Towards Robustness Assessment in Virtual Testing

Manufacturing Influences by Simulation-based Methods in the VPH

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Bremen

DLR

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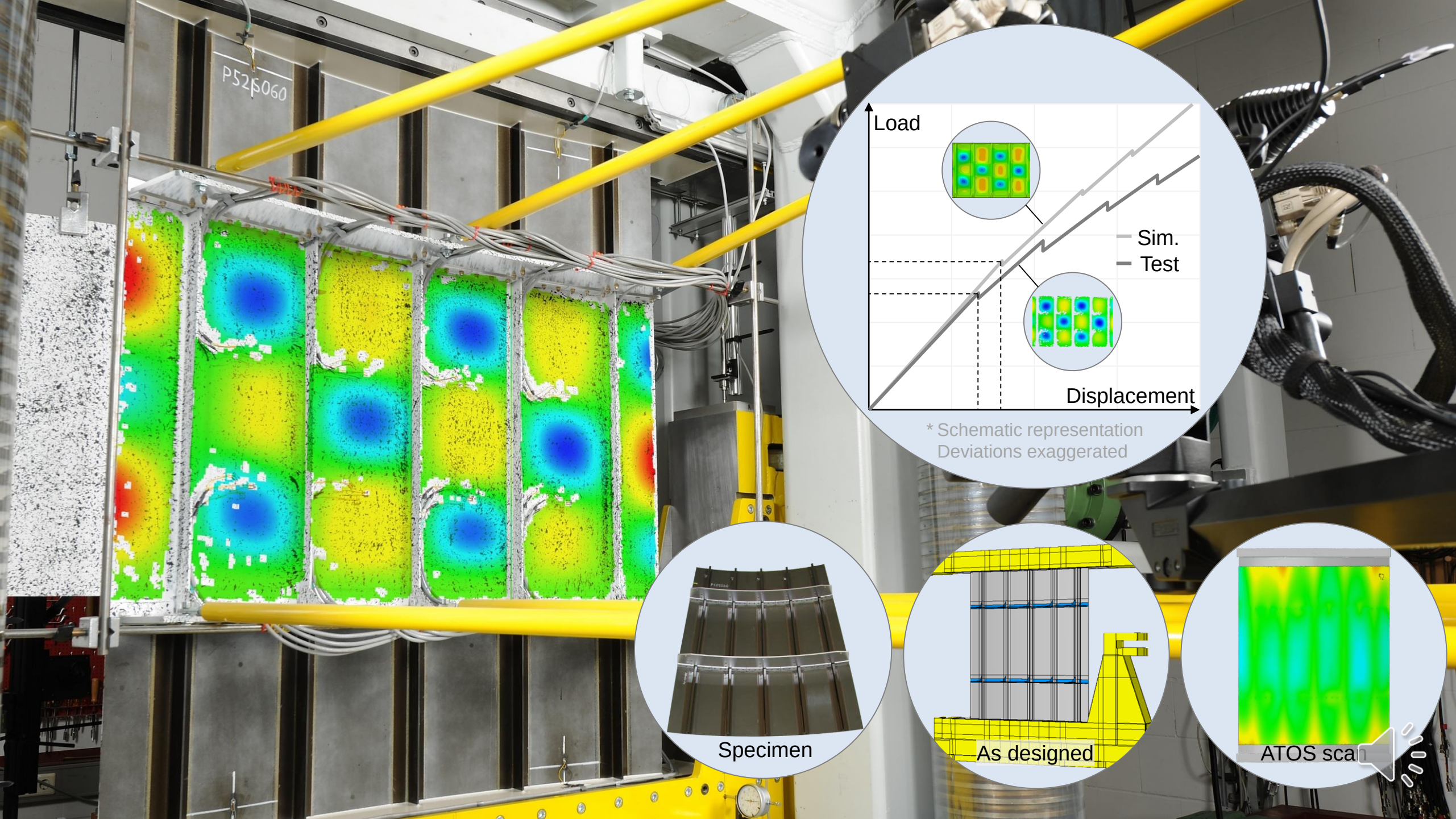
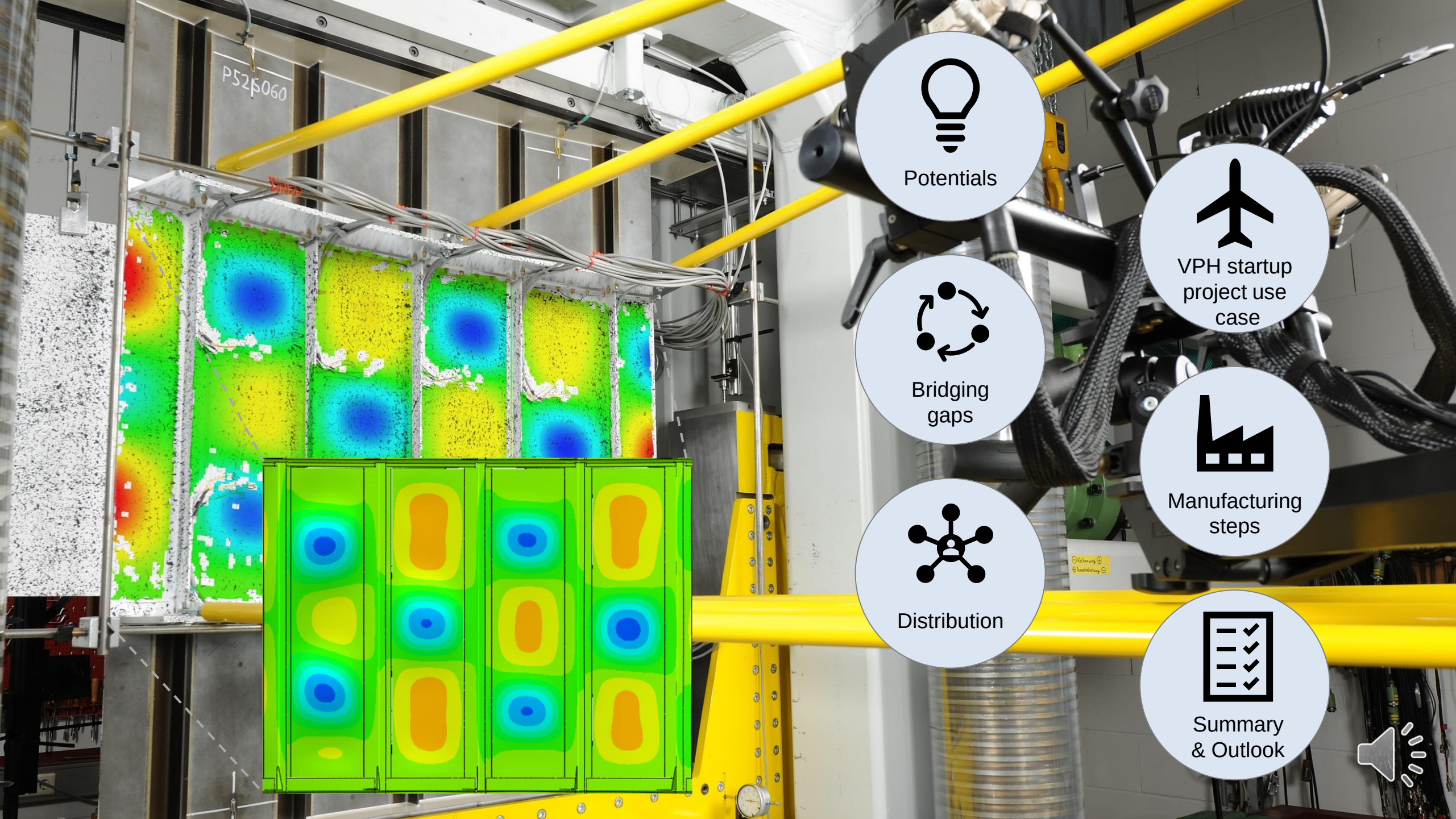
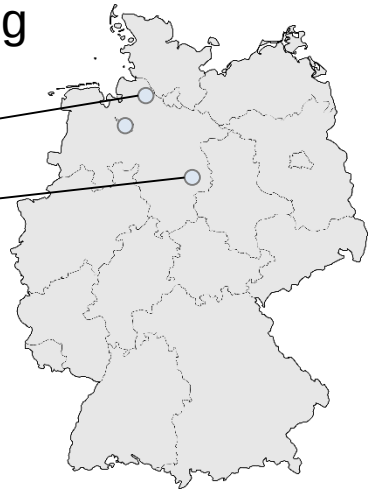
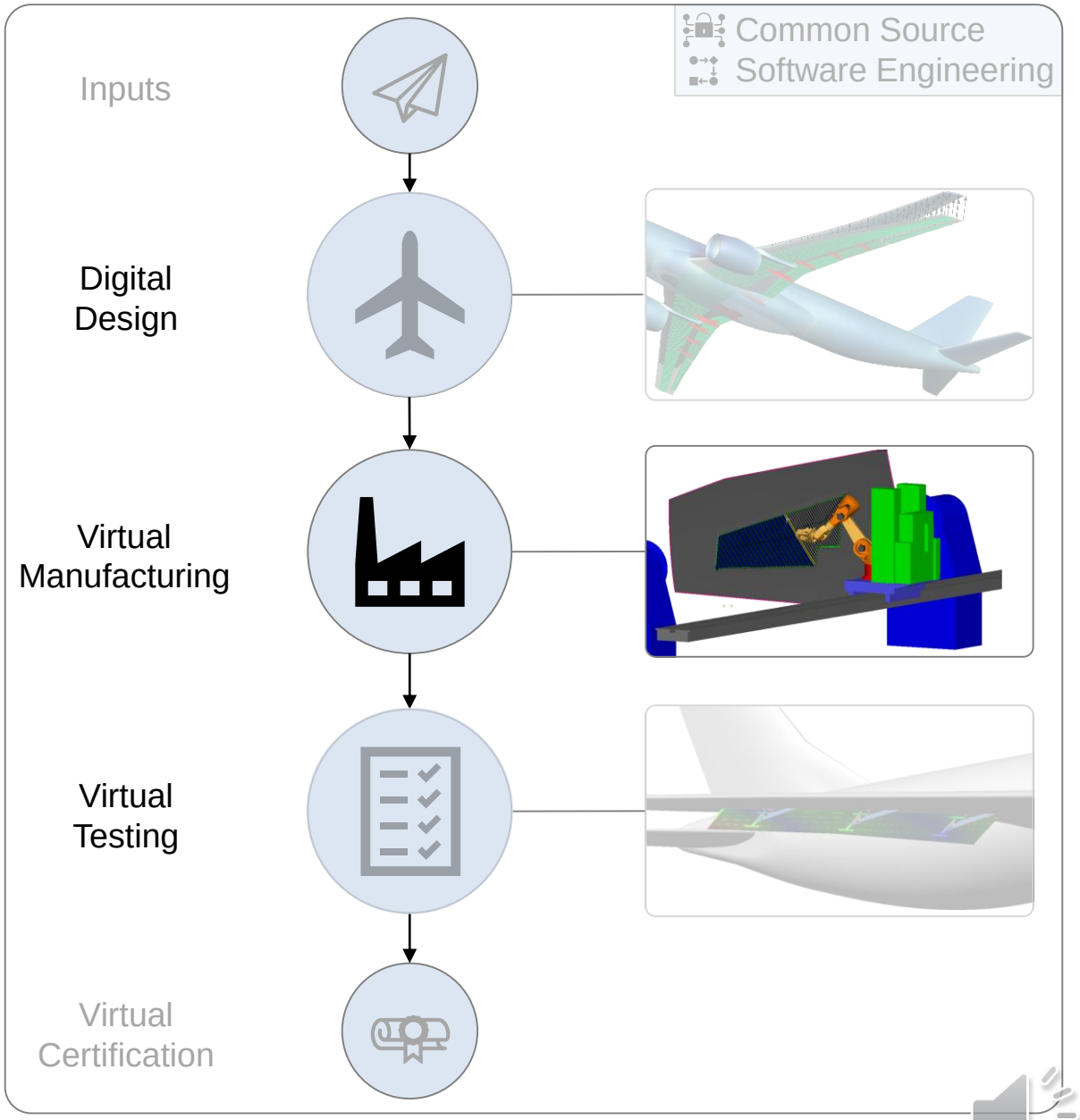

P52P060
Load
Sim.
Test
Displacement
* Schematic representation
Deviations exaggerated
Specimen
As designed
ATOS scan


P52P060
Potentials
VPH startup project use case
Bridging gaps
Manufacturing steps
Distribution
Summary & Outlook

VPH end-to-end process

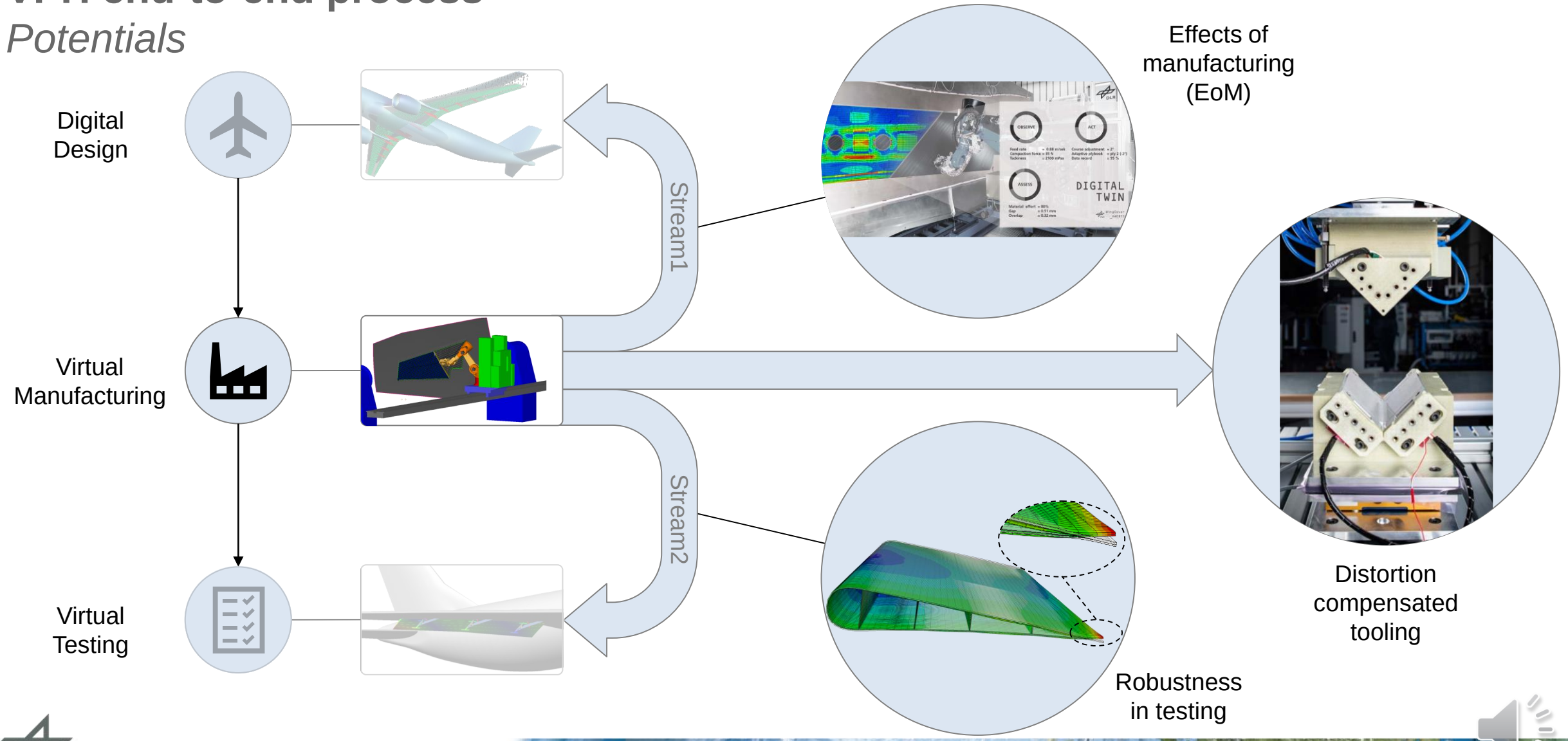
- Input:
  - Structural concept → CPACS
  - Manufacturing concept
- Result of Digital Design:
  - Virtual product state “as-designed“
  - Sizing information
- Focus virtual manufacturing @ VPH startup-project:
  - FA @ ZLP Stade
  - FA @ Braunschweig





VPH end-to-end process

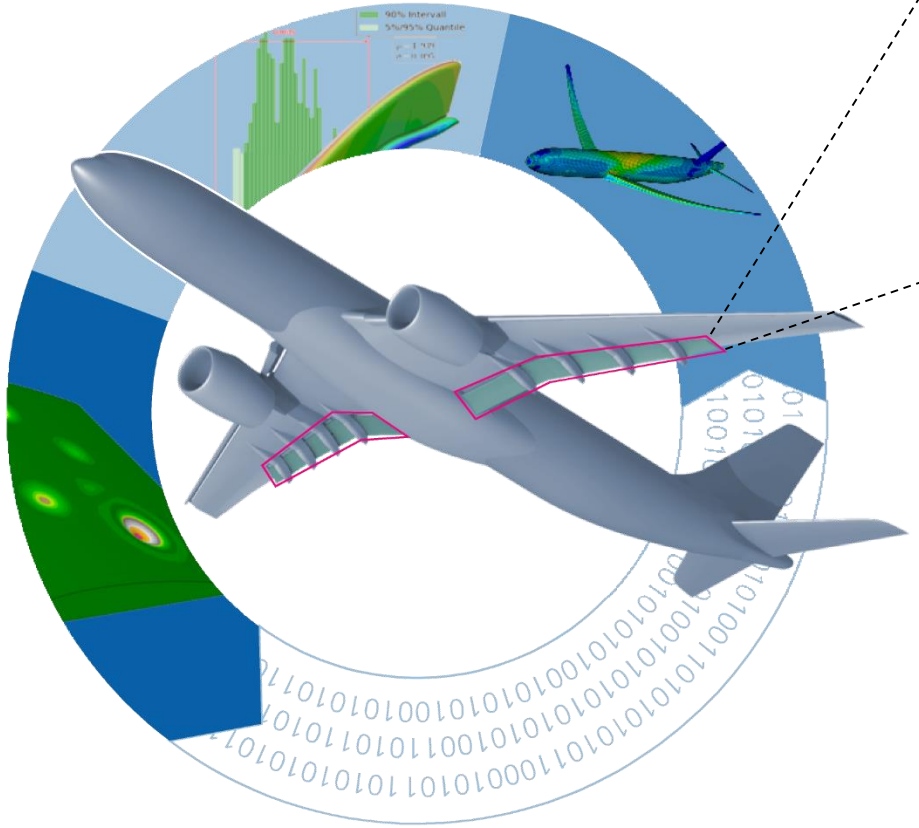
Potentials

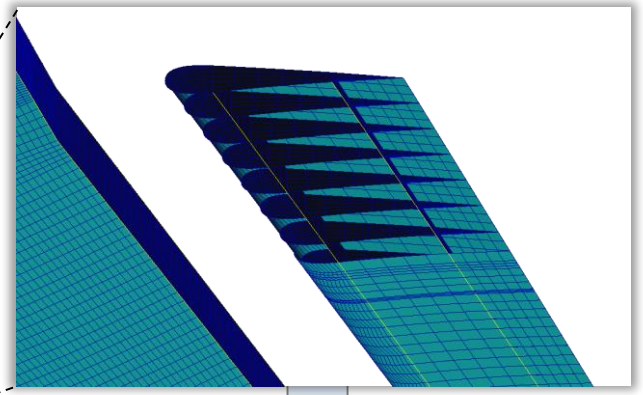


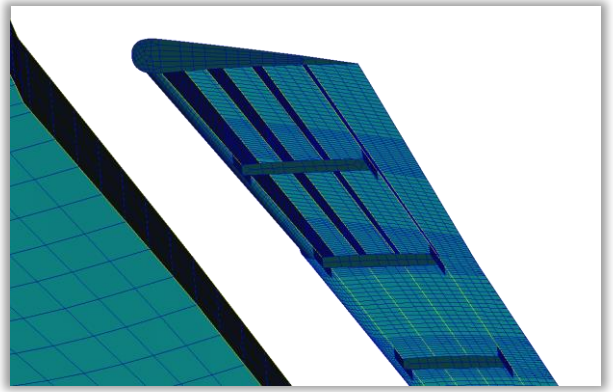
VPH startup-project use case

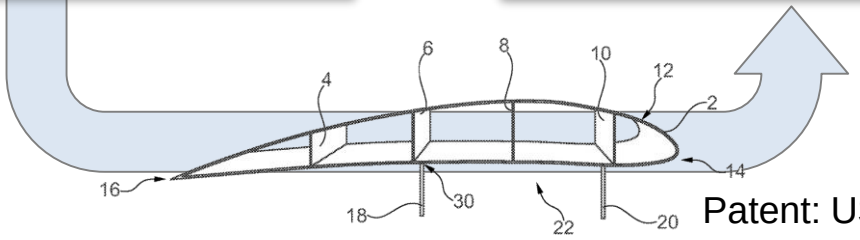
Concepts - Structural

- Baseline: Reference aircraft









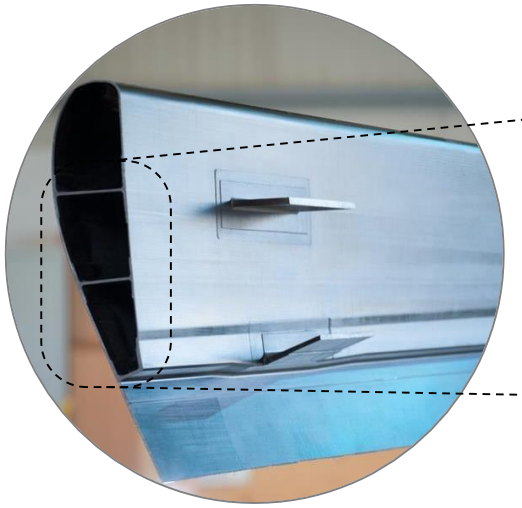
Patent: US10131418B2

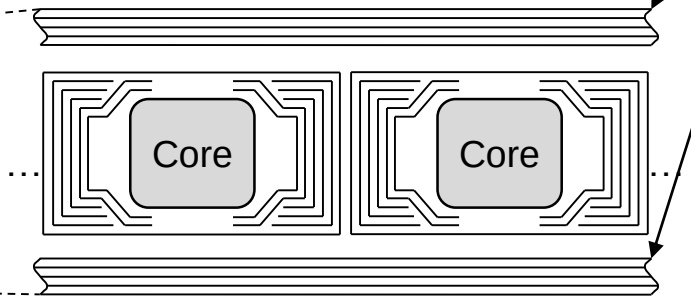
- Composite multi-spar moveable & integral load introduction
- Wing of Tommorrow [1]:
  - High degree of integration
  - Cost effective
  - High rate capable
  - Faster development times

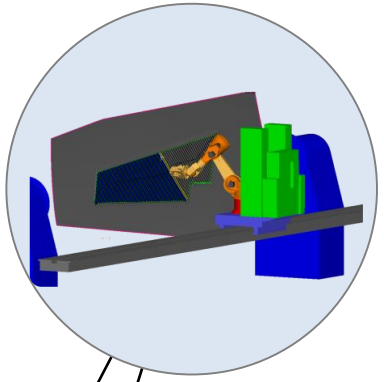
VPH startup-project use case

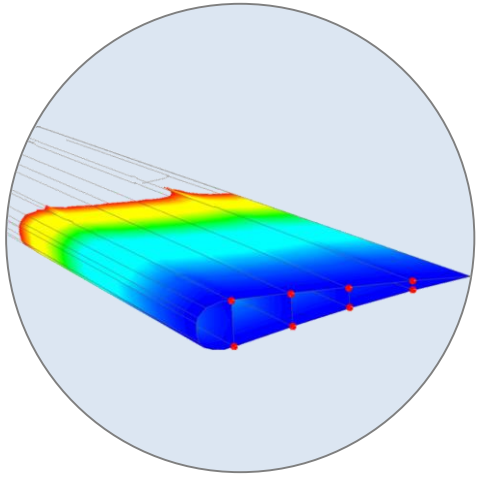
Concepts - Manufacturing

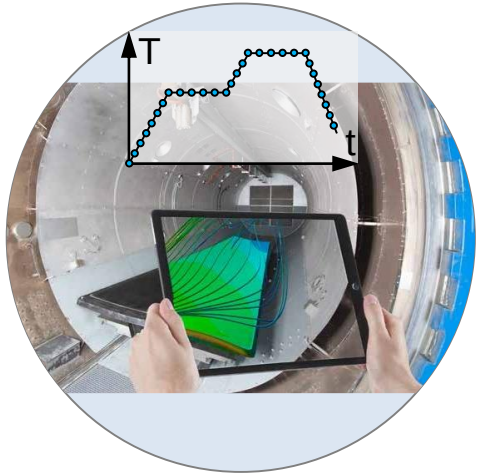
- Specific for material system, manufacturing technology & equipment
- RTM process @ Airbus, FACC Wing of Tomorrow [1]
- Slightly modified approach:









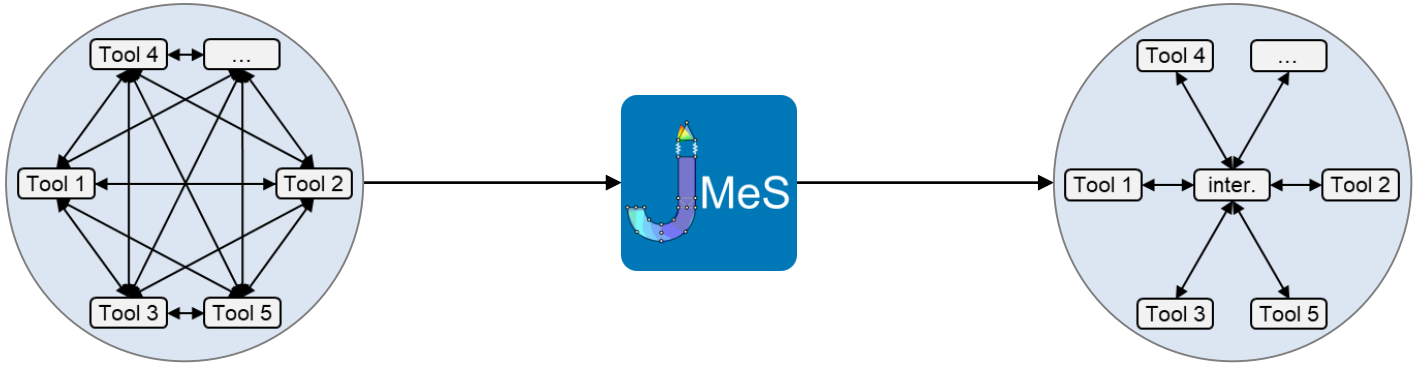


© FACC, [1]

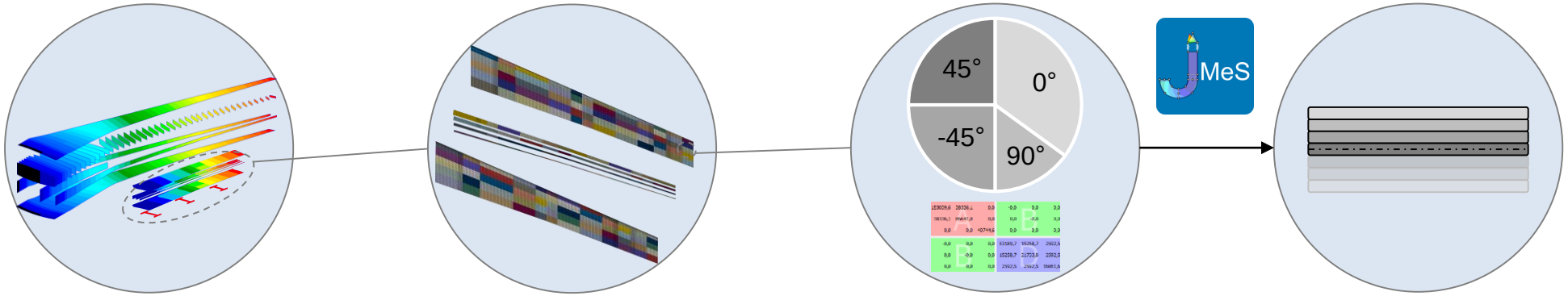
- Stream 1:
  - Dry-fibre AFP skins
  - EoM analysis
- Stream 2:
  - Infusion
  - Curing

Bridging gaps

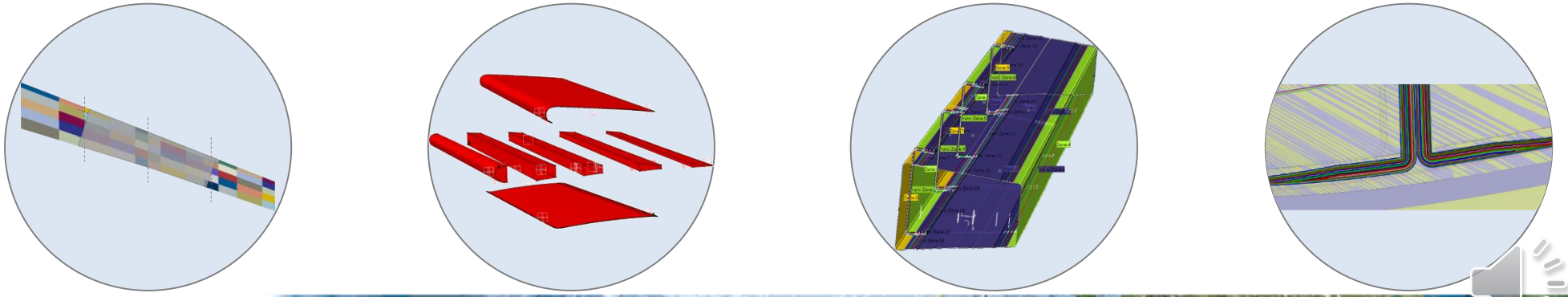
- Common language



- Applications
  - Stacking sequence optimization
  - Mapping
  - Model info



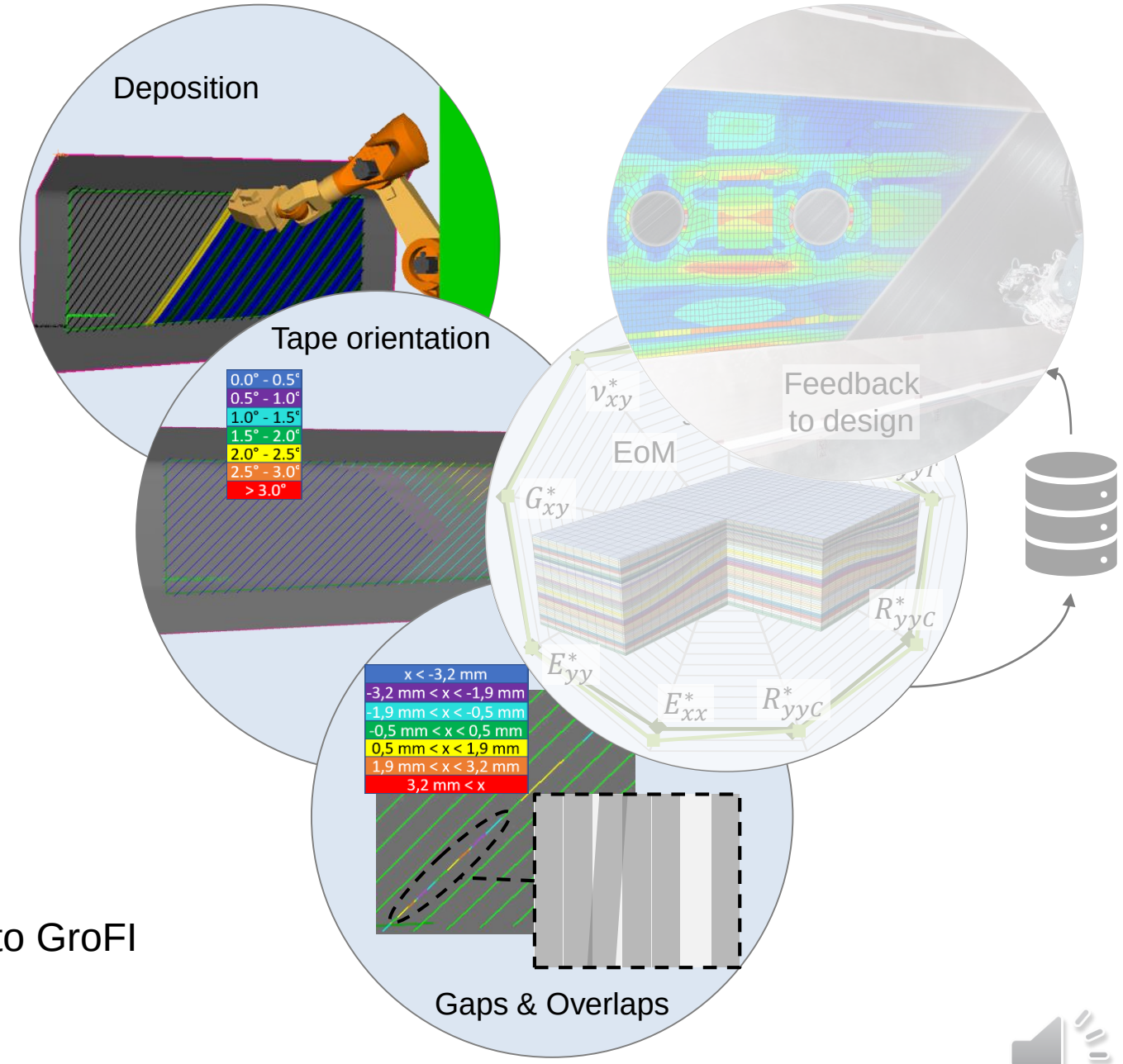
- CAD/CPD



Manufacturing steps

Stream1: AFP & EoM

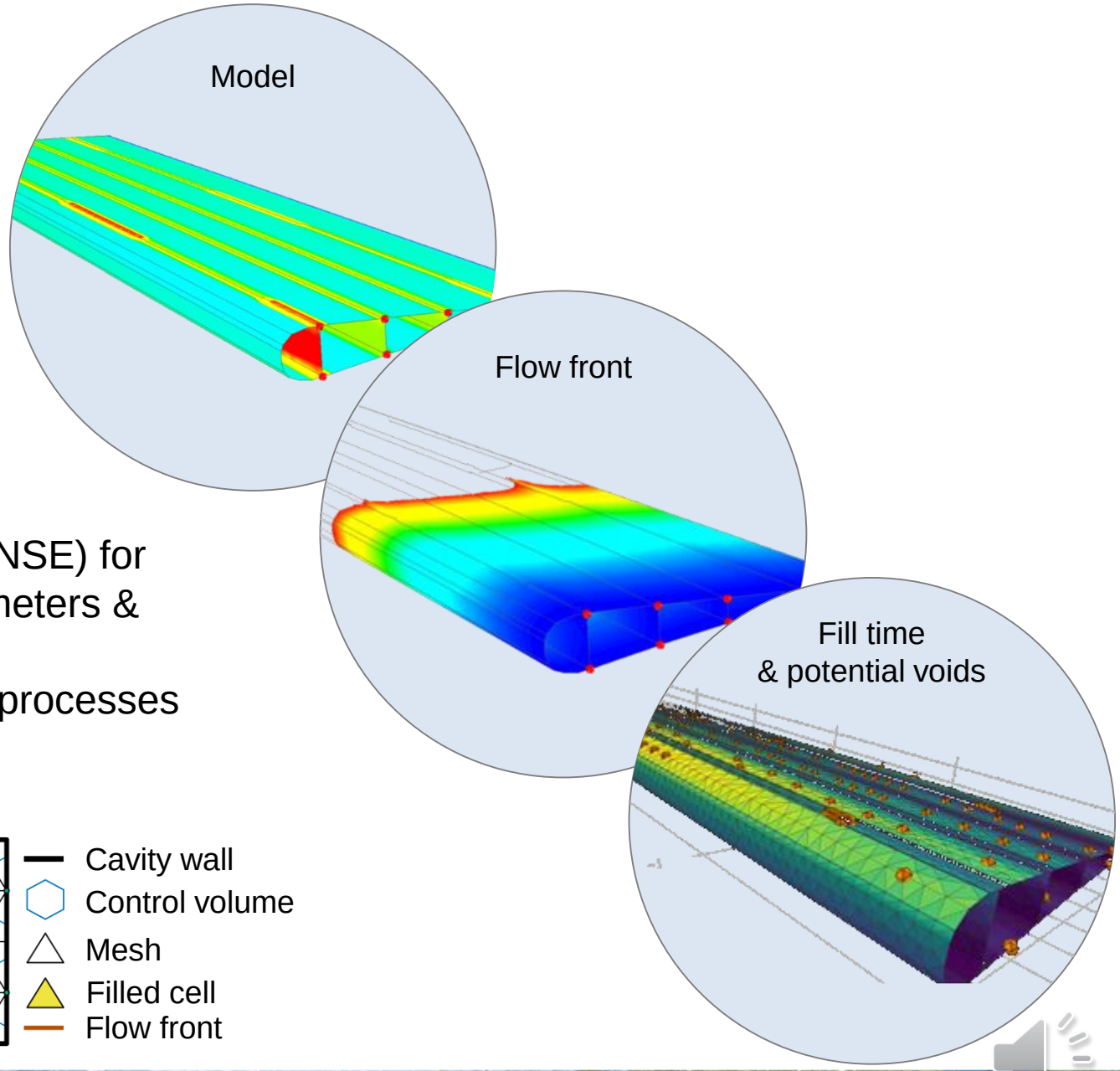
- Why?
  - Detection of deviations of manufacturing steps on structural performance compared to as-designed model
  - Evaluation of impact on sizing result
- What?
  - CAM modeling of tape deposition [2]
  - Evaluation of
    - Tape orientation
    - Gap & overlap analysis
    - Effects of manufacturing [3]
- How?
  - AFP: Modified fives ACES version adapted to GroFI
  - Input: CAD model
  - EoM: SMETANA

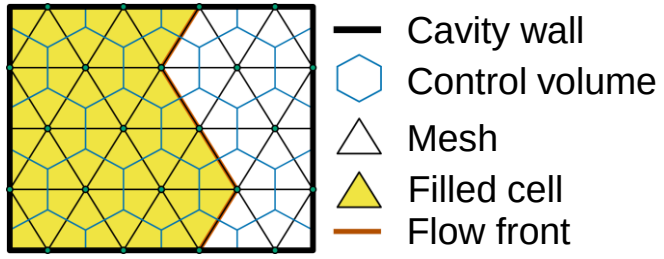


Manufacturing steps

Stream2: Infusion

- Why?
  - Evaluation of impregnation process
  - Detection of voids
- What?
  - Liquid composite moulding (LCM) simulation
  - Subelement of resin impregnation system (RINSE) for optimization of impregnation strategies, parameters & mold concepts [4]
  - Used in-situ monitoring & adjustment of LCM processes
- How?
  - Galerkin FE method
  - Control volumes for flow front
  - Input: Layup file

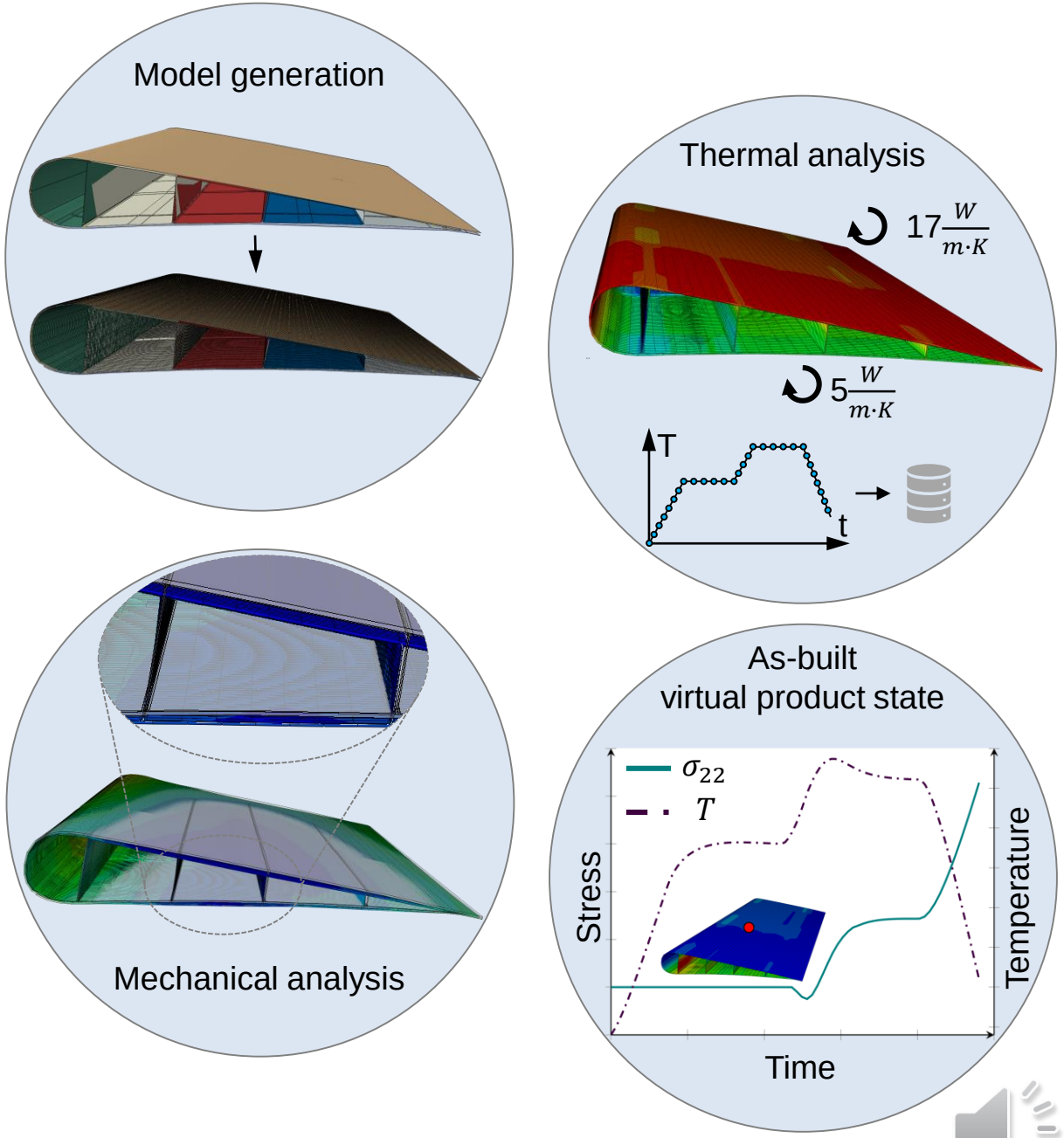




Manufacturing steps

Stream2: Curing

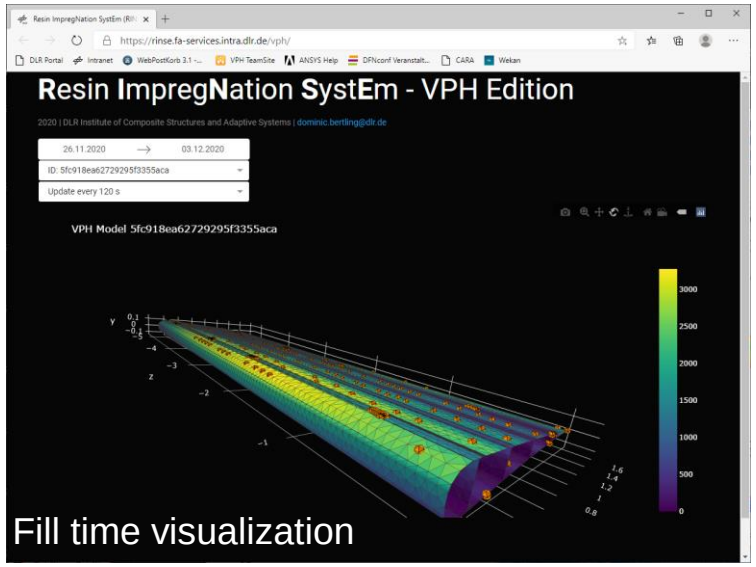
- Why?
  - Determination process-induced deformations & residual stresses
- What?
  - Transient sequential temperature-deformation analysis considering exothermal reaction
  - Static analysis, viscoelastic material model based on Poon [5]
- How?
  - User defined models: HETVAL, UMAT, UEXPAN for Abaqus
  - Implemented in MCODAC library
  - Input: Layup file



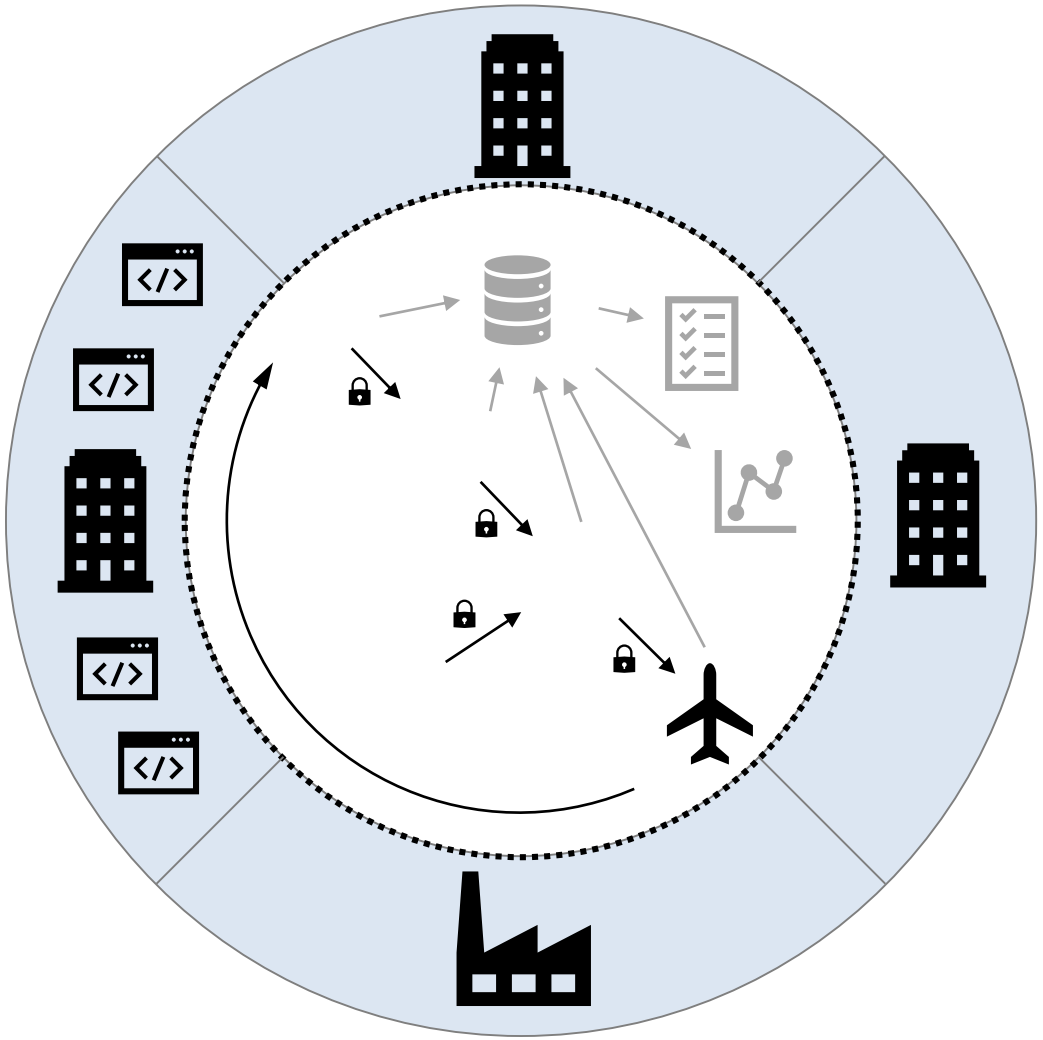
Distribution

- Collaborative (virtual) product development
- VPH platform → access to DLR assessment capabilities

- Currently:
  - RCE components, access via RCE network
  - Facilitate access by use of Restful API-Services
  - Learn about
    - Usage
    - Usability
    - Documentation
    - Tutorials
    - …

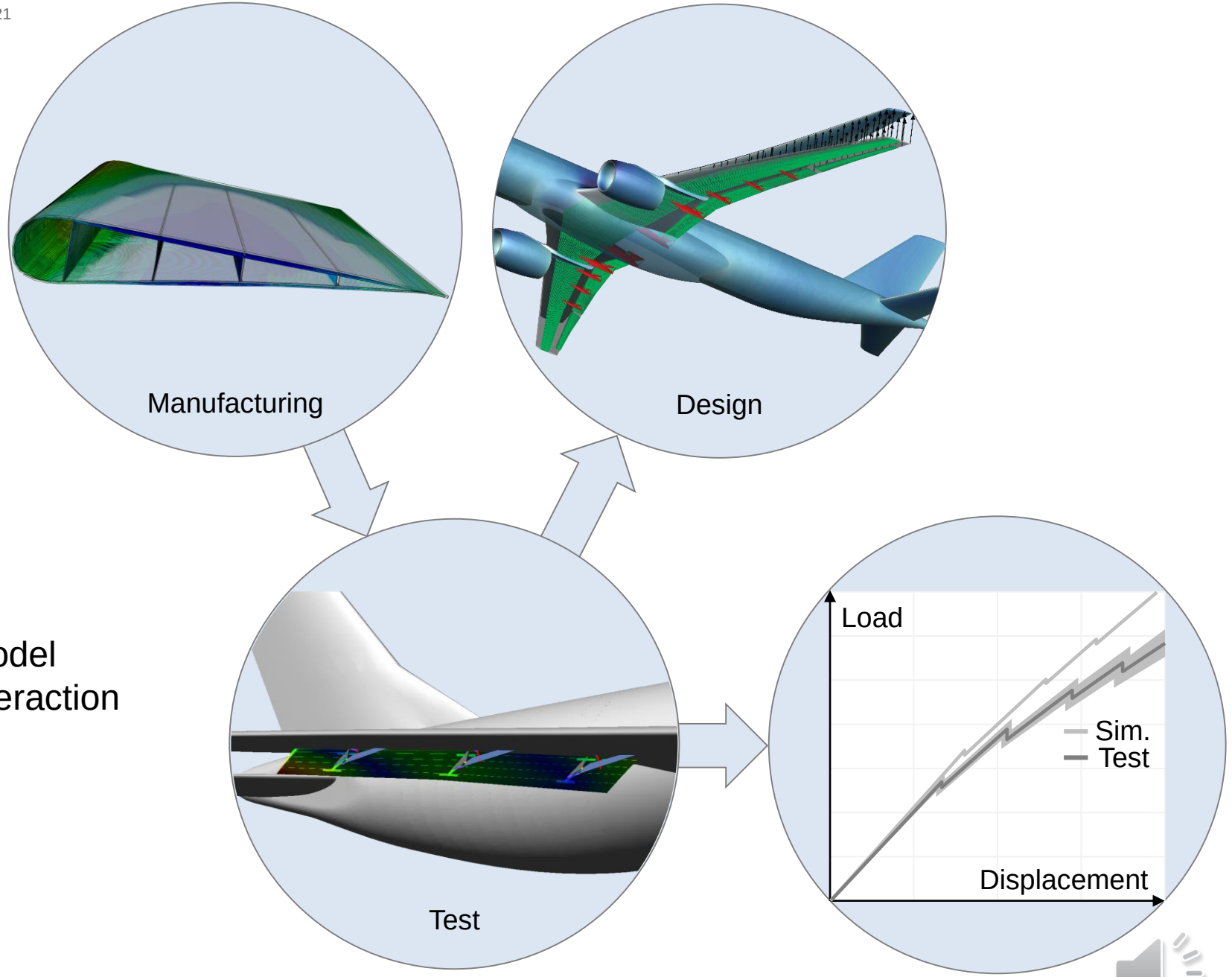


Fill time visualization



Summary & outlook

- Add. integration & implementation
  - Effects of manufacturing
  - Cost & ecology assessment
  - Assembly
  - Virtual autoclave
  - Feedback to testing
  - Robustness
- Lessons learnt
  - Manufacturing ready GFEM model
  - Increased assessment step interaction
  - Onthology development
- V & V: Use case demonstrator
- New use cases: LH2-tank



Thank you for your attention!

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European Union
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European Regional Development Fund

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