Benefits of the Mapping Tool ENVYO for Simulation of Braided Composites

Information day ENVYO

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Content

1. The research campus ARENA2036 and the project DigitPro
2. Generating the finite-element model of a braided tube on the mesoscale
3. Mapping meso-macro with ENVYO for the structure simulation
4. Conclusion and future perspective

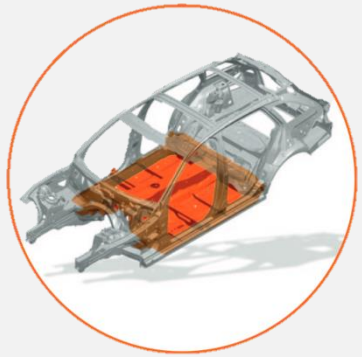
The research campus ARENA2036

Active **R**esearch **E**nvironment for the **N**ext generation of **A**utomobiles

- Developing the industry 4.0 with increased flexibility and reduced energy needs
- 3 research fields + 1 transverse research field

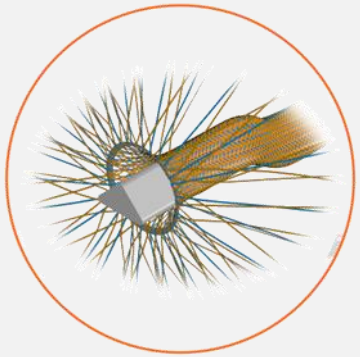
LeiFu
Material and design

– Lightweight materials
– Function integration



DigitPro
Digital Prototype

– Process simulations
– Virtual testing



ForschFab
Research factory

– manufacturing processes of the future

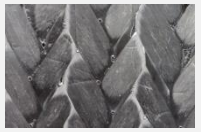
Khoch3 (transversal research field)
Creativity – Cooperation – Competences

ARENA2036 research factory in S-Vaihingen

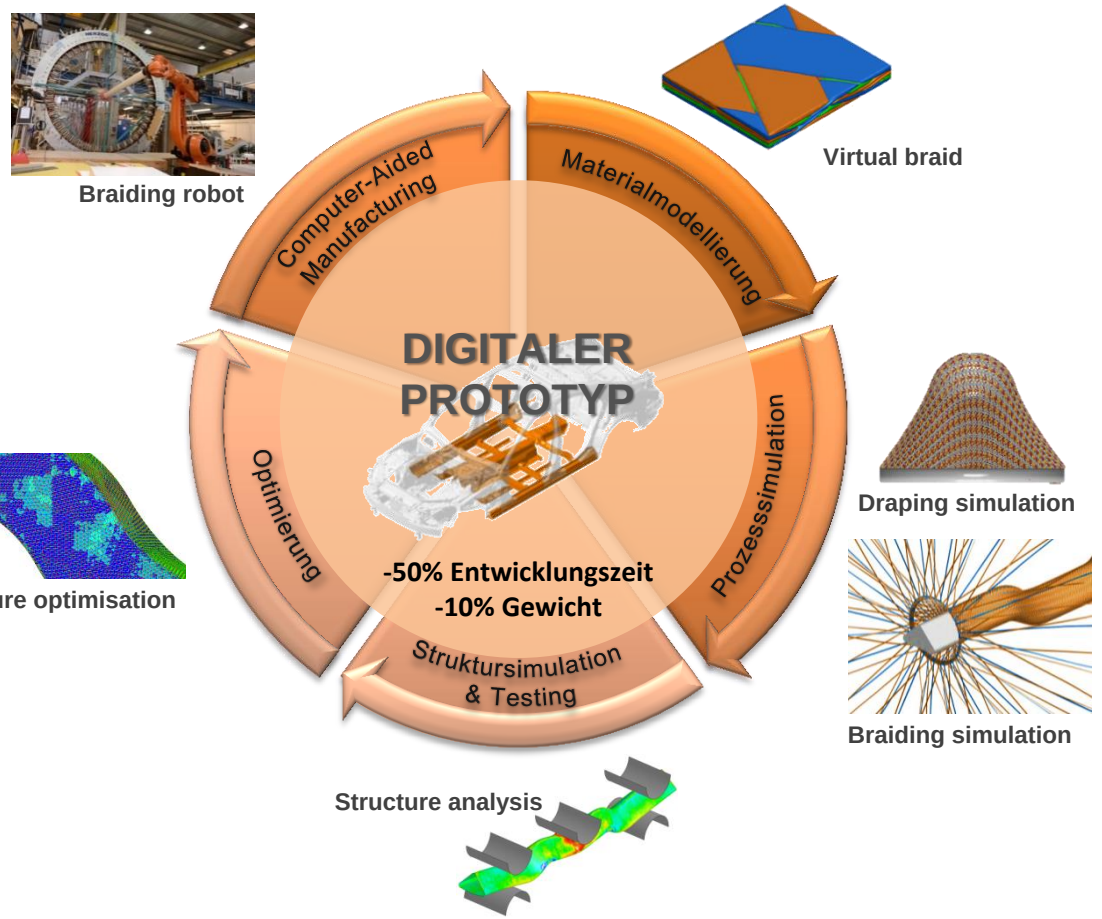
DigitPro – Digital Prototype

- closed, numerical process chain
- from the presizing up to the final product
- modelling on meso- and macroscales
- various simulation tools
- HDF5 format

Investigated textile fibre architectures

– Braided composites 

– **O**pen-**R**eed-**W**eaving



Process chain at the example of a braided structure

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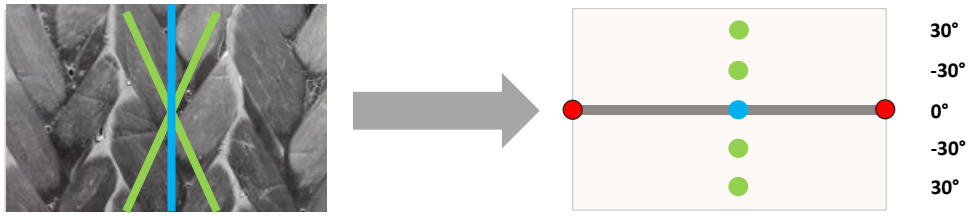
Investigation of braided structures - methodology

Reference approach

Modelling with UD-plies



Advantages

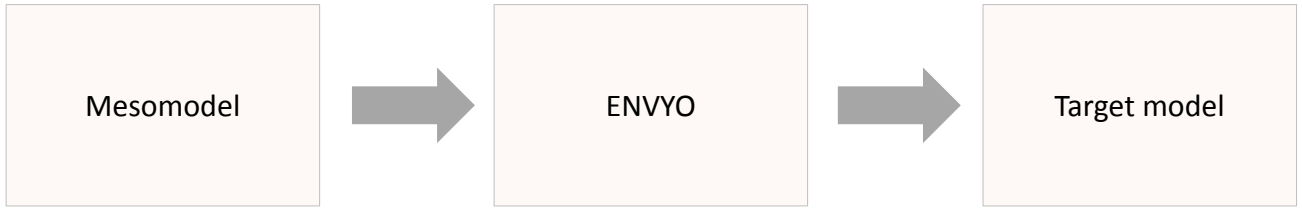
- „universal“ approach (weave / UD...)
- fast model generation
- low computing time

Drawbacks

- local effects are not considerated
- fibre architecture is not reproduced

Mapping approach

1. Generation of a realistic FE-Model on the mesoscale
2. Transfer of yarn orientations on a target mesh



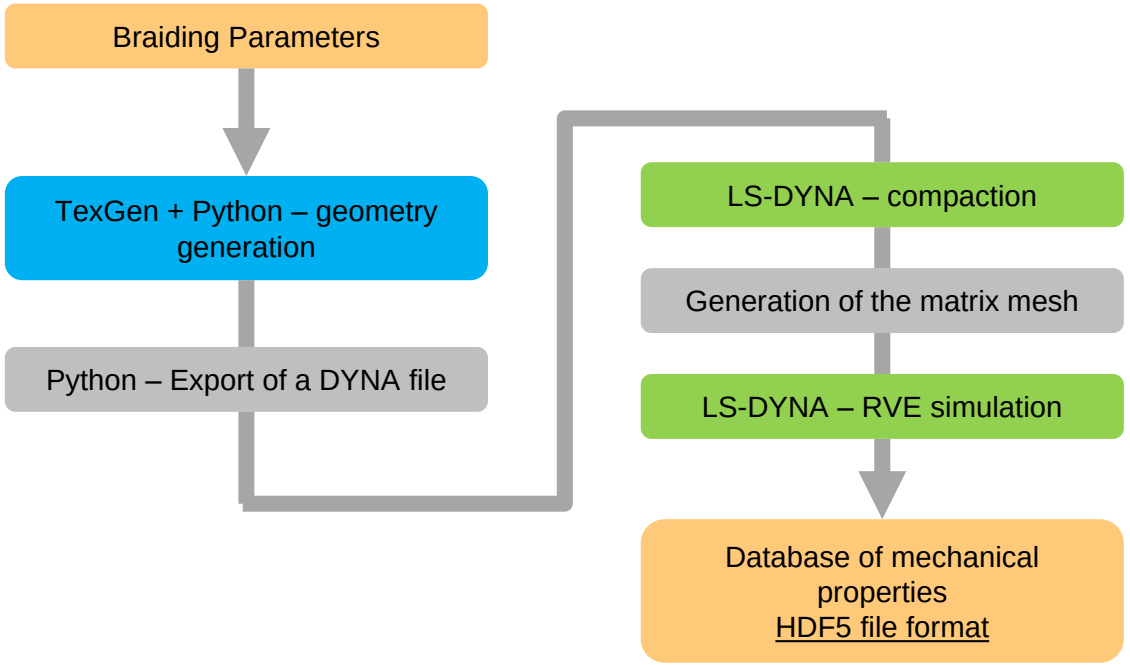
Advantages

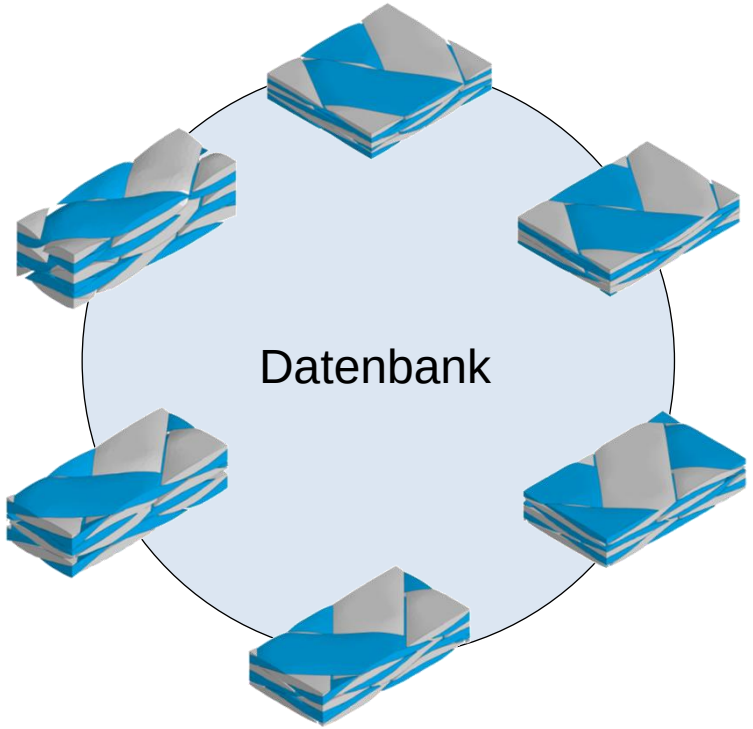
- realistic approach
- consideration of manufacturing effects

Drawbacks

- complex model generation
- increased computing time

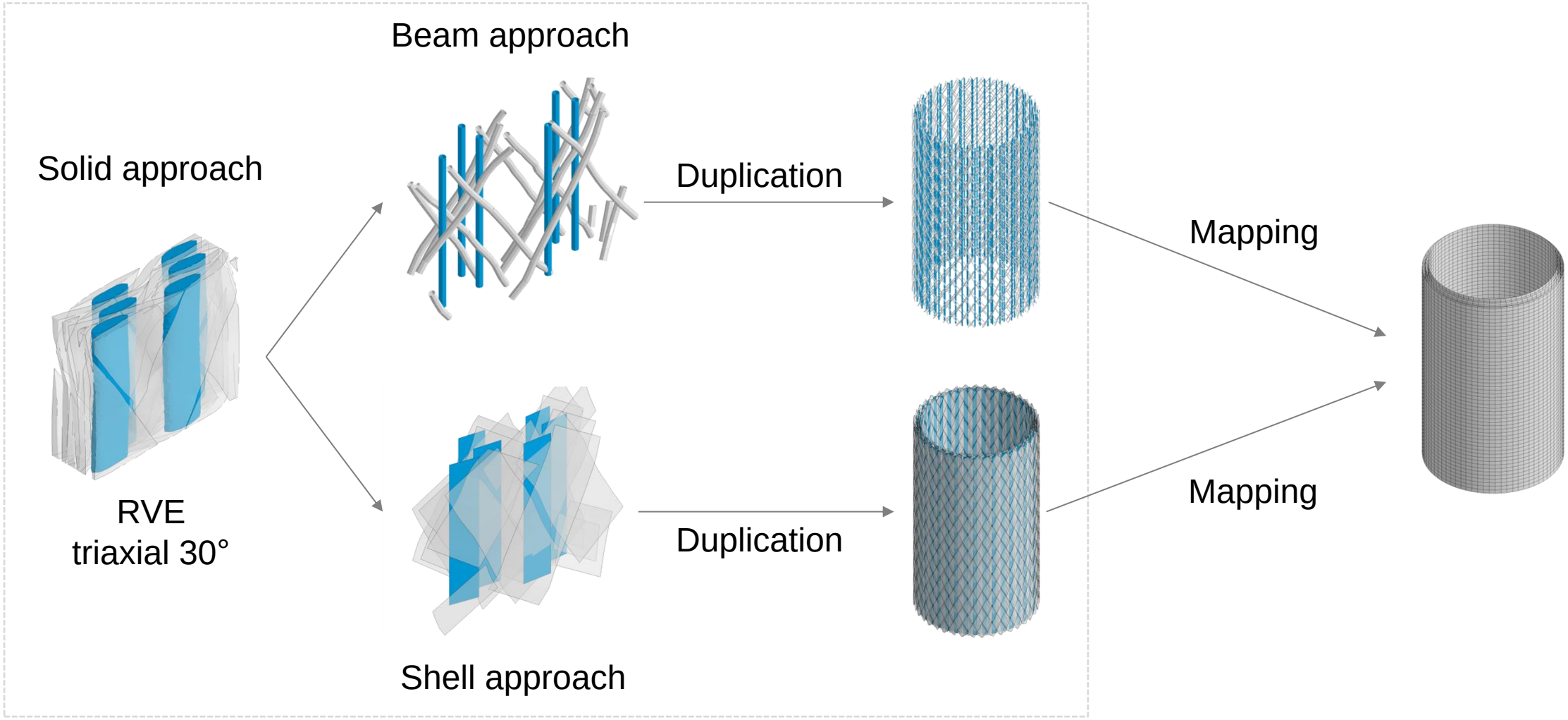
Generation of a Representative Volume Element - RVE





- Material-database for the mechanical properties of braids
- RVE as a basis for detailed investigations
- Geometry as a basis for the generation of more complex parts

Generation of a mesoscopic tube model



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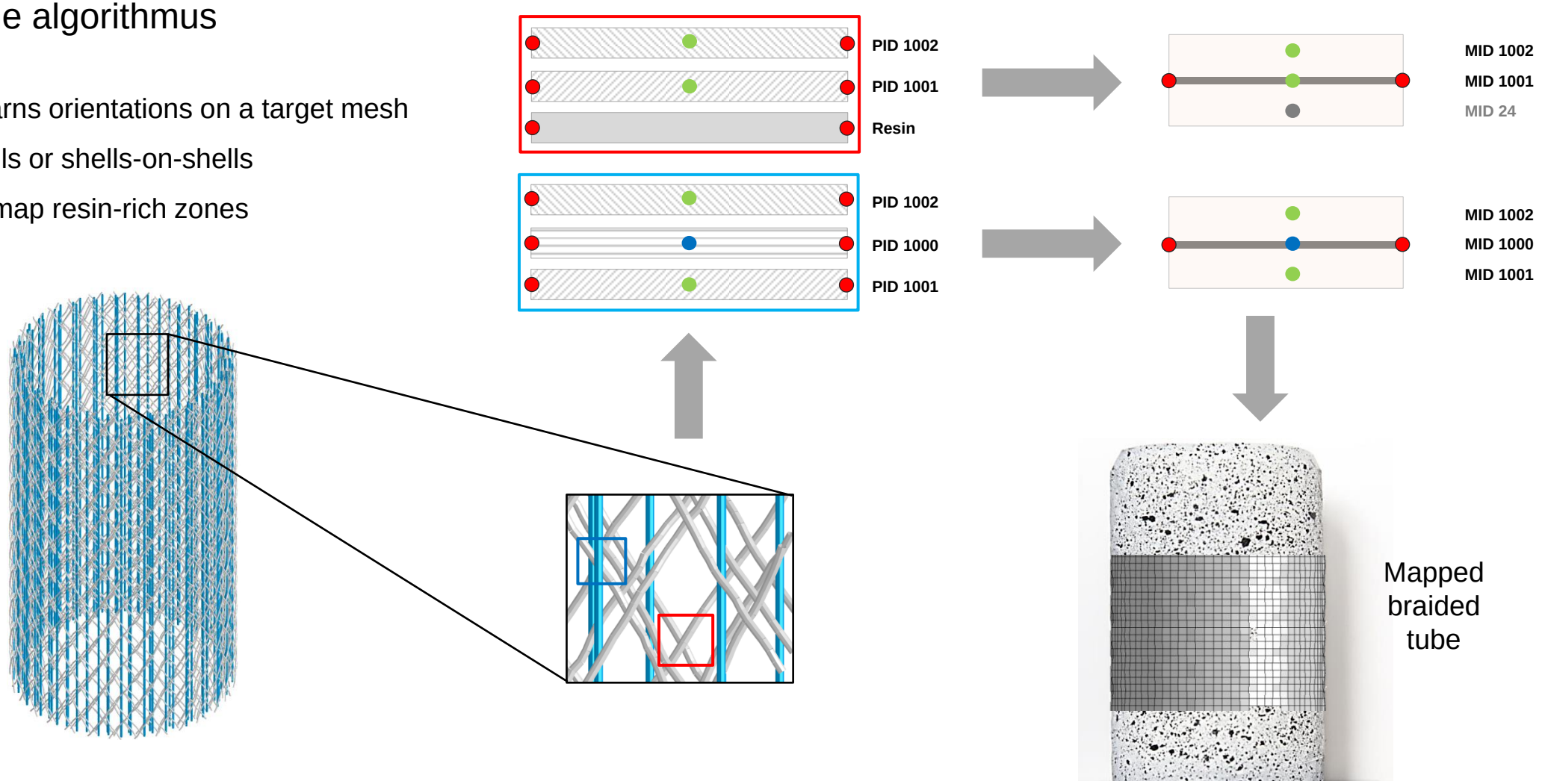
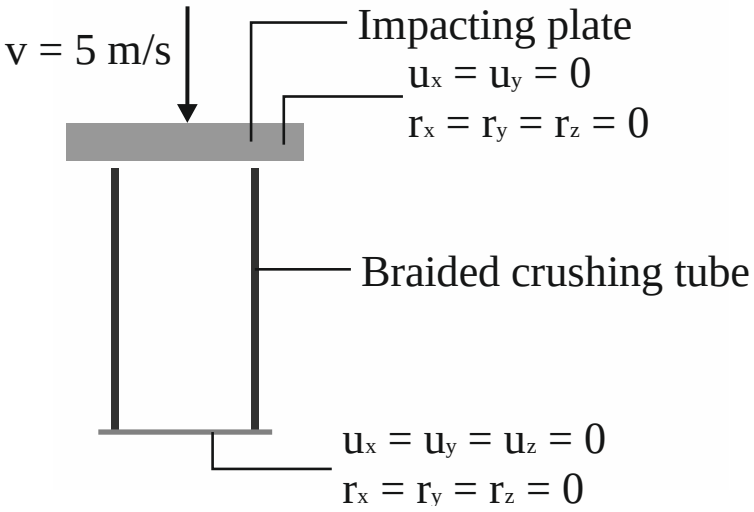
The mapping algorithmus ENVYO

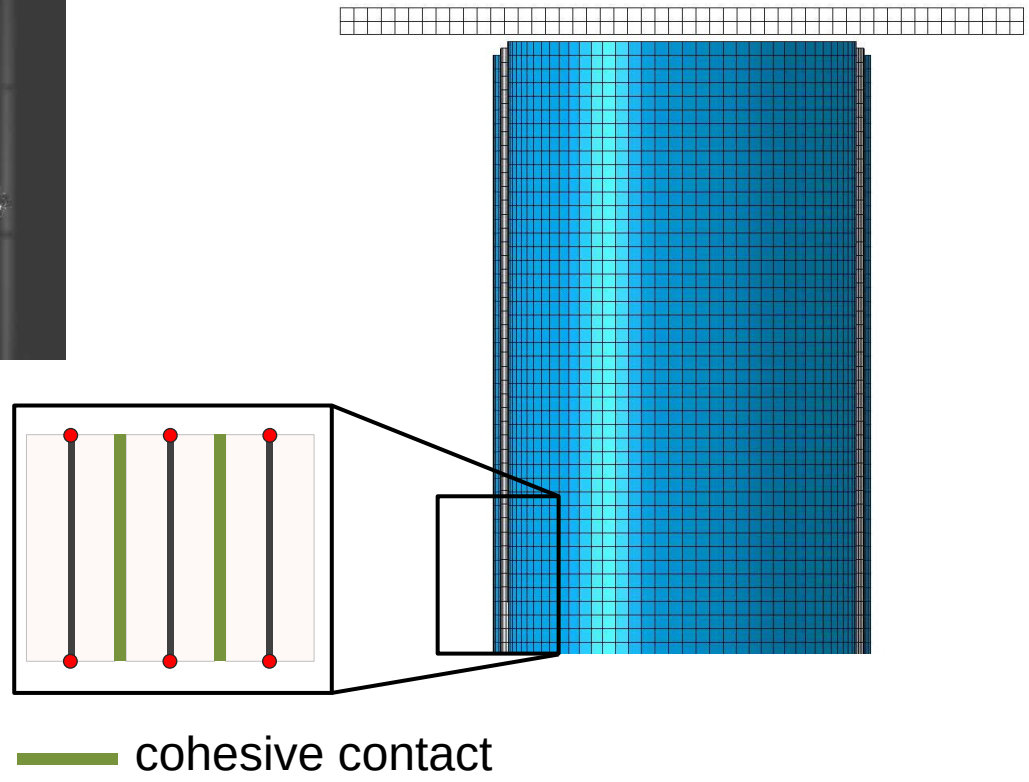
Principle of the algorithmus

- Mapping of yarns orientations on a target mesh
- Beam-on-shells or shells-on-shells
- Possibility to map resin-rich zones



Investigation of the mapping tool ENVYO – crushing test on triaxial braid 30°

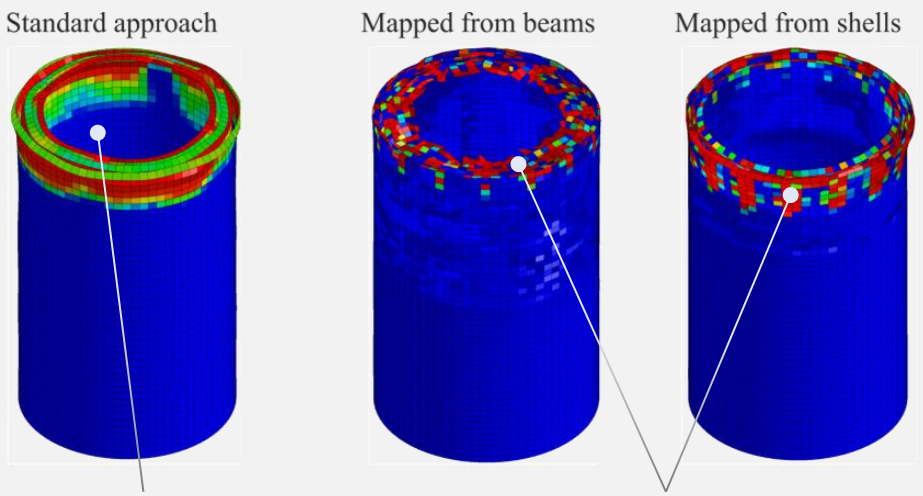




- Each layer is represented by a shell element
- Use of cohesive contact between the layers
  - CONTACT_SURFACE_TO_SURFACE_TIEBREAK, OPT = 8

Results of the numerical crushing test

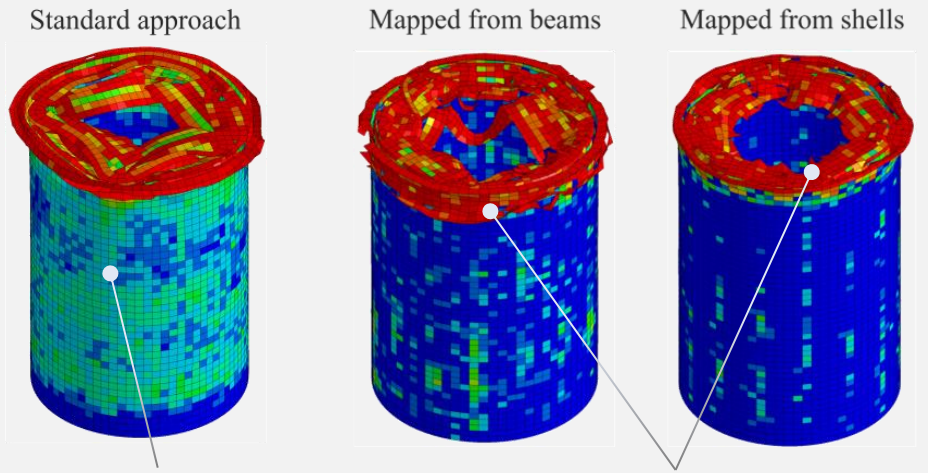
Fibre compression damage mode



Damage smeared in the tube circumference

Localised damage in the axial yarn regions

Matrix damage mode

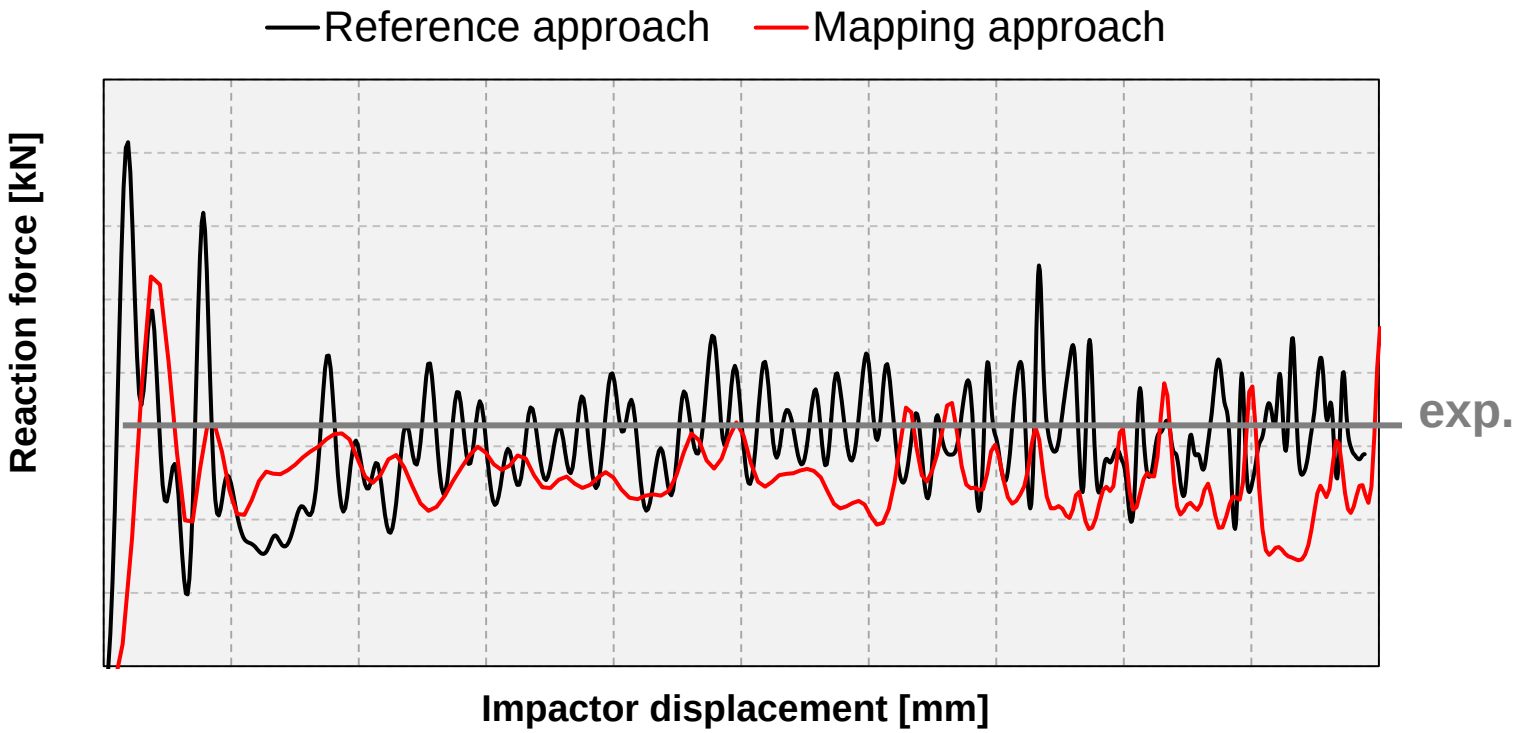


Fast damage propagation in the tube length

Localised damage in the crashfront

- The mapping approach renders more realistically the braids failure modes.
- The computing time is slightly increased (5% longer by same element length in reference and mapped model) due to the use of *ELEMENT_SHELL_COMPOSITE_BETA

Results of the numerical crushing test



- Reduced tube stiffness and crushing load in the simulation of the mapped FE-model (same for shell or beams).
  - Influence of axial yarns → element length of the target mesh
  - Influence of matrix-rich zones → scaling factors (for the beam radius or the shell element thickness)

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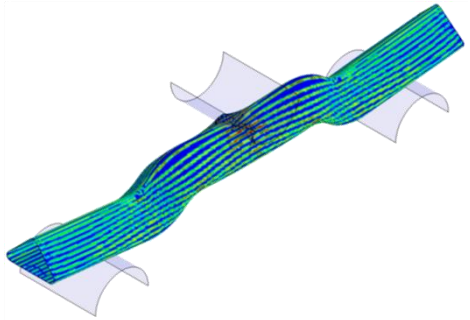
Conclusion

- The potential of the mapping tool ENVYO is investigated within the project DigitPro.
- The yarns orientations of mesoscopic models can be mapped on a target mesh for structure simulation.
- ENVYO offers several mapping alternatives:
  - Mapping shells-on-shells or beams-on-shells,
  - Layered-shell or stacked-shell approach,
  - Mapping of resin-rich zones (manufacturing effects),
  - Scaling factors for the beam ands shells during the mapping,
  - ...
- The mapping approach allows considering potential effects of complex fibre architectures on the mechanical behaviour of composite structures.

Future perspectives

- More detailed investigation will be performed on the mapping tool in order to define mapping rules for braided composites:
  - Influence of the element length of the target mesh,
  - Influence of the scaling factors...
- The mapping tool will be developed to consider further manufacturing effects.
- The prediction potential will be investigated with other braided crushing tube (braid angles of 45° and 55°)
- The results will be validated within the closed process chain on generic components and real composite structures.



Mapped generic braided component

Thank you for your attention!

ARENA2036 DigitPro

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

FORSCHUNGS CAMPUS
öffentlich-private Partnerschaft für Innovationen

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