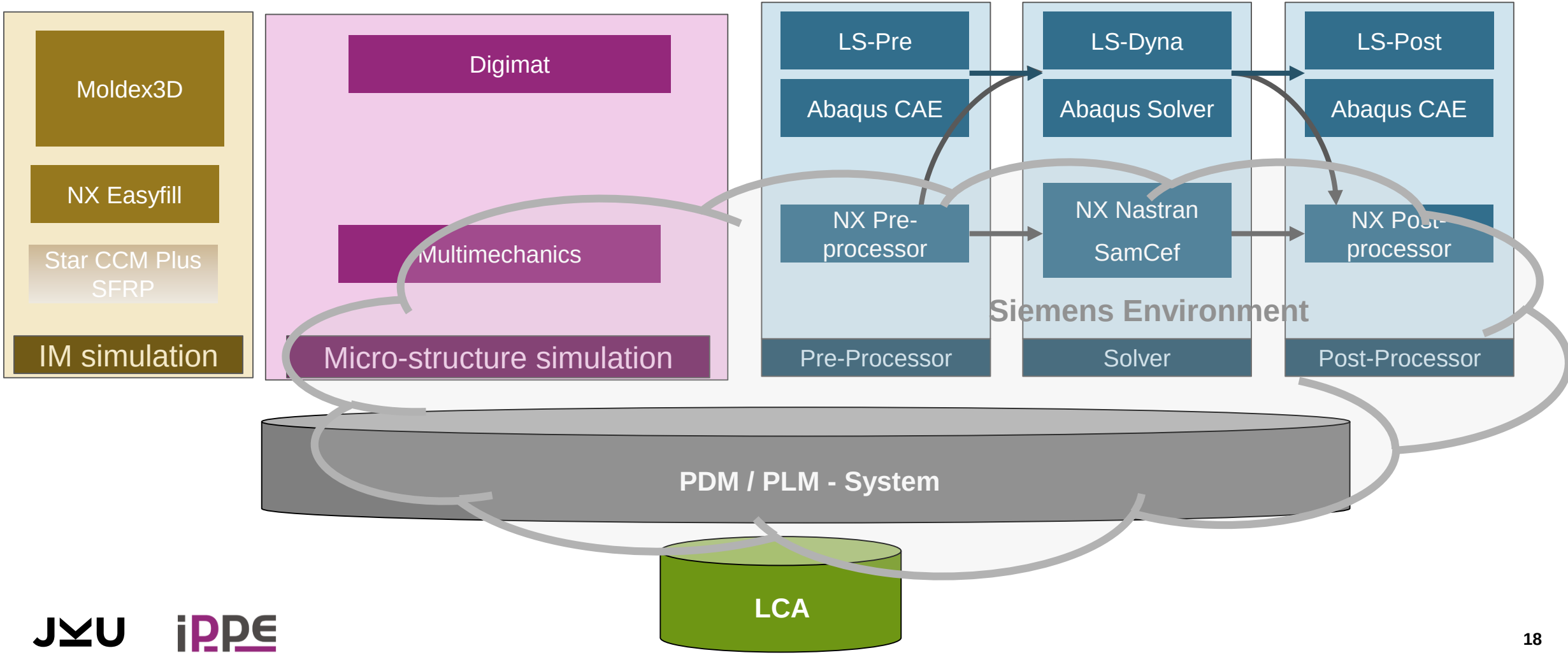
Internal LITFactory Chase Cooperation (Kobler, Seebach),

JKU LIT Factory

MODELING & SIMULATION METHODOLOGY

SIMULATION WORKFLOWS

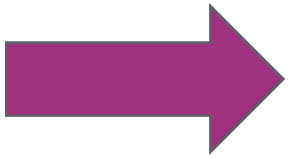
- SIEMENS ROUTE
- ROUTE WITH OTHER SOFTWARE TOOLS



Design of Components

FUNCTIONALIZATION OF COMPONENTS FOR

- **INDIVIDUAL AND SMALL BATCH AND**
- **LARGE BATCH PRODUCTION**



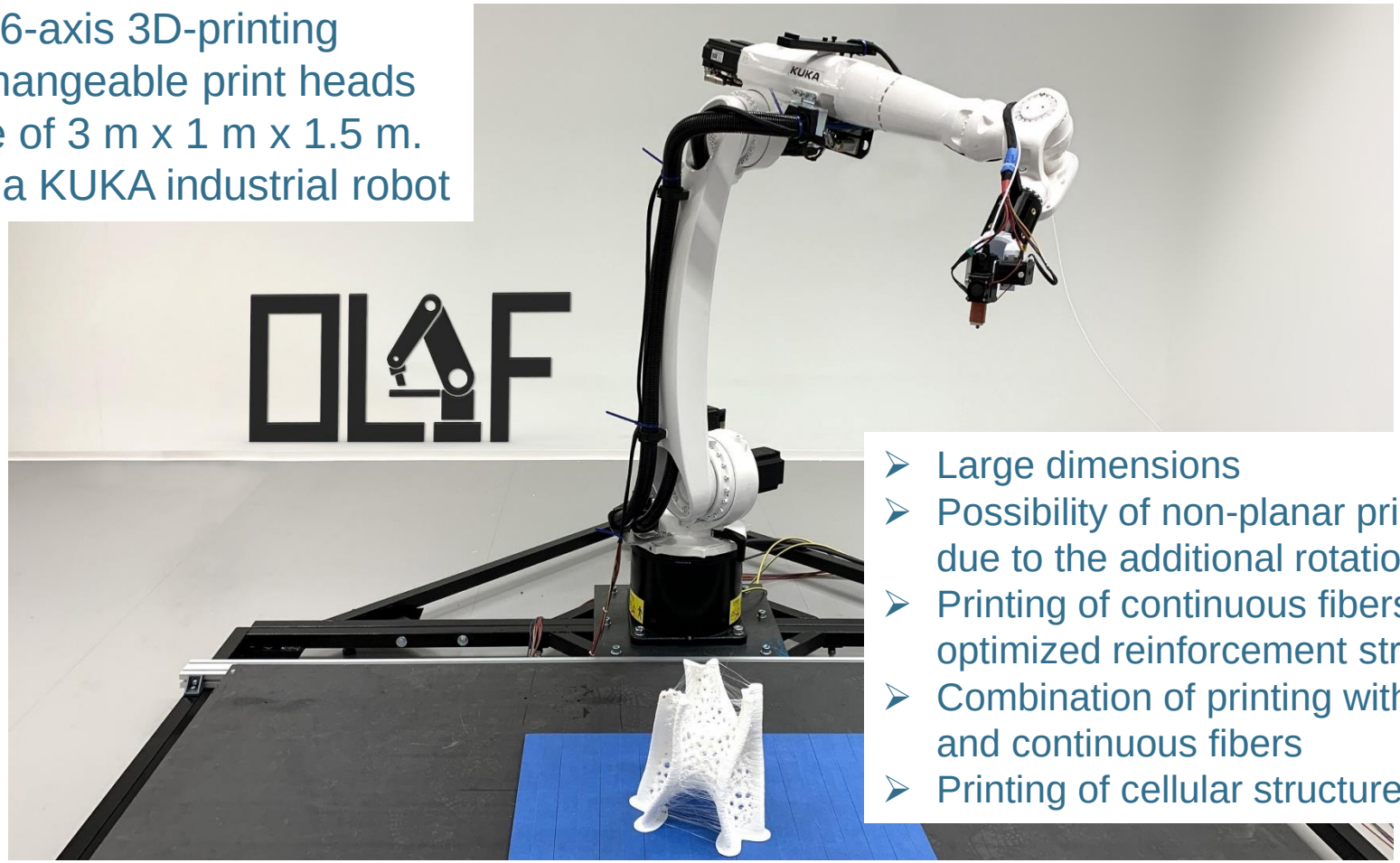
iPPE Institute of Polymer Product Engineering

iPiM Institute of Polymer Injection Moulding and Process Automation

Robot Assisted Additive Manufacturing

Unique components

- **OLAF** is a flexible 6-axis 3D-printing system with interchangeable print heads and a build volume of 3 m x 1 m x 1.5 m.
- OLAF is based on a KUKA industrial robot



Functionalization of injection molded or tape layed parts

- Large dimensions
- Possibility of non-planar printing (**curved layers**) due to the additional rotational axis
- Printing of continuous fibers for production of optimized reinforcement structures
- Combination of printing with filament, granulate and continuous fibers
- Printing of cellular structures

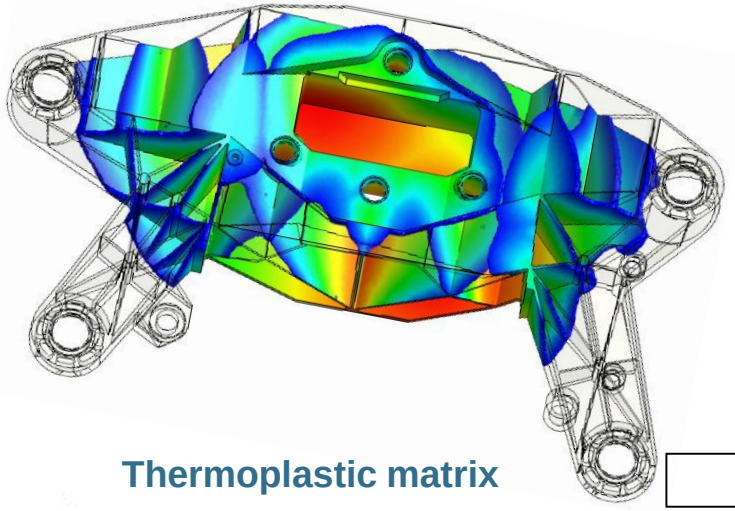
For more info please visit the Locomotion Lab

Martin Reiter, Sebastian Lämmermann, IPPE JKU

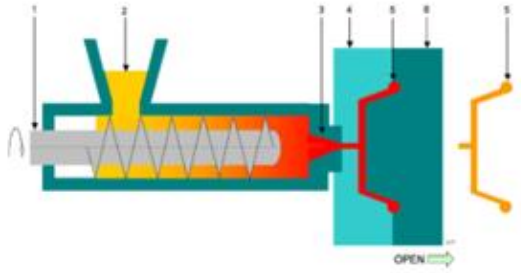
Design of Components

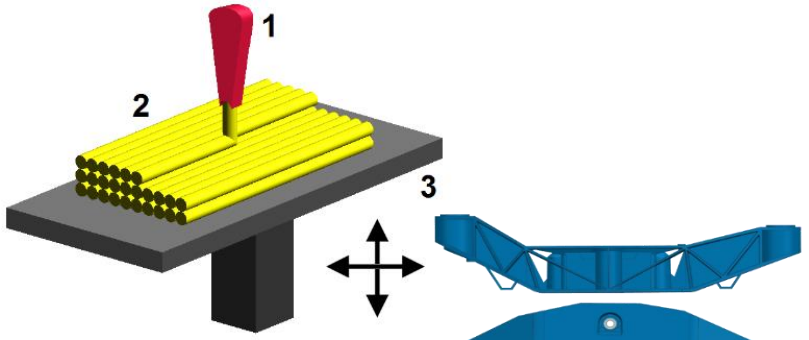
ALTERNATIVE AND COMPETITIVE PROCESSING -1: DISCONTINUOUS FIBERS

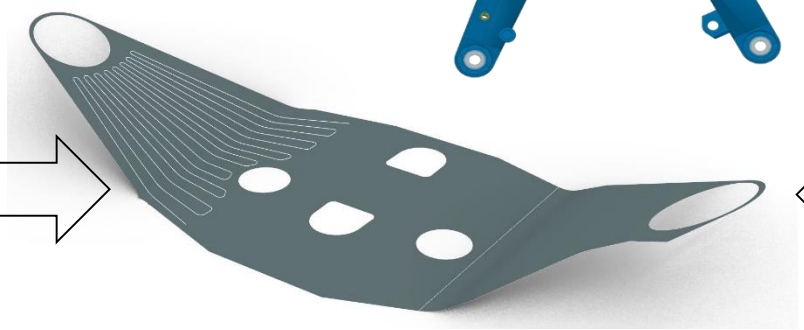
Injection Moulding, sfrp



Thermoplastic matrix







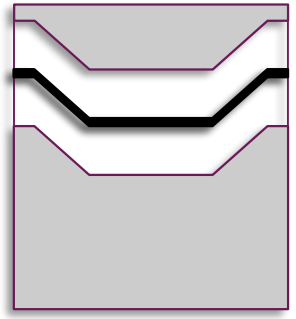
3D-printed structures in/on injection molded parts

Additive Manufacturing

Compression Moulding, CF SMC

Thermoset matrix

Thermoplastic matrix

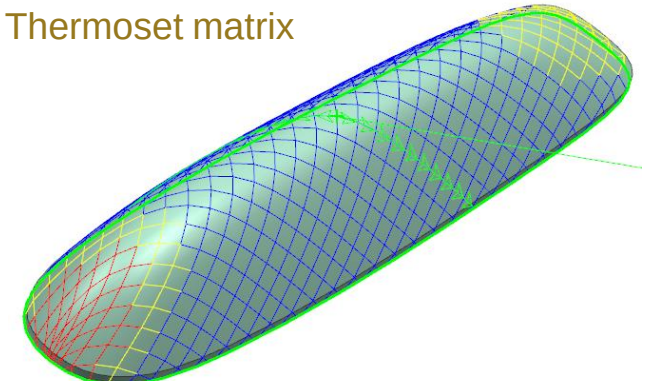


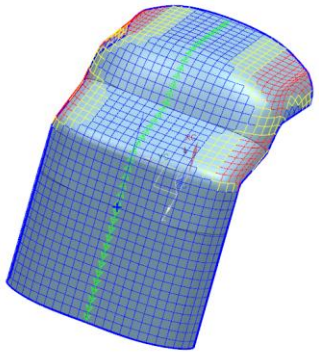
Design of Components

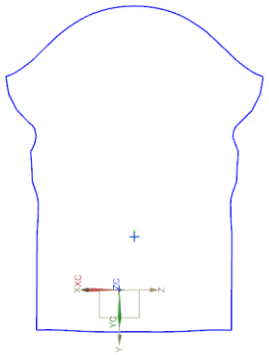
ALTERNATIVE AND COMPETITIVE PROCESSING -2: CONTINUOUS FIBERS

Draping and RTM

Thermoset matrix



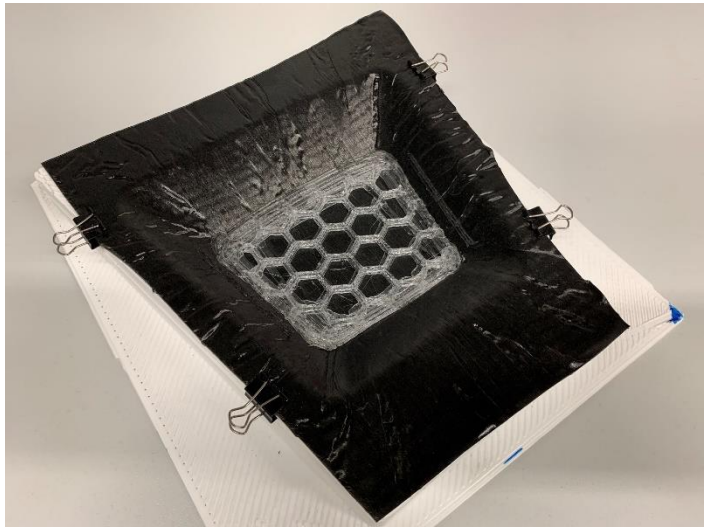




Conventional production

Flat patterns

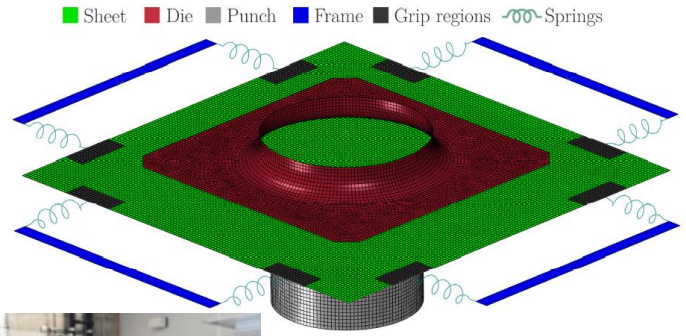
Functionalization: 3D-printed (FFF) honeycomb in thermoformed part

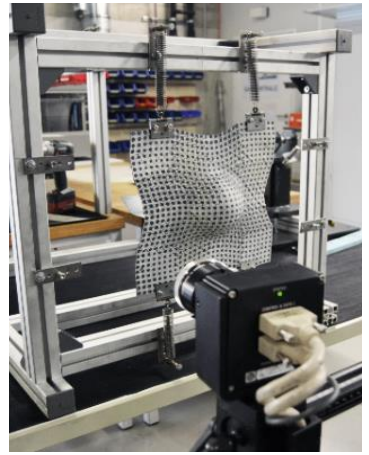


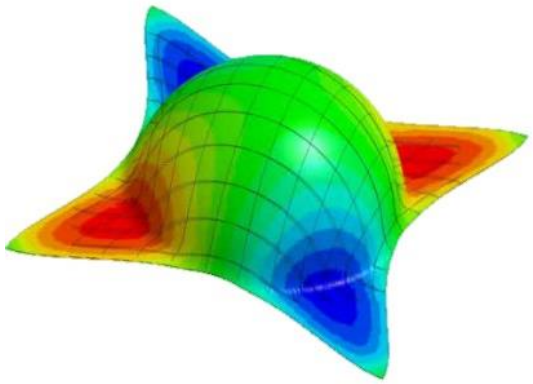
Additive Manufacturing

Thermforming

Thermoplastic matrix





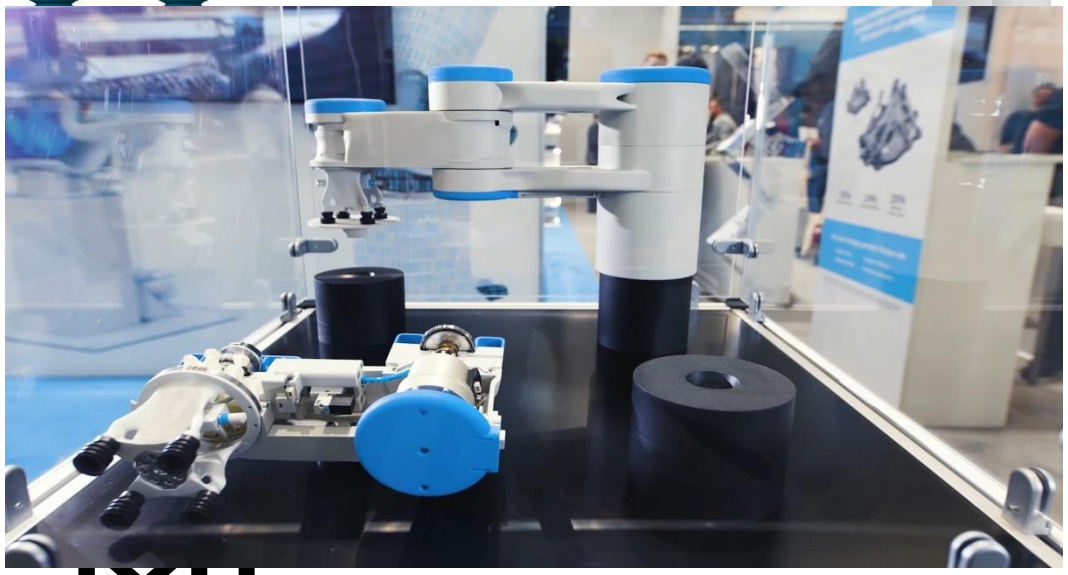


Novel production

LIT Factory

Design of Components

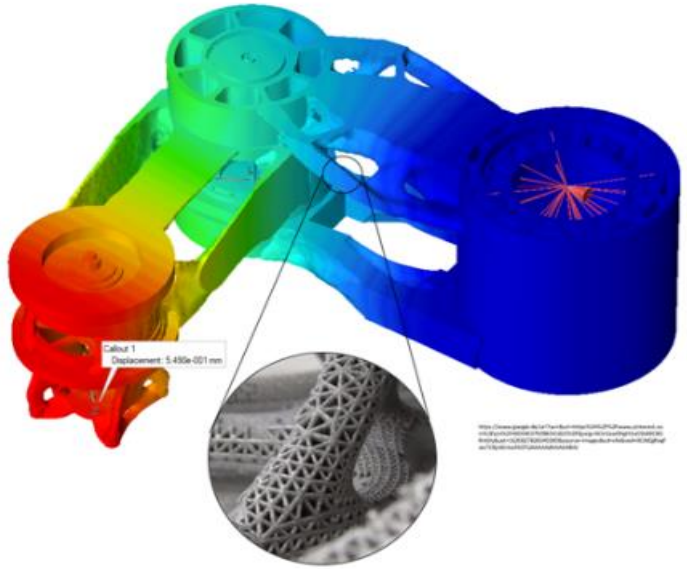
➢ Design “with” Material

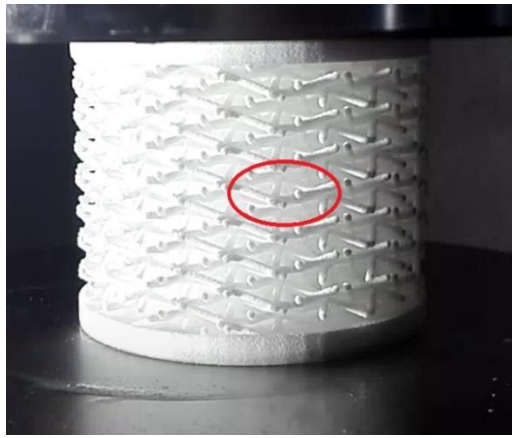


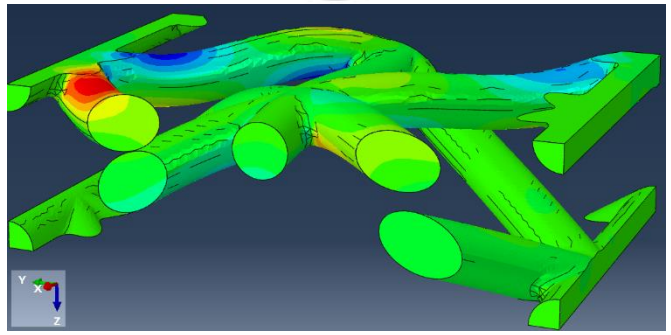
➢ Design “the” Material

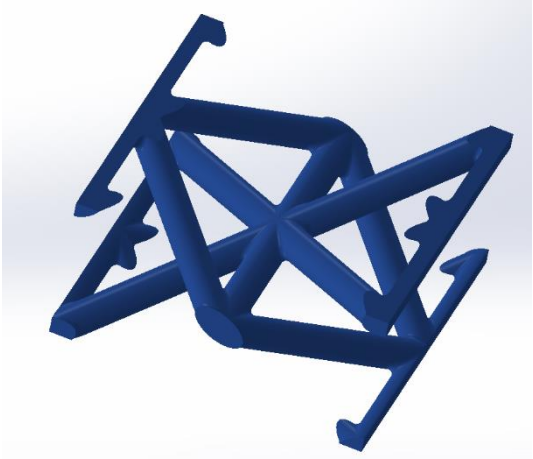
(Selective Compliance Assembly Robot Arm) **SCARA**

3D printed robot (PolyJet+SLS) (DiMap H2020, 2017-2020)









Hössinger-Kalteis, 2021; G. Dämmer, PhD, 2021

DIGITIZATION – AUTOMATIZED AND INDIVIDUALIZED SMALL BATCH ADDITIVE MANUFACTURING

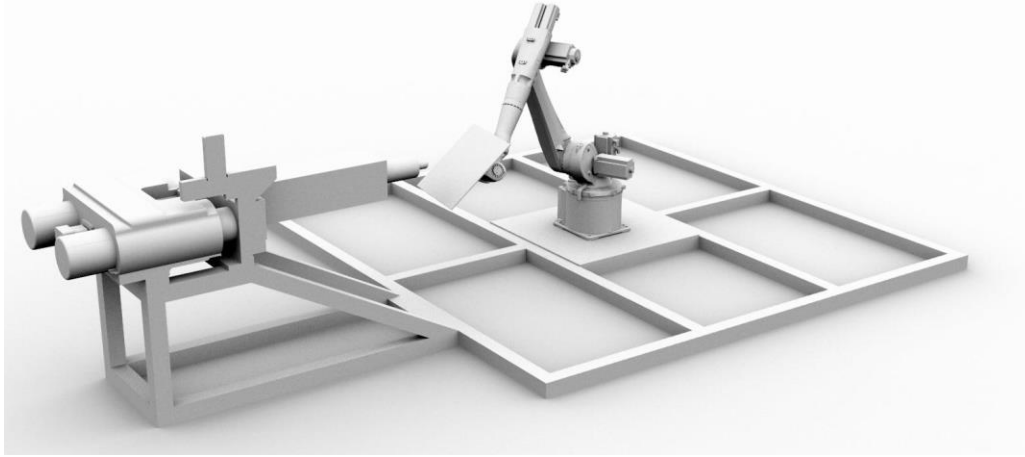
5G application

UI	Extruder/Printer	Robotics	QM

Improved User Interface

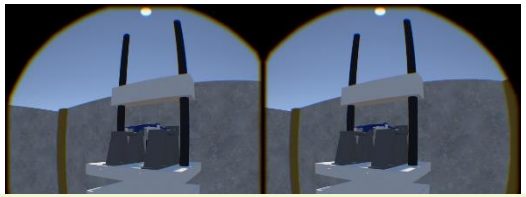
3D Printers

3D printing robot



Testing machine

Data Base for AM Materials



Virtual reality

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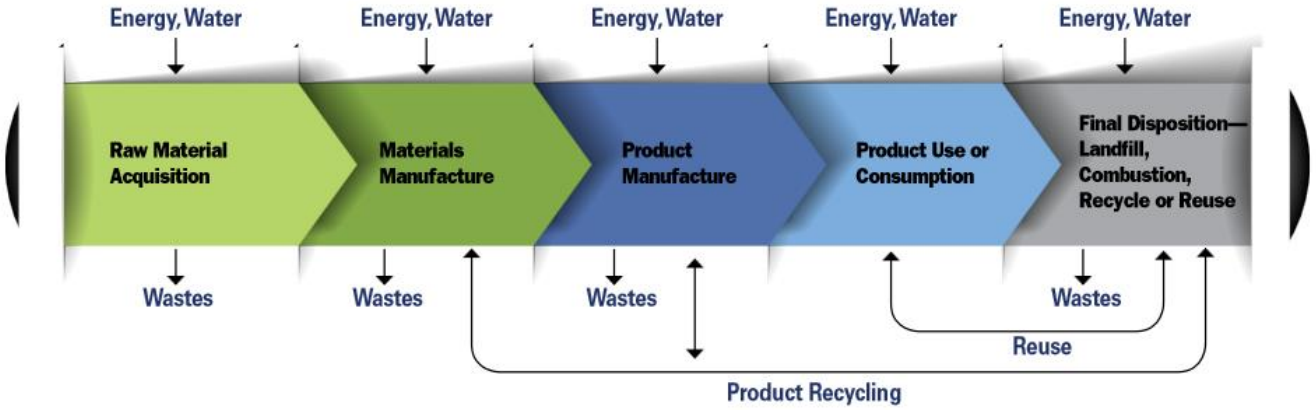
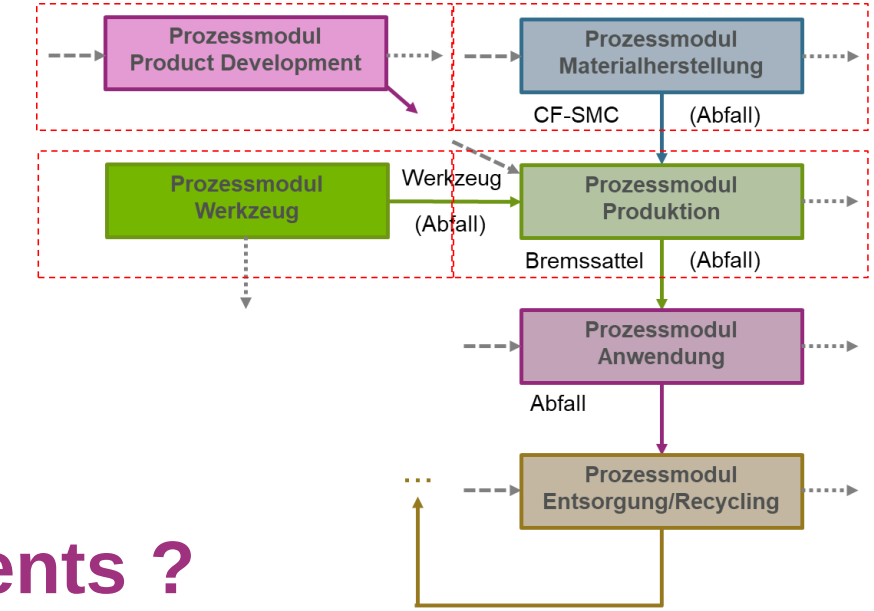
LCA of a Composite Component

General Scheme

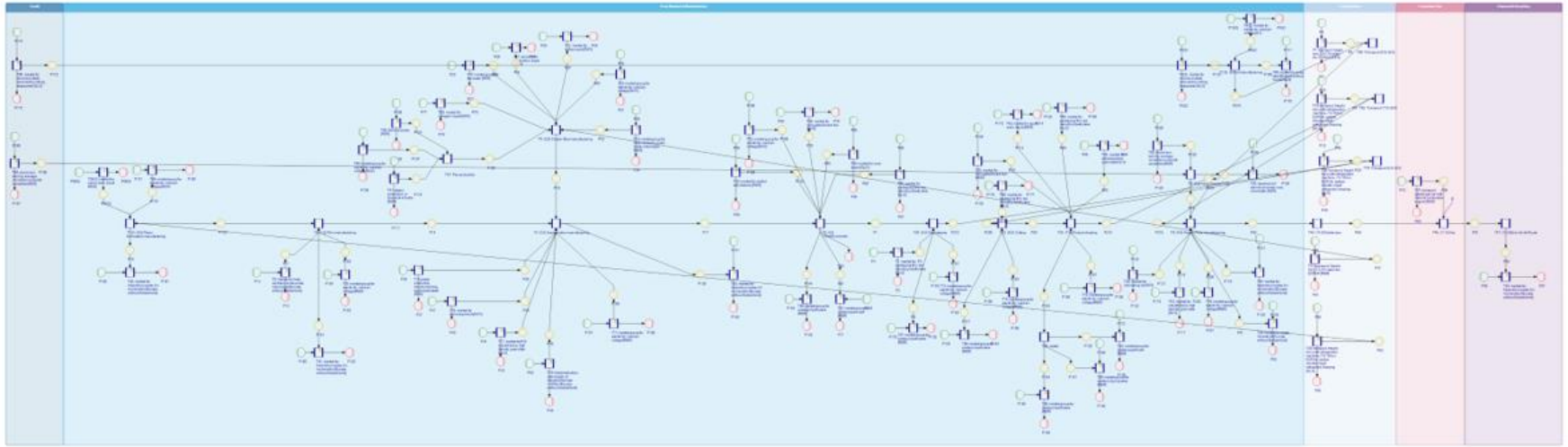


Specific Model



Hybrid or homogenous components ?

Implementation in Software Tool (Umberto)



Stelzer, 2022

Company partner: ipoint (Vienna, A)

JKU LIT Factory

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Danke für die Aufmerksamkeit

Kontakt:
Prof. Zoltan Major
zoltan.major@jku.at
+43 732 2468 6591