CG Rail's contribution:

Development of innovative lightweight structures for trains

Meeting with External Advisory Board, January 17th 2022

Advanced Car body shells for railways and light material and innovative doors and train modularity

Project coordinator: Fundació Eurecat
Project start date: 01/12/2019
Project end date: 28/02/2022

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3. Innovative integrated Joint design for composite Sidewalls (WP4)
4. Process simulations (WP3/WP4/WP9)

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Introduction

- CG Rail is involved in the Blocks
  1) „lightweight Carbody“ within WP’s 1/3/4
  2) „Interiors“ within WP9

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Background

- CG Rail is…
  - Located in **Dresden/Germany** as an internationally established centre for new lightweight technologies
  - Engineers from different scientific fields (Lightweight design, Railway engineering, Aerospace engineering, ...)
  - Unique local network of innovation partners in Dresden and Saxony / more than 250 suppliers all over Europe
  - Quality management system (QMS) according to ISO 9001:2015
  - CG Rail is an **independent platform for all customers worldwide**!

Lightweight CFRP car body shell (CETROVO)

CETROVO train on InnoTrans 2018

Background

- Clusters and networks

COMPOSITES UNITED

Member of „Composites United e.V.“

Rail.S

Member of „Rail.S“

SET4FUTURE

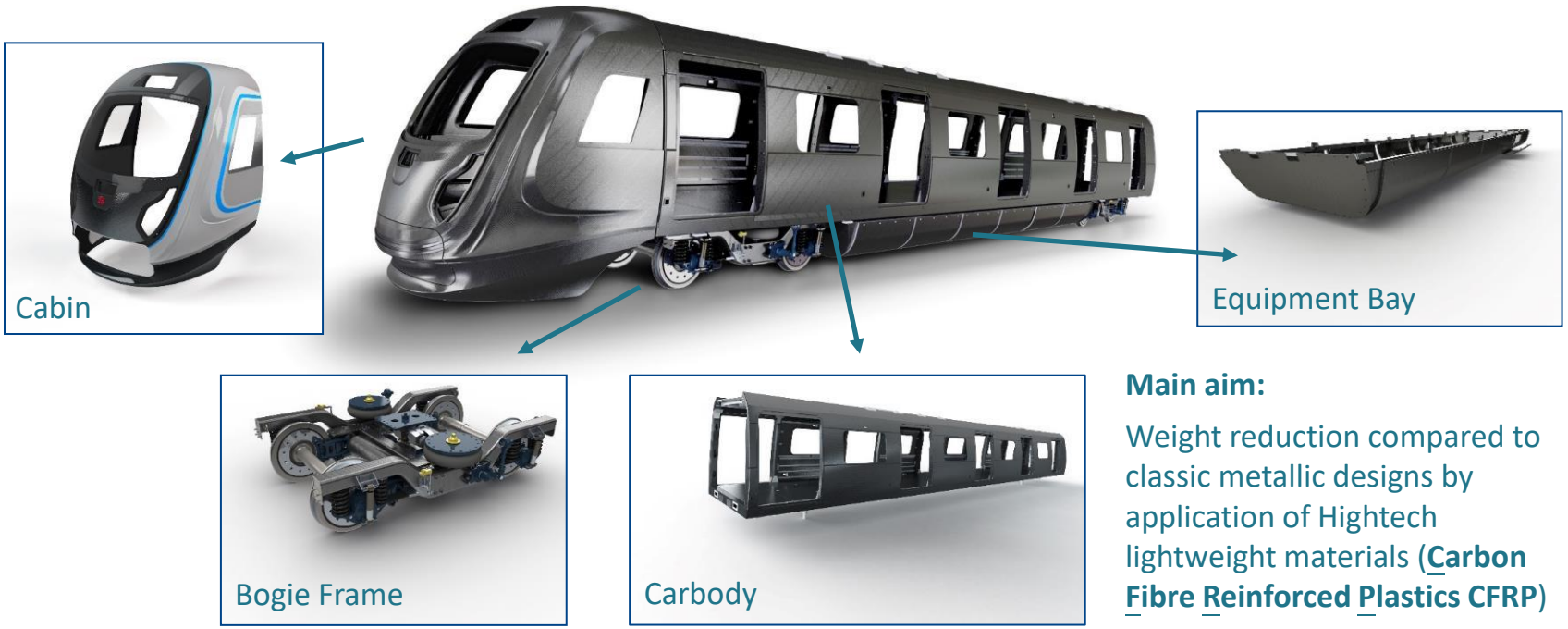
Member of innovation cluster SET4Future„Rail.S“

INTERNATIONAL MONORAIL ASSOCIATION

Member of International Monorail Association

Background

Project "Next Generation Metro Train (NGMT)" – a benchmark project & non-funded



Main aim:

Weight reduction compared to classic metallic designs by application of Hightech lightweight materials (**Carbon Fibre Reinforced Plastics CFRP**)

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Background

"Next Generation Metro Train (NGMT)" – Carbody

- **Development of CG Rail, manufactured with partners, assembled at CG Rail in Dresden**
- **Weight reduction of 30 %** compared to classic metallic carbodyshells
- Succesfully tested on track

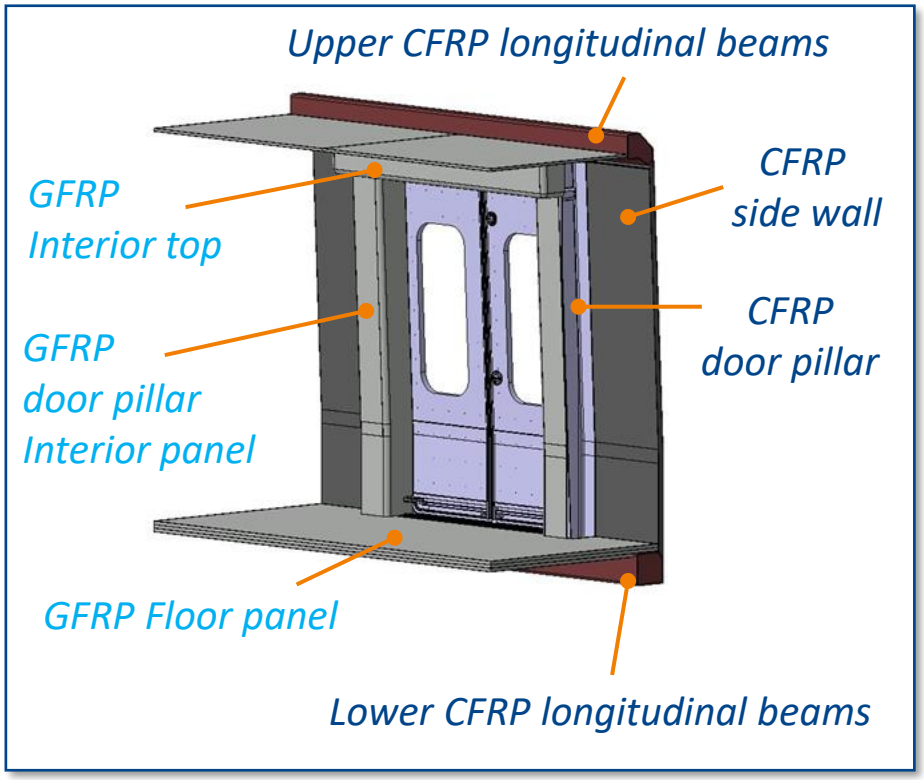
Aim & Motivation

Current status	Challenge	Goals CARBODIN
Use of pre-impregnated semi-finished products (so-called "*prepreg*")	High material and processing costs (refrigerated storage)	Use of cheaper input materials (fibres and resins)
Use of hot setting resin systems	High production costs (energy-intensive and expensive machines)	Use of cold curing resin systems
High number of variants of components with similar shape	High tool costs due to individually designed moulds	Use of modular mould systems

The achievement of the objectives requires
specially adapted design and suitable manufacturing processes and automation.

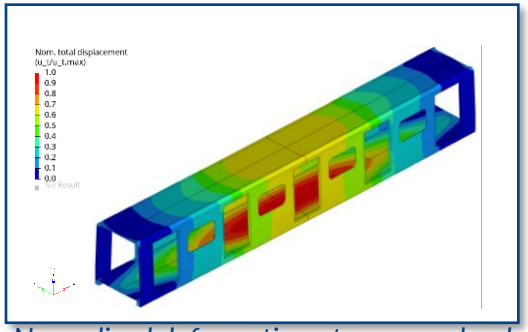
1. New composite carbody design (WP1)

Differential design of the modular lightweight CFRP



Creation of lightweight design of the composite carbody demonstrator

- *CFRP structural components*
- *GFRP interior components*
- *selection of joining technologies*
- *FEM simulation (dimensioning based on DIN EN 12663-1)*



Normalized deformation at max. payload

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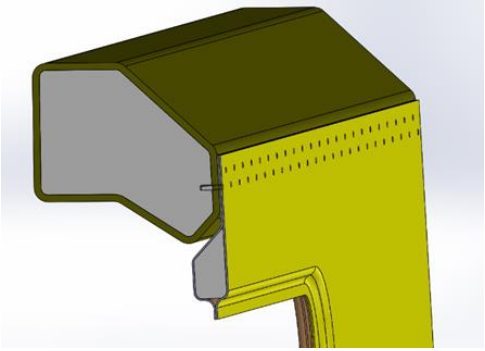
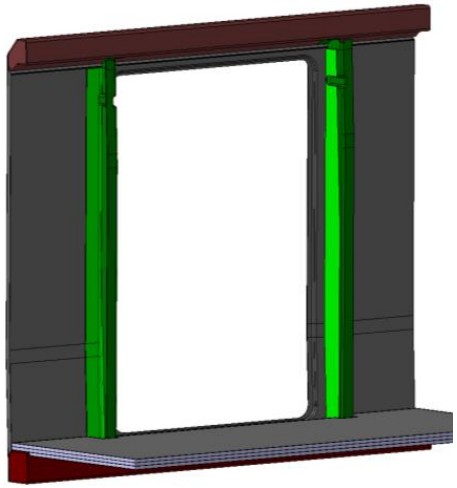
1. New composite carbody design (WP1)

Sidewall designed for cost-efficient Resin Infusion process



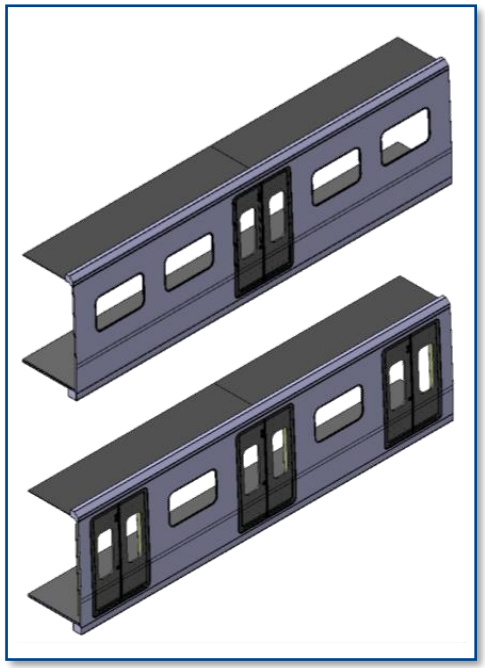


Sidewall in CFRP sandwich design

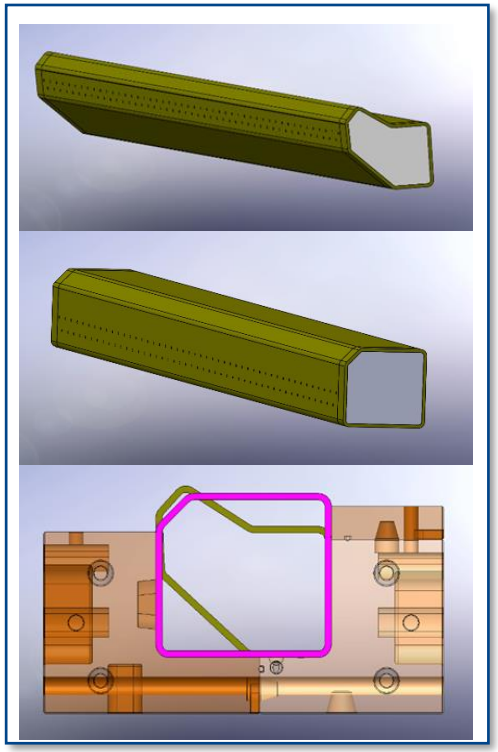
- ✓ *sidewall can be manufactured with moulds existing of mould holder and exchangeable blocks for cut-outs (door or windows)*

2. Design for modularity

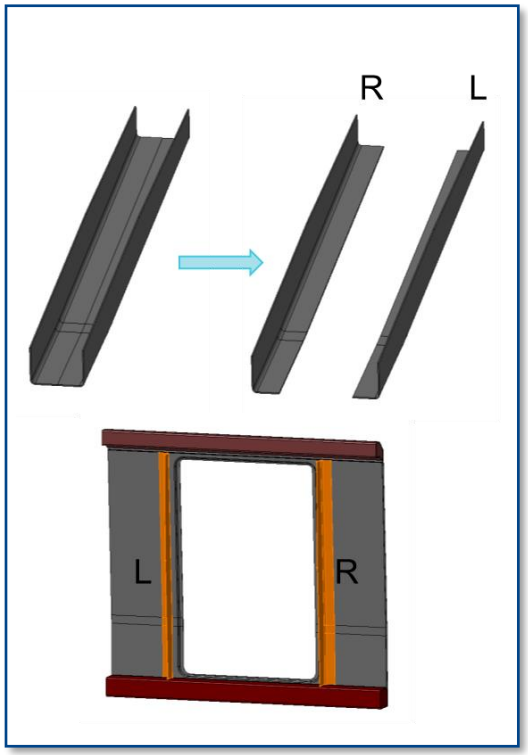
Cost-efficiency, modular moulds, multi-purpose design



Choice of different side wall configurations



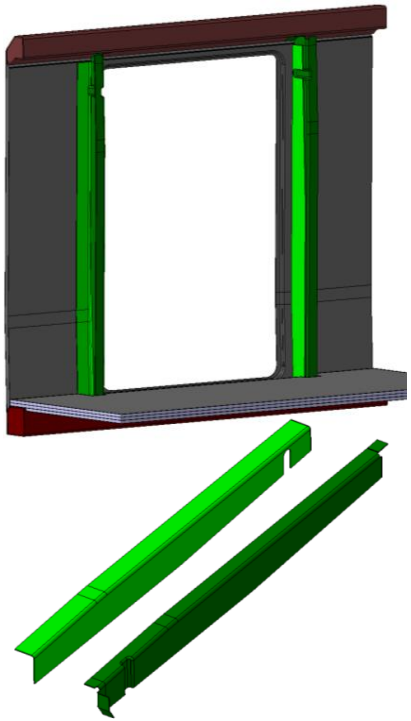
Similar geometries to reduce number of moulds



intelligent & efficient design

2. Design for modularity

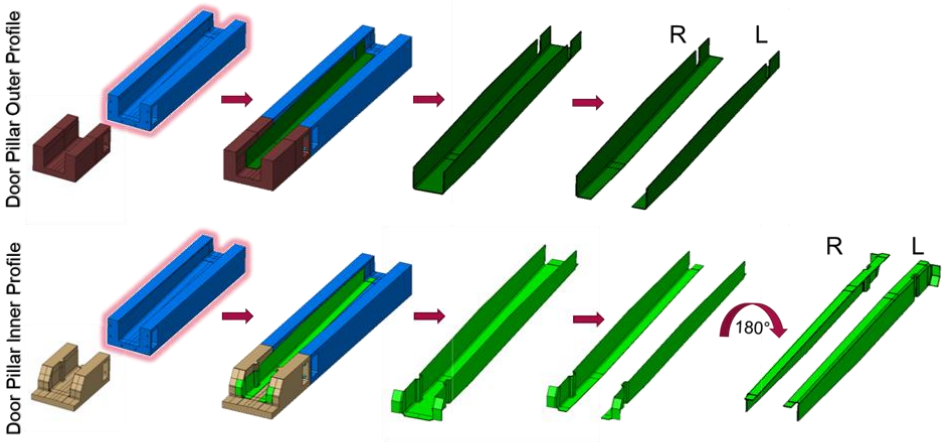
Door pillar design approach



Door pillars exist of inner and outer profile

intelligent & efficient design

→ *Reduced number of moulds*
→ *Less part manufacturing*



R… Door Pillar Profile for right-hand side of door
L… Door Pillar Profile for right-hand side of door

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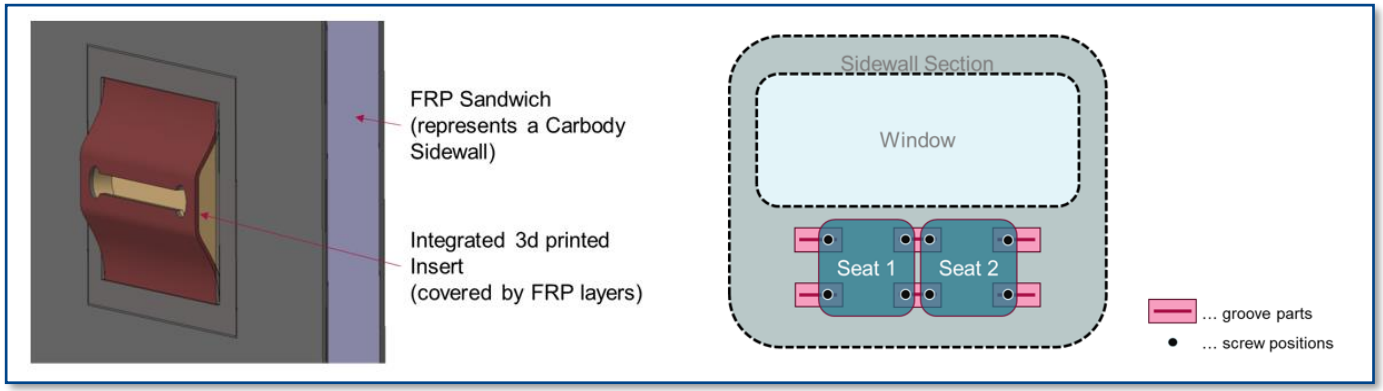
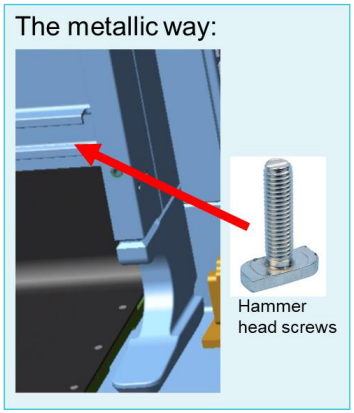
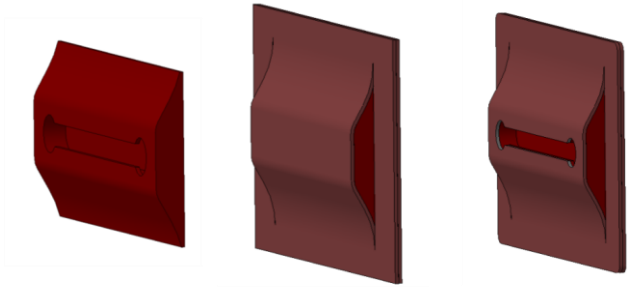
3. Innovative integrated Joint design for composite Sidewalls (WP4)

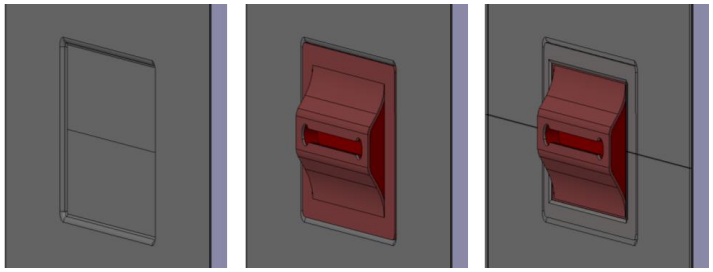
Integrated composite joint using 3d printed insert







Pre-manufacturing (embedding/curing)



Integration in sidewall manufacturing process

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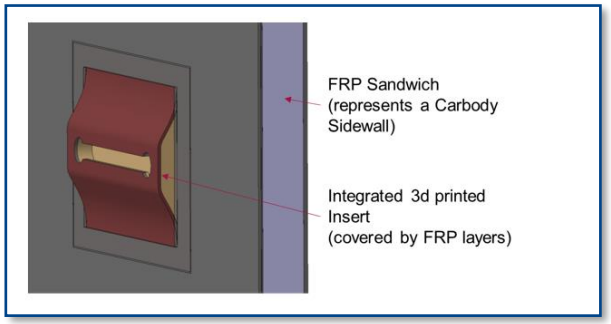
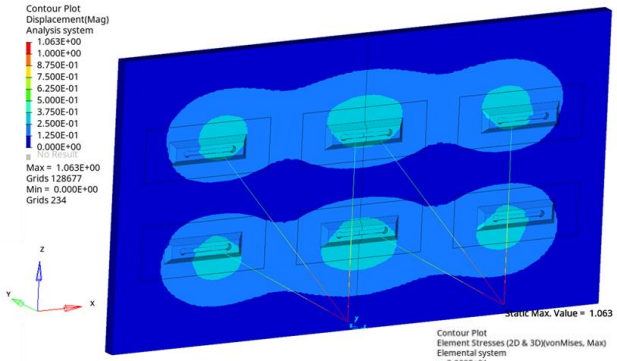
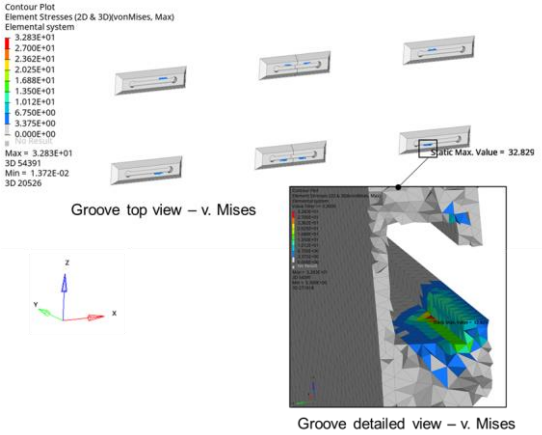
3. Innovative integrated Joint design for composite Sidewalls (WP4)

Integrated composite joint using 3d printed insert – a real study case







→ *calculated with real load cases by means of FE*
→ *Experimental tests and verification is ongoing*

Fullfils required technologies:

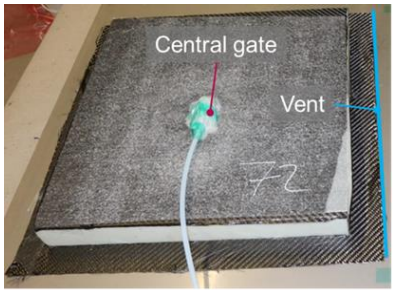
- *integrated multi-material (Composite + 3d printed inserts)*
- *co-curing/bonding*
- *modular concept (different groove lengths and dimensions)*

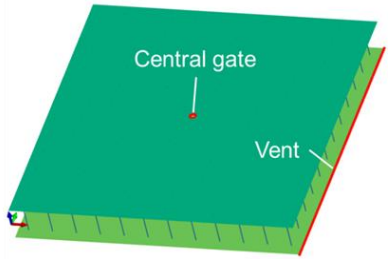
4. Process simulations (WP3/WP4/WP9)

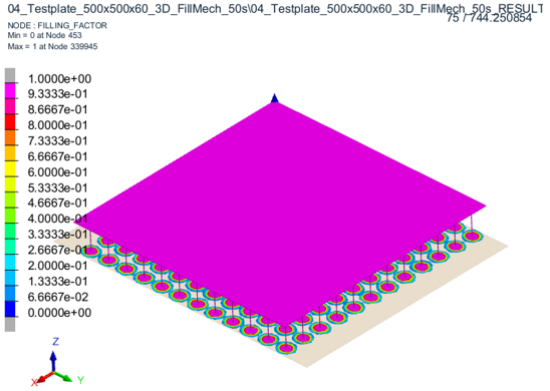
Resin infusion simulations

A) Basic studies on the influence of

- Different modelling degrees (2d, 3d and 3d + external pressure)
- Line or central gate (inlets)
- Pressure and wall thickness variations of components made with VARI process







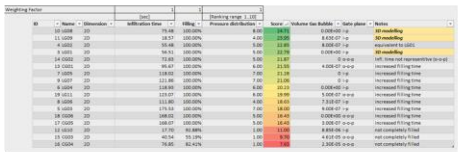
4. Process simulations (WP3/WP4/WP9)

Resin infusion simulations

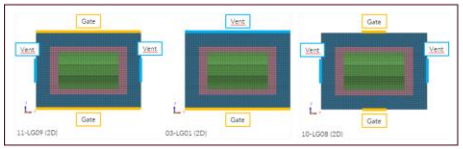
B) WP4 Joint simulation

- Finding the suitable inlet and outlet setup for resin infusion out of 17 variants

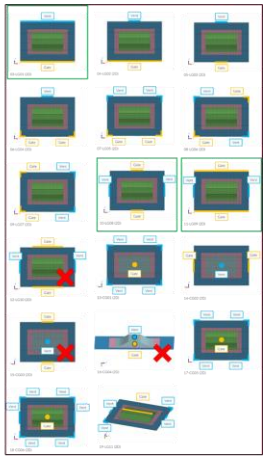
- Investigation of 17 gate variants
- Evaluation of variants based on infiltration time, filling factor and pressure distribution
- 3 variants with highest score are investigated in more detail (3D & mechanical pressure)



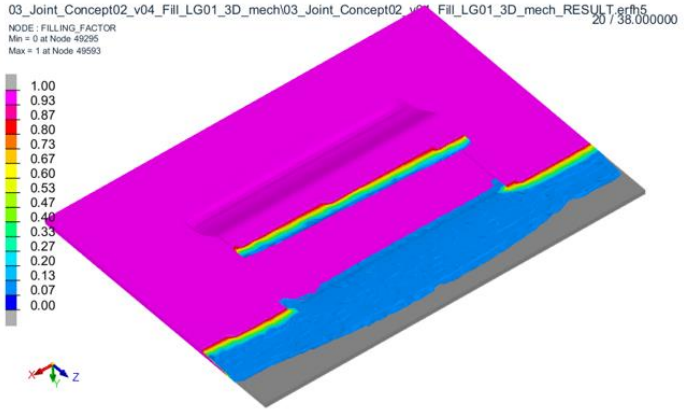
Evaluation table



Gate concepts for more detailed investigations and 3D analysis



Gate study

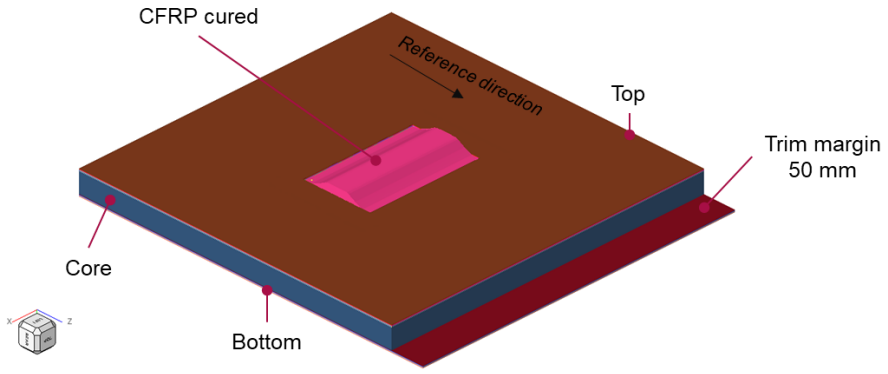


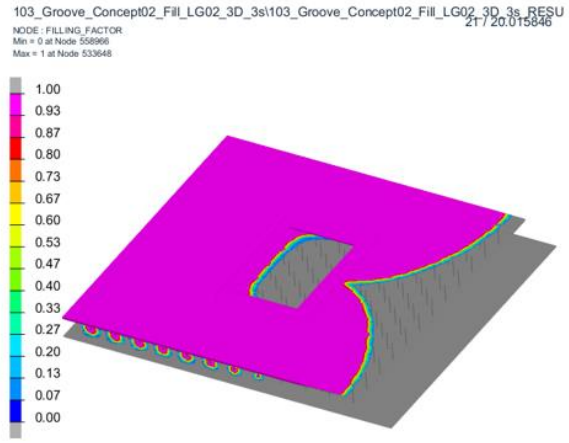
4. Process simulations (WP3/WP4/WP9)

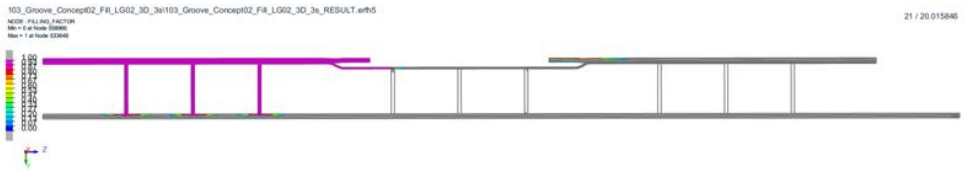
Resin infusion simulations

B) WP4 Joint simulation

- Verifying if co-curing around embedded insert is successful





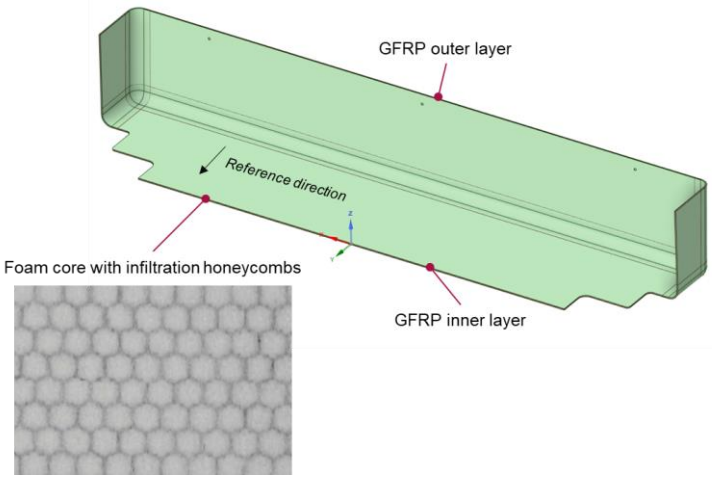


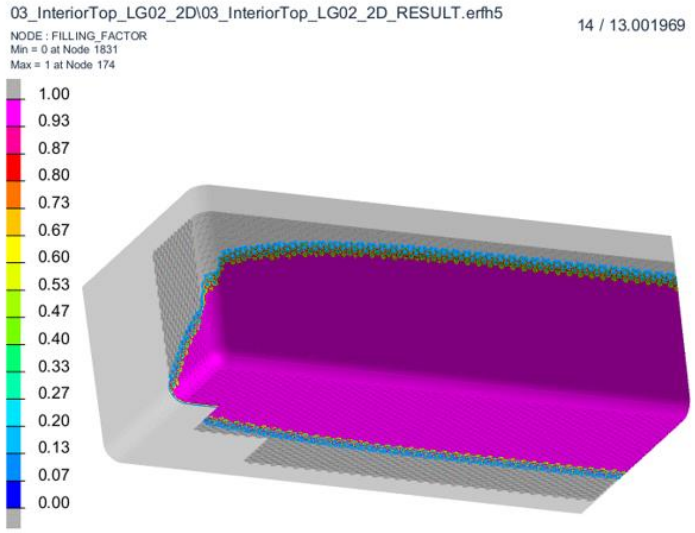
4. Process simulations (WP3/WP4/WP9)

Resin infusion simulations

C) WP9 interior top filling simulation

- Investigating inlet and outlet arrangement





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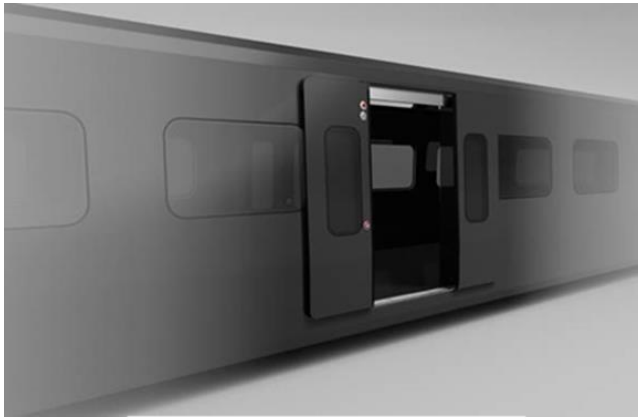
4. Process simulations (WP3/WP4/WP9)

Resin infusion simulations

- ✓ Simulate resin infusion process before manufacturing
- ✓ Select best suitable resin inlet and outlet positions
- ✓ 1st step for reproducible high-quality parts
- ✓ Reduce trial-and-error manufacturing
- ✓ Reduce manufacturing waste

CARBODIN
CAR BODY SHELL, DOORS AND INTERIORS

Thank you for your attention!



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