Lightweight Design Concept Methodology of the Extended Market Wagon: A Shift2Rail Project

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Europe's Rail

FR8RAIL IV

Extended Market Wagon (EMW)

- Design concept within the FR8RAIL IV Project / Europe's Rail / Horizon 2020 No. 101004051

- Objective FR8RAIL IV
  - Increasing the efficiency and reliability of rail freight transportation
  - New lightweight wagon designs and running gear
  - Automation and digitalization of wagons
  - TRL 7 of these technologies

- Objective EMW undercarriage
  - Modern, robust and innovative lightweight wagon structure
  - Increase payload per meter of train

- Challenges
  - Tight schedule (rapid development and manufacturing cycle)
  - Conventional manufacturing methods / ease of manufacturing
  - Achieving goals while keeping LCC low and simplicity high

Partners

DLR, ceit, CAF, ConTraffic Consulting Network for Traffic System, KNORR-BREMSE, DIE BAHNINDUSTRIE. VDB VERBAND DER BAHNINDUSTRIE IN DEUTSCHLAND E.V.

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Requirements

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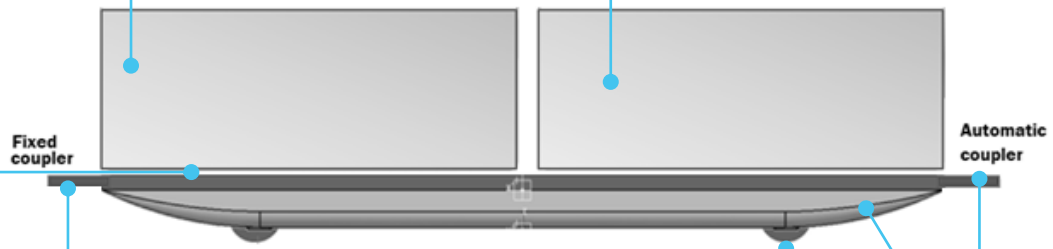
High competitiveness
- 2x20' Swap-Bodies (17 t each)
- 2x20' Standard Containers
- 40' and 45' Standard Container

Mass
- Tare: 500 – 600 kg/m
- Max: 2700 kg/m
- Max 22.5 t / axle

Loading level
- < 1000 mm above TOR
- High Cube Swap-Bodies



Couplers per wagon
- 1 fixed center coupling
- 1 DAC type 5
- 22 double wagon units
- No buffers

Two-axle wagon
- Profile: UIC G2
- v_{max}: 140 km/h

Reduction of aerodynamic drag
- Full coverage
- Short coupling lenght

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Topology Optimization

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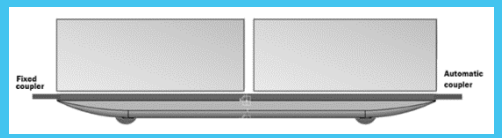
Requirements

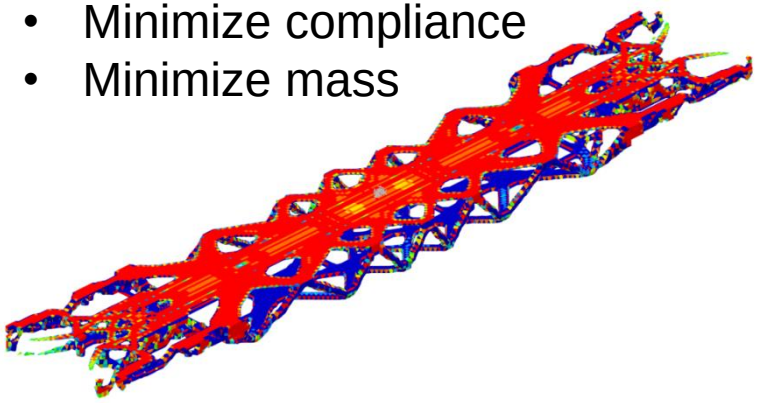


Evaluation

Setup of model

Optimization

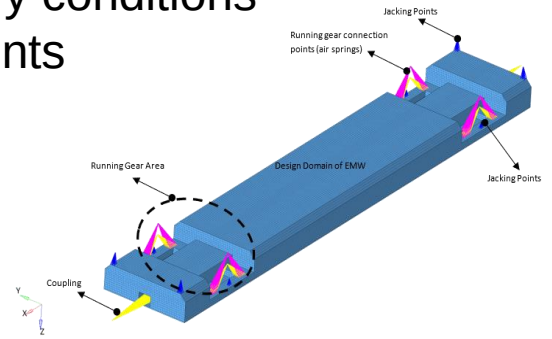
- Minimize compliance
- Minimize mass

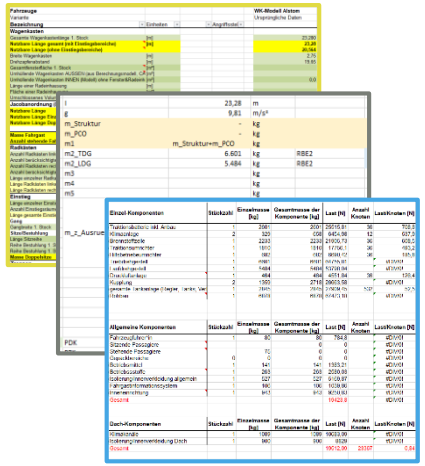


Iterative process

Setup of model

- Meshing
- Boundary conditions
- Constraints





Calculation

Implementation of masses and loads according to European standards

Topology Optimization

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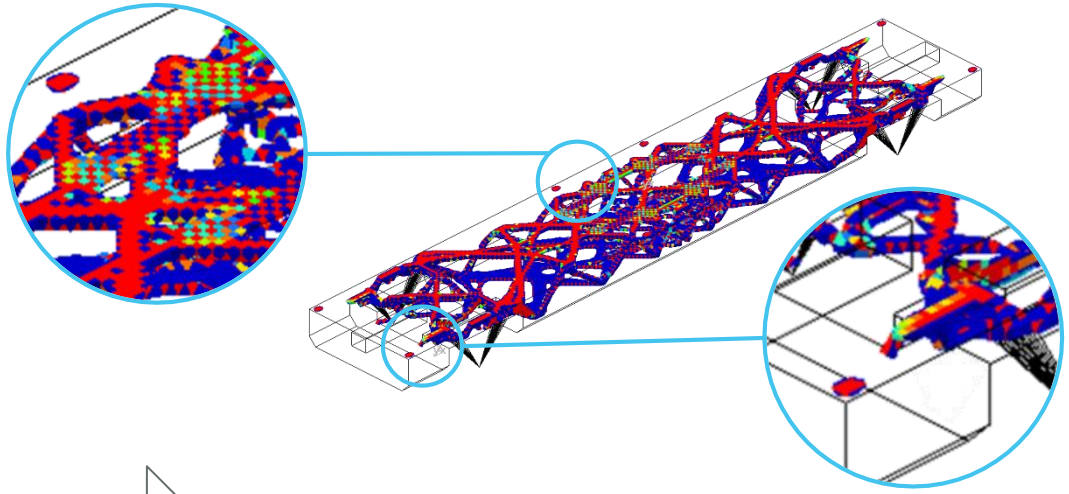
- Objective: minimum mass
  - Without manufacturing constraints
- Note:
  - Checkerboard
  - Twistlocks not connected



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  - With manufacturing constraints
- Note:
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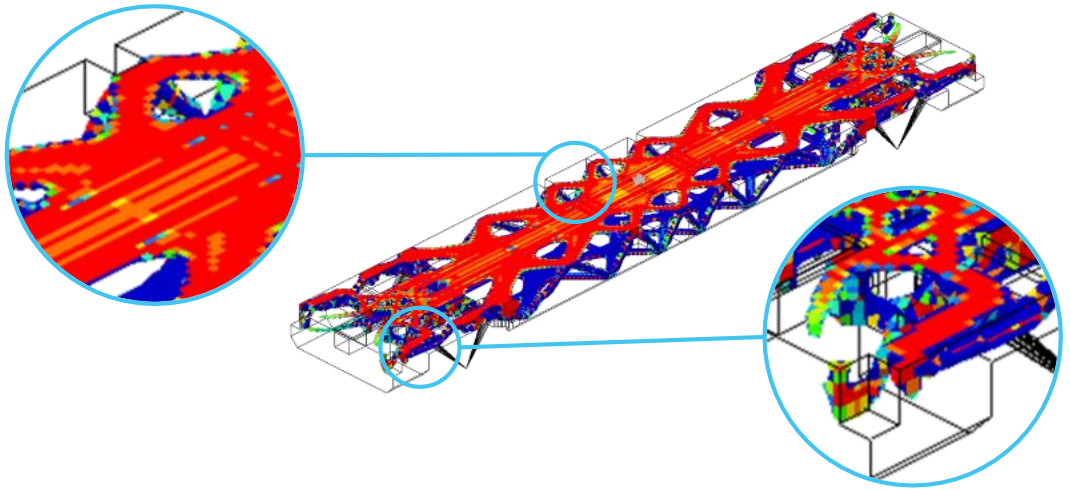
  - Twistlocks connected



Goal: to find a lightweight structure that has the required stiffness and is manufacturable.

Concept Construction CAD – Process

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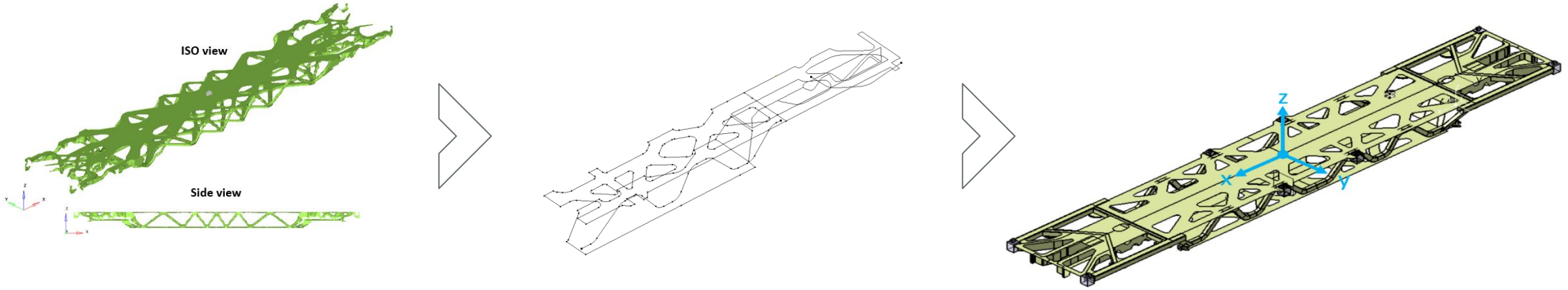
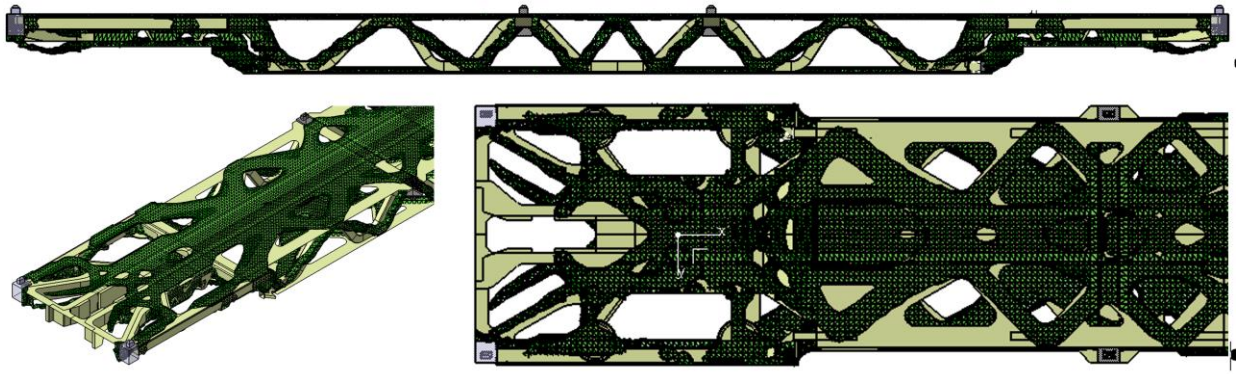


- Result of topology optimization

- Skeleton-based construction
  - Closely followed the topology optimization
  - Fast adjustments

- Sheet metal and tubing design



Manufacturing Methods

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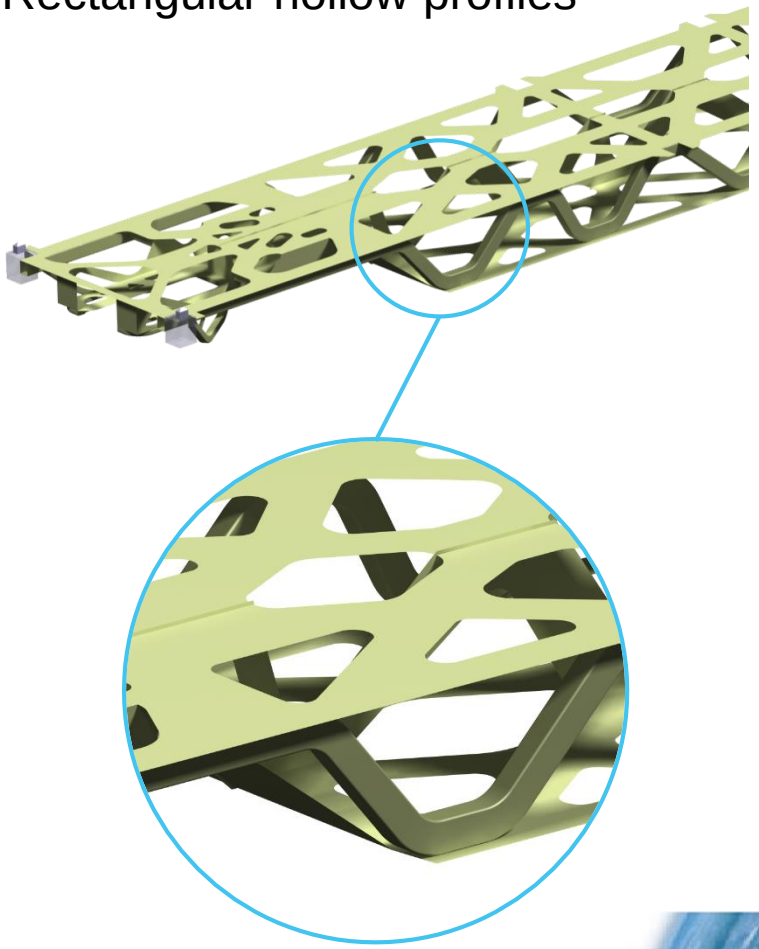
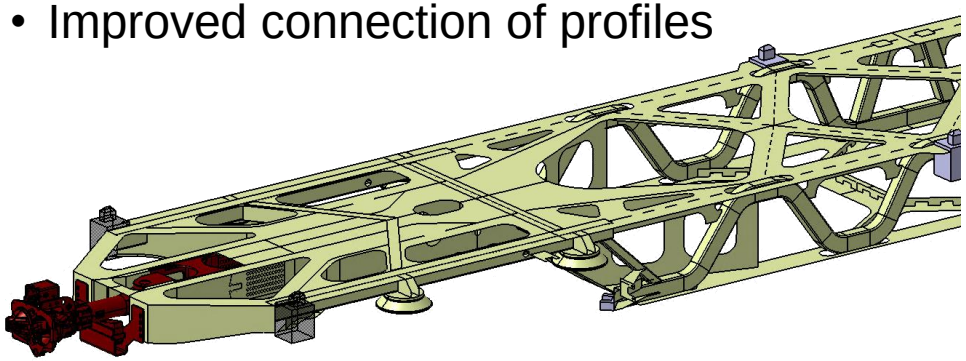
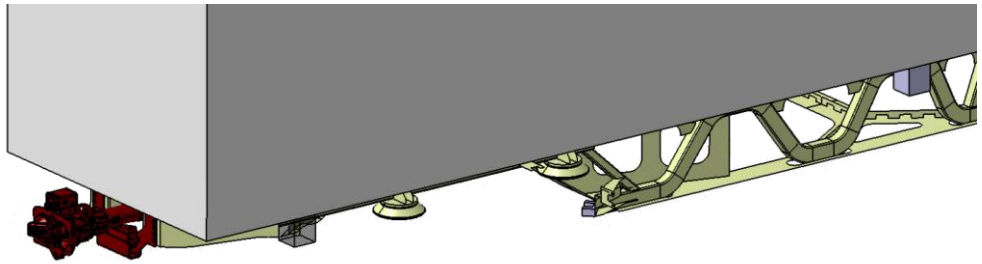
- First Approach
  - Rectangular hollow profiles



- Second Approach
  - Couplers shifted forward (Swap-Bodies)
  - Loads shifted to the outer beams
  - Improved connection of profiles





Manufacturing Methods – Final Design

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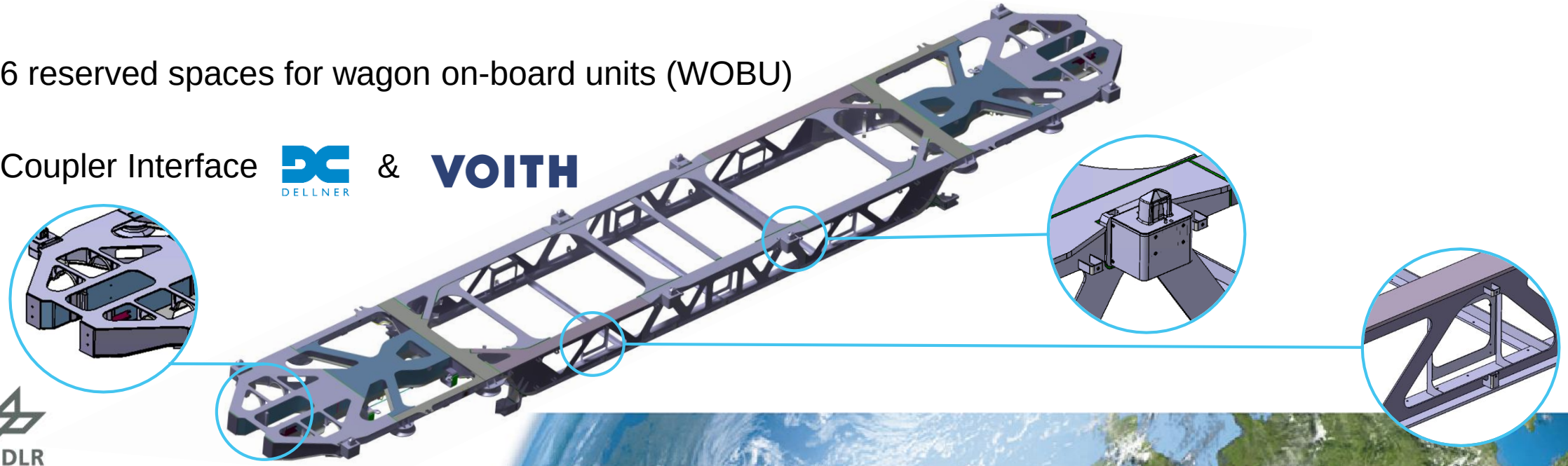
- Material availability ⇔ tight schedule
  - sheet metal with cutouts according to topology optimization (instead of tubing)
  - prevent buckling / increase natural frequencies with the help of light webs to stiffen the longitudinal and lateral frames
- 2D-Surface Concept Model ⟩ production-ready 3D-Model

Industrial Partner
HÖRMANN VEHICLE ENGINEERING

- Automatic twistlocks are integrated and welded via receivers into the beam profiles
- 6 reserved spaces for wagon on-board units (WOBU)
- Coupler Interface DELLNER & VOITH



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Results

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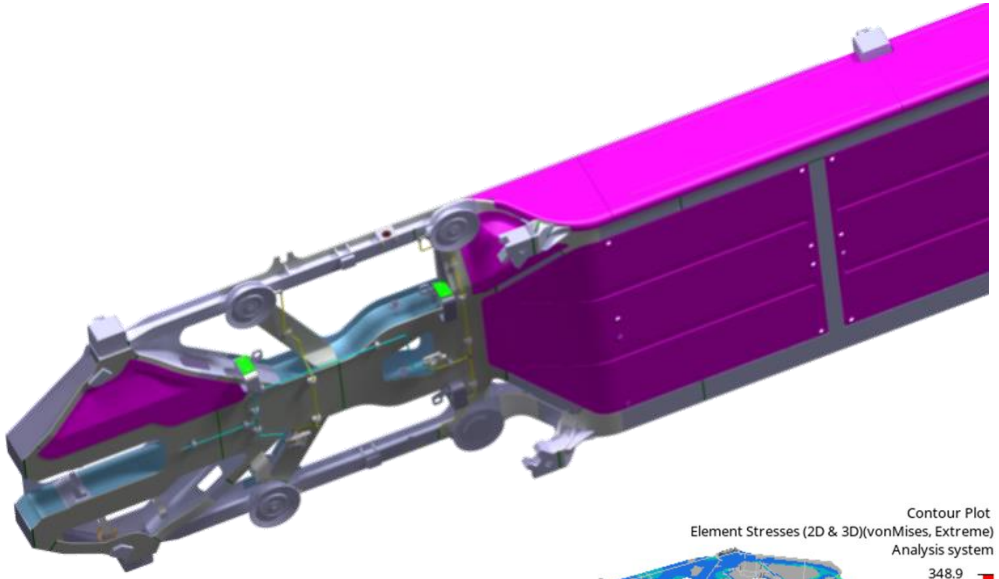
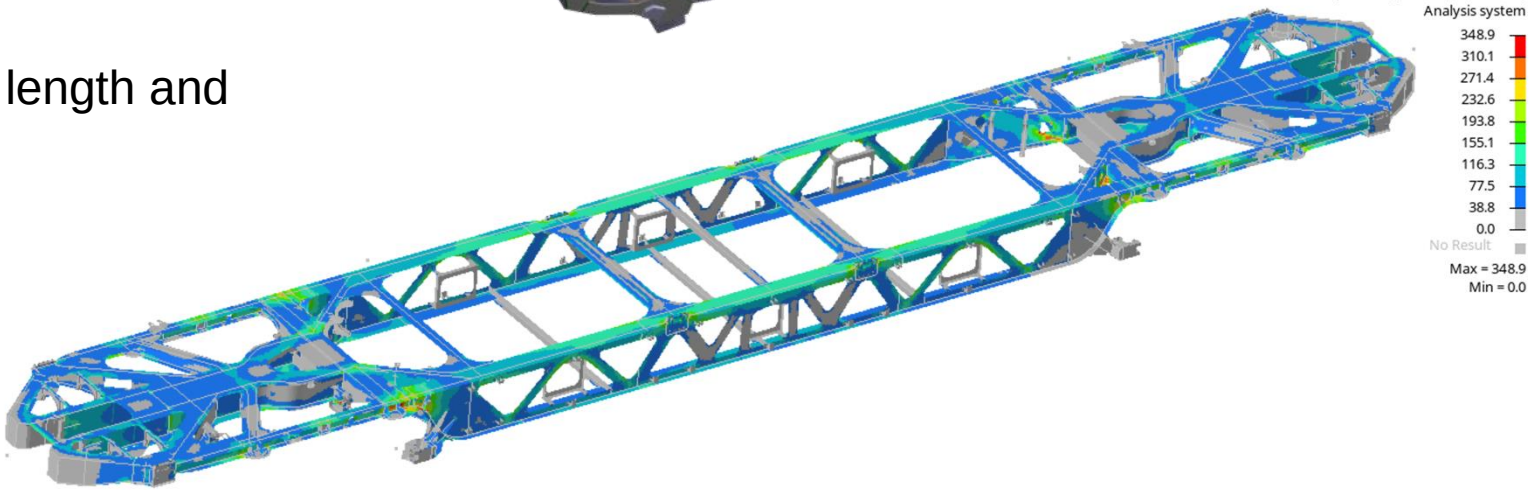
- Total mass: 12 tonnes
  - - 19.6 % specific mass reduction in comparison to similar class wagon (LGS 580)
    - - 3.4 % total mass with 20.1 % increase in length
  - Decrease: specific energy per payload kg
  - Decrease: greenhouse gas emission
  - Increase: payload mass
  - Increase: economic efficiency



- Reduced drag through short coupling length and aerodynamic fairing



- Final Design has been verified with FEM analysis results

Conclusion

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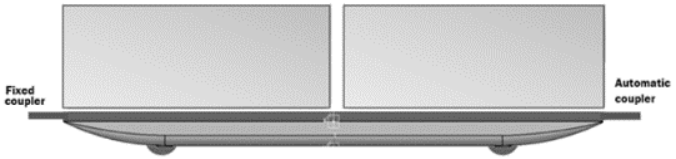
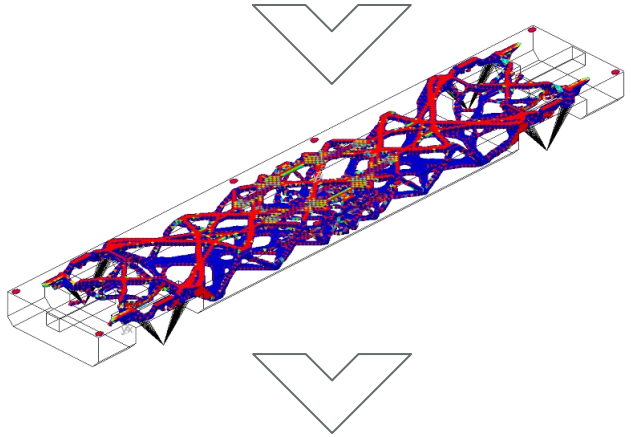
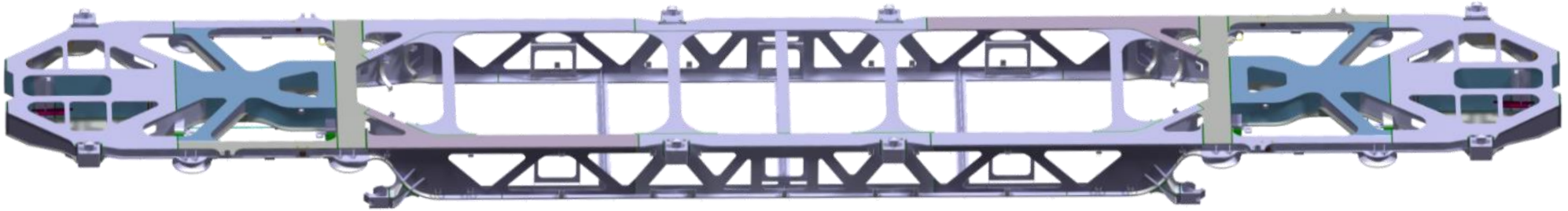
- A high lightweight freight wagon structure was developed
  - Iterative design process of requirements, calculation and construction
  - 19.6 % specific mass reduction compared to LGS 580



- Increased competitiveness of freight rail transportation
  - Different container sizes possible
  - Reduced drag
  - Increased payload per metre of train



- Next steps
  - 1:1 demonstrator at InnoTrans 2022
  - Testing of the EMW on track under real conditions



Thank you for your attention!

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