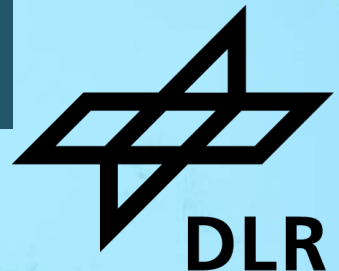
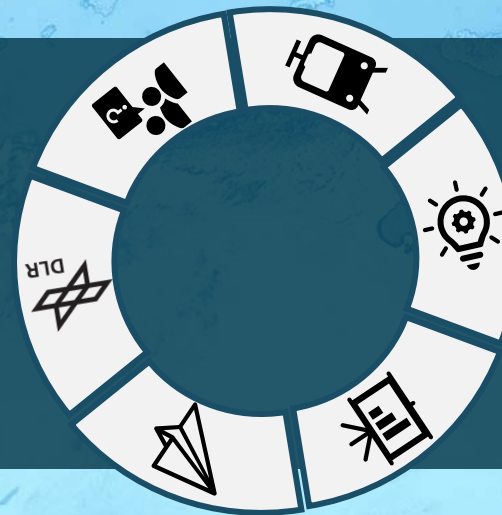
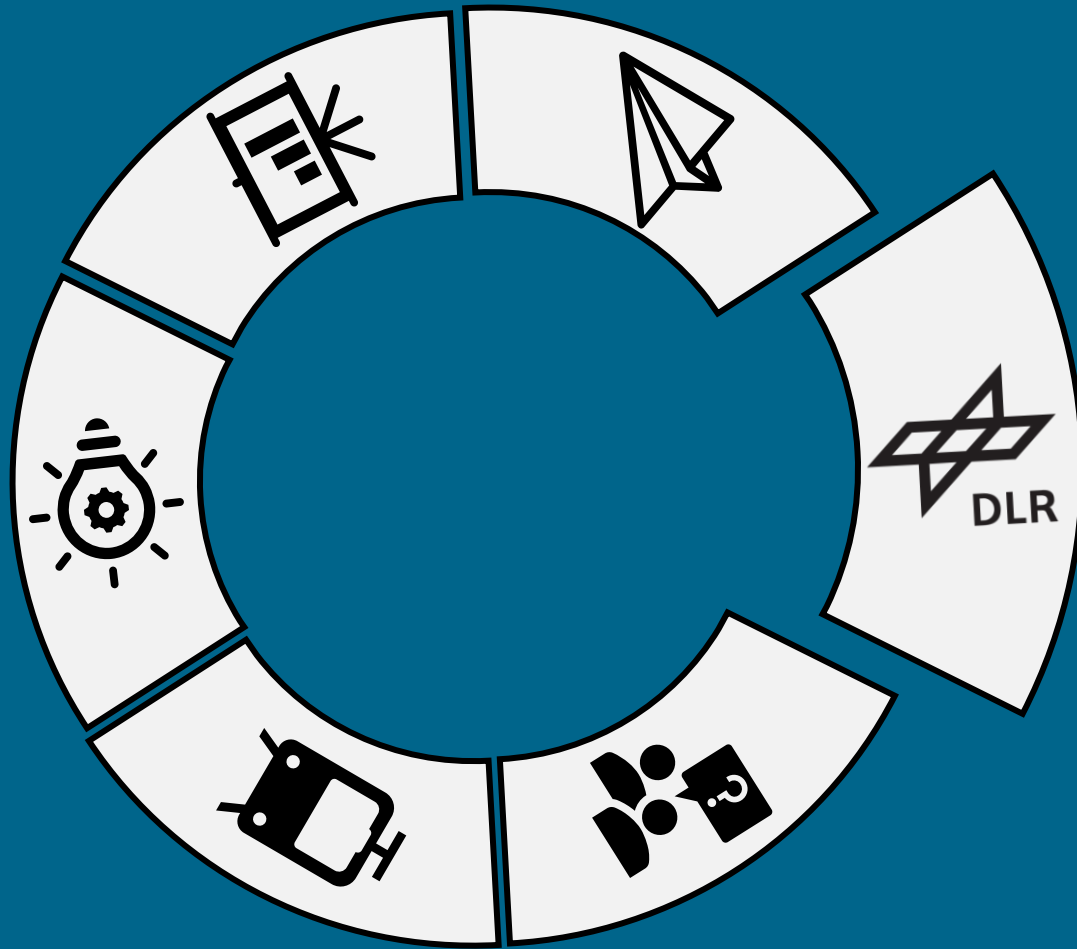


Simulation-based design process for railway metallic structures

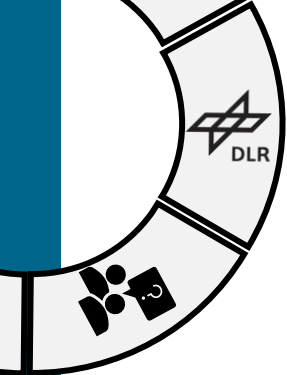
Dipl. Ing. Mathilde Laporte

Dr. Ing Gerhard Hippmann

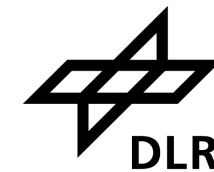
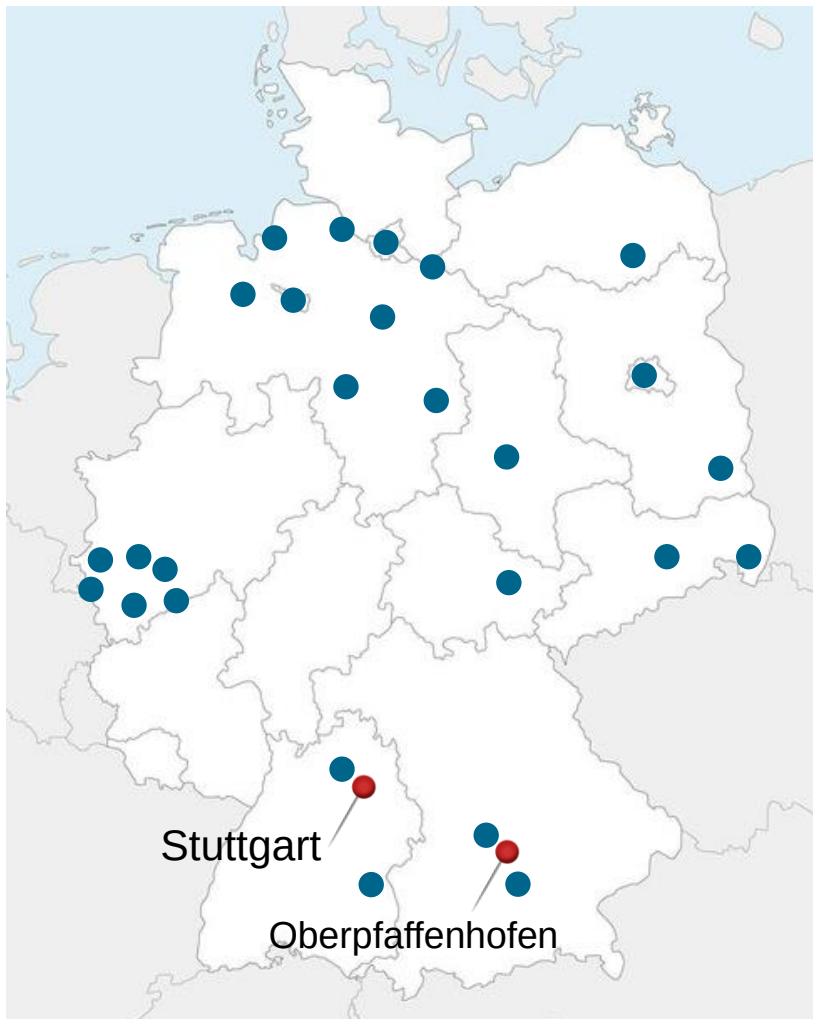




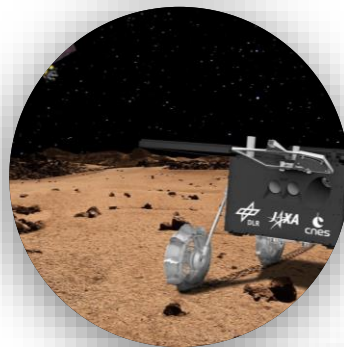
Who are we?



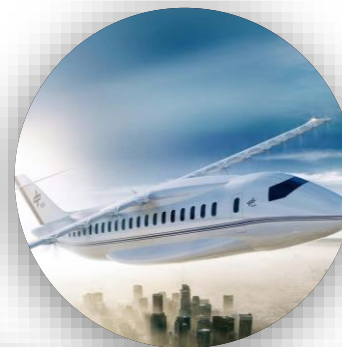
Who are we?



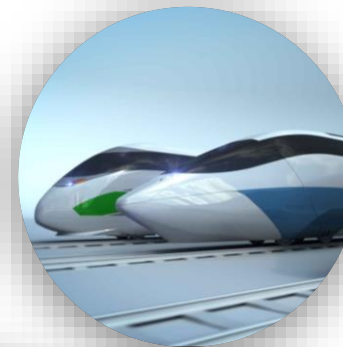
Aerospace



Aeronautics



Transport



Security



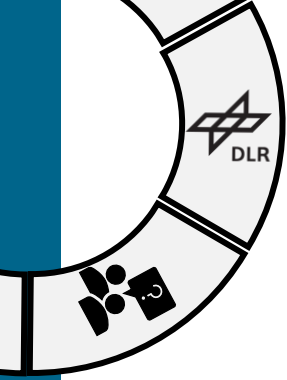
Energy



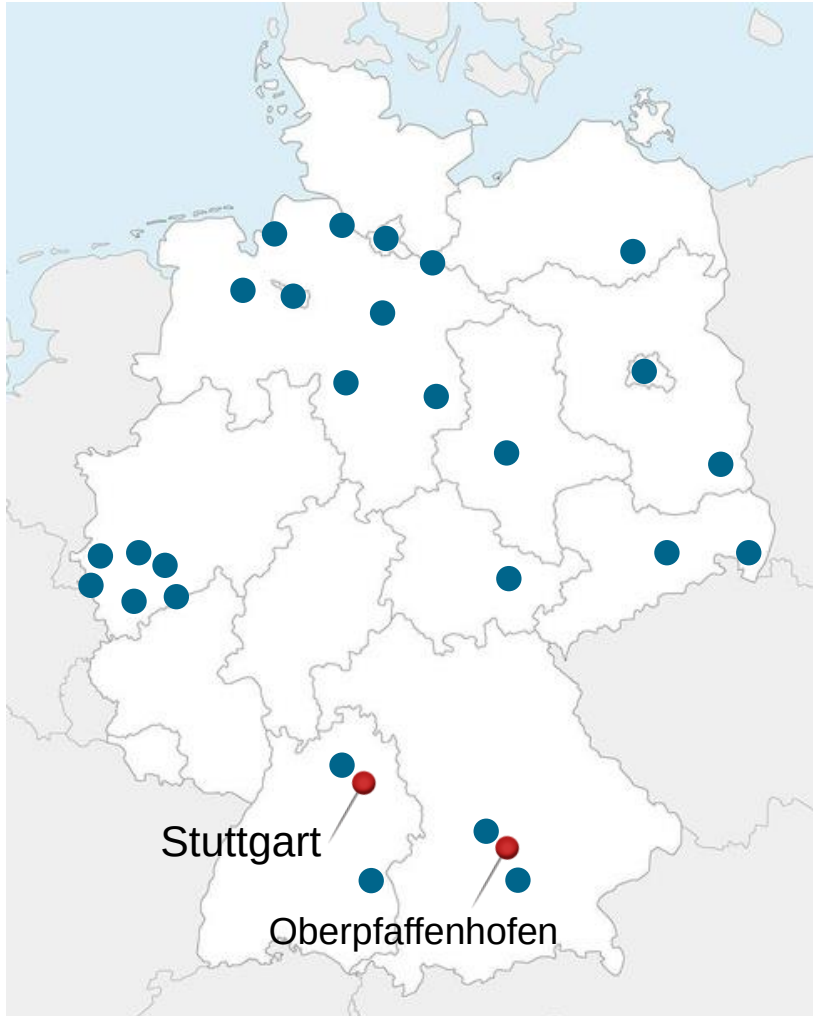
>10 000 Employees

> 50 Instituts

Over 30 locations



Who are we?



Stuttgart

Institut of Vehicle Concept

Department Vehicle Architectures
and Lightweight Design Concepts

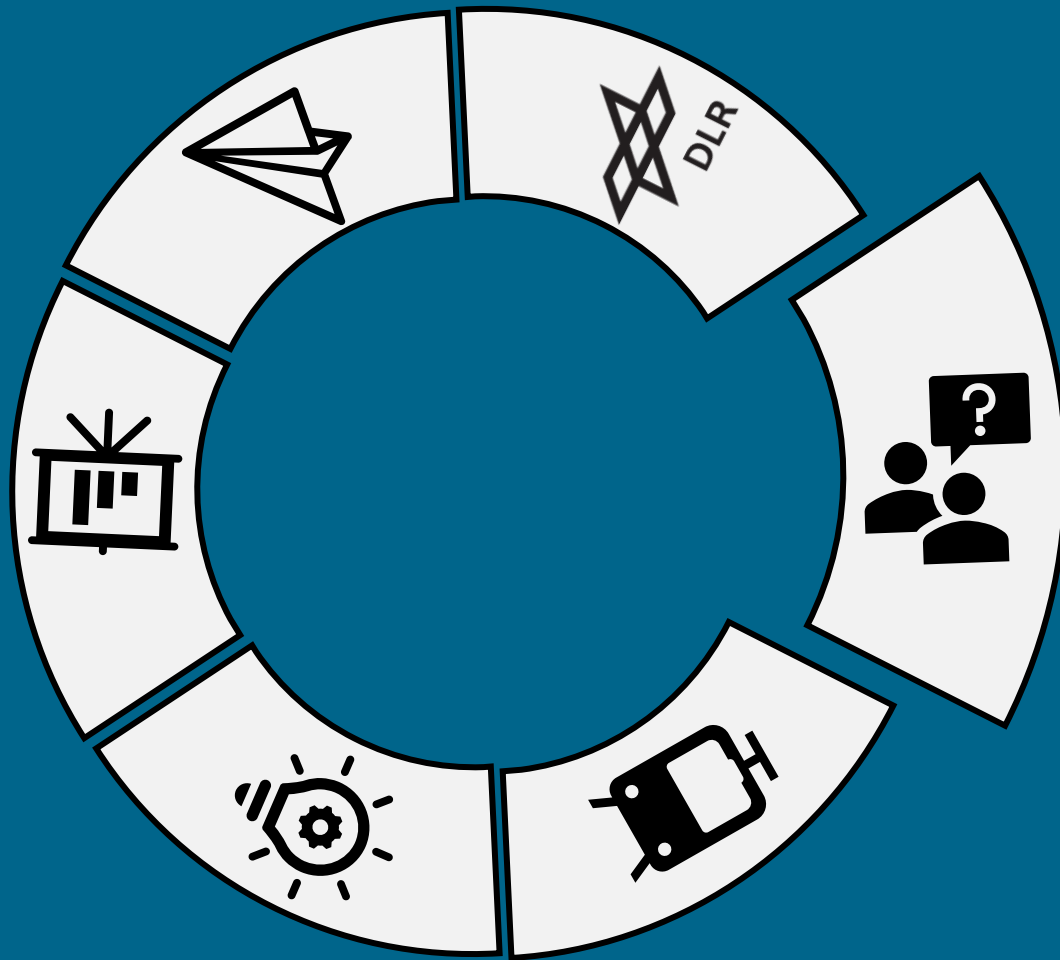


Oberpfaffenhofen

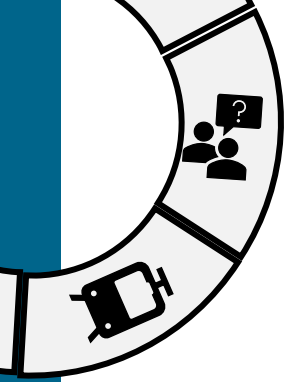
Institut of Vehicle Concept

Department Vehicle System
Dynamics and Control Technology



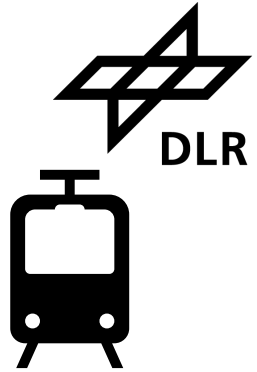


Challenges



Challenges

Main goal: Increase the attractiveness of the rail transport



Improve passengers comfort

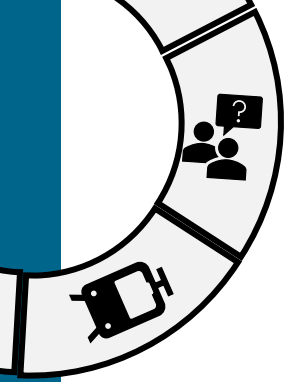


Increasing mass



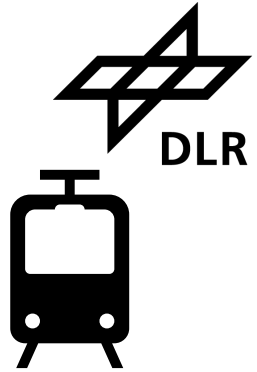
Reduce CO₂ emissions

**Lightweight
design**



Challenges

Main goal: Increase the attractiveness of the rail transport



Improve passengers comfort



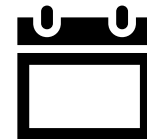
Reduce CO₂ emissions

**Lightweight
design**

**Use the operating loads from standards!
But...**



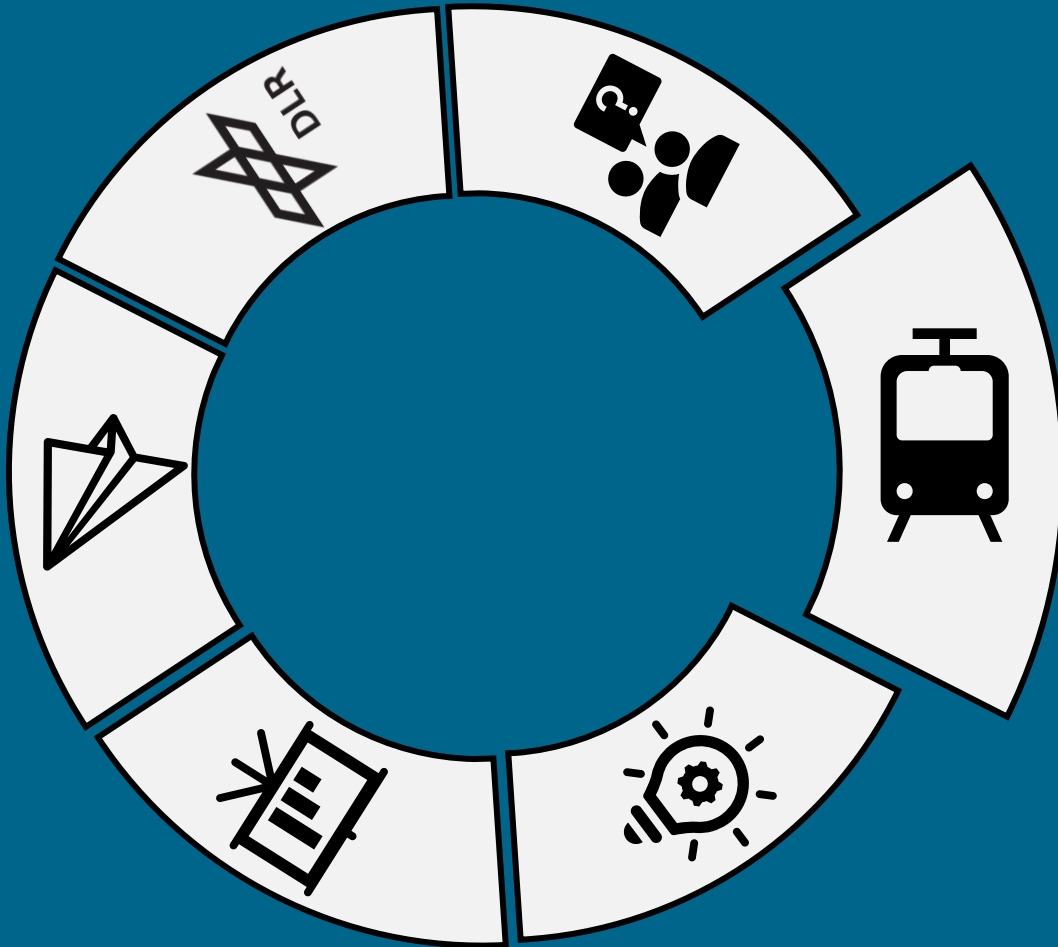
Unknown origin



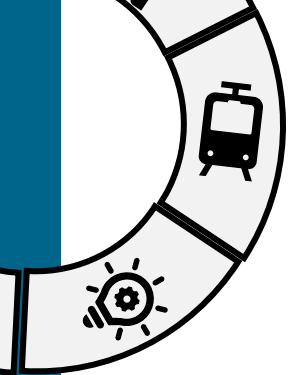
Not up-to-date

Oversizing



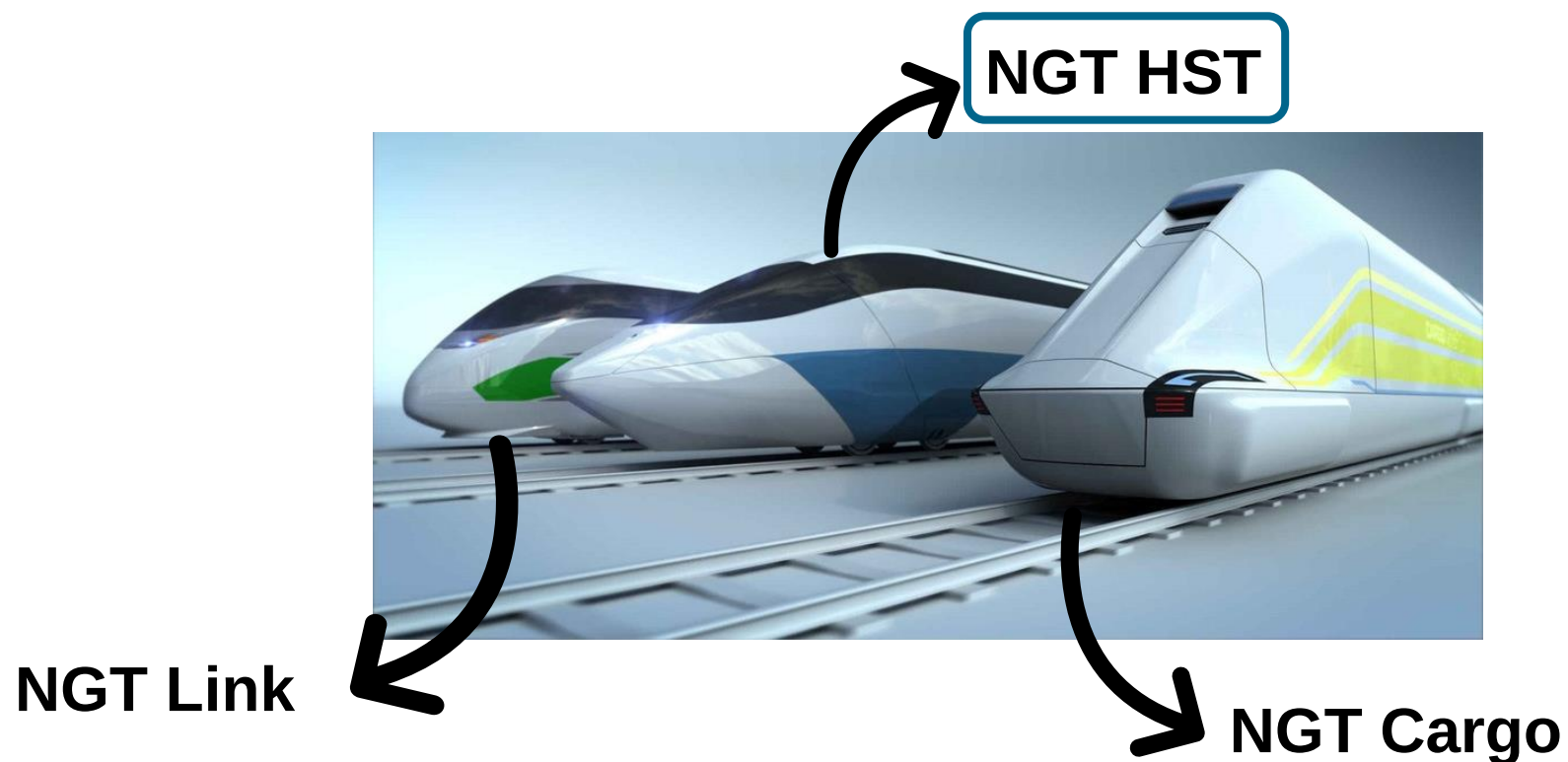
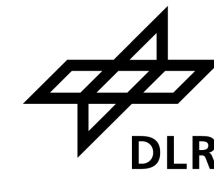


Our project



Our project

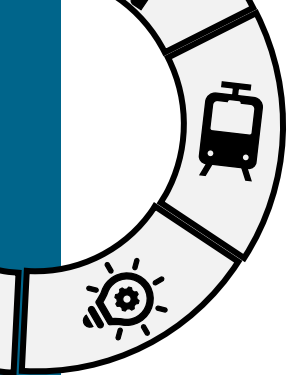
NGT: Next Generation Train



NGT HST

NGT Link

NGT Cargo



Our project

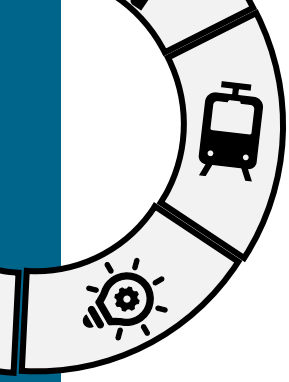
NGT: Next Generation Train



NGT HST

Up to 400 km/h 790 passengers

- **HST:** High Speed Train
- Double-decker
- **Low energy** requirements
- Reduce **noise**
- Increase **comfort**
- Improve driving **safety**
- Reduce **wear and tear**
- **Lower cycle** costs



Our project

NGT: Next Generation Train

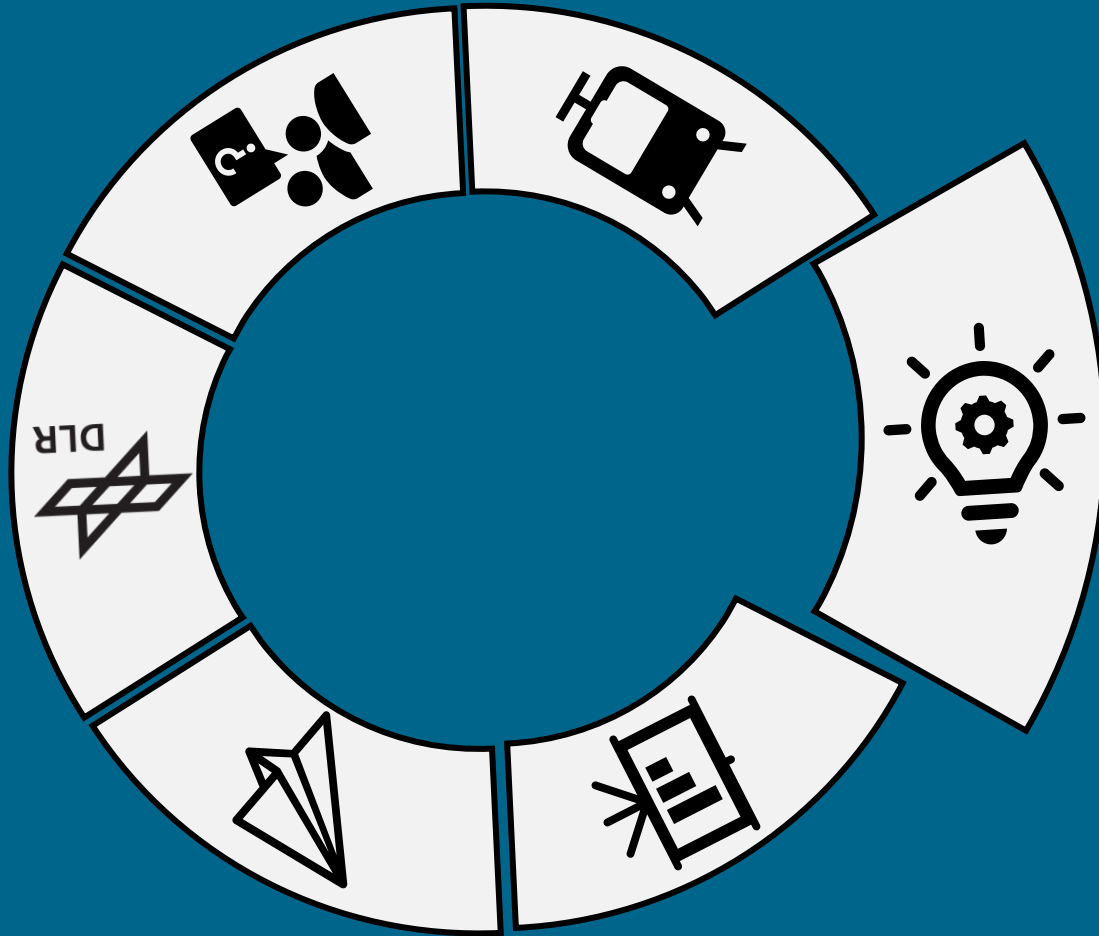


How can we respond to all challenges as quickly as possible and at the lowest cost?

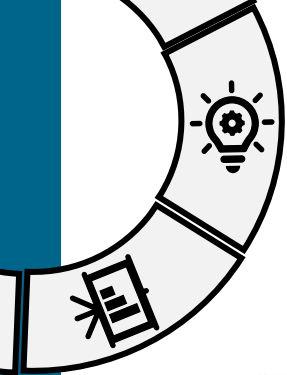
NGT HST

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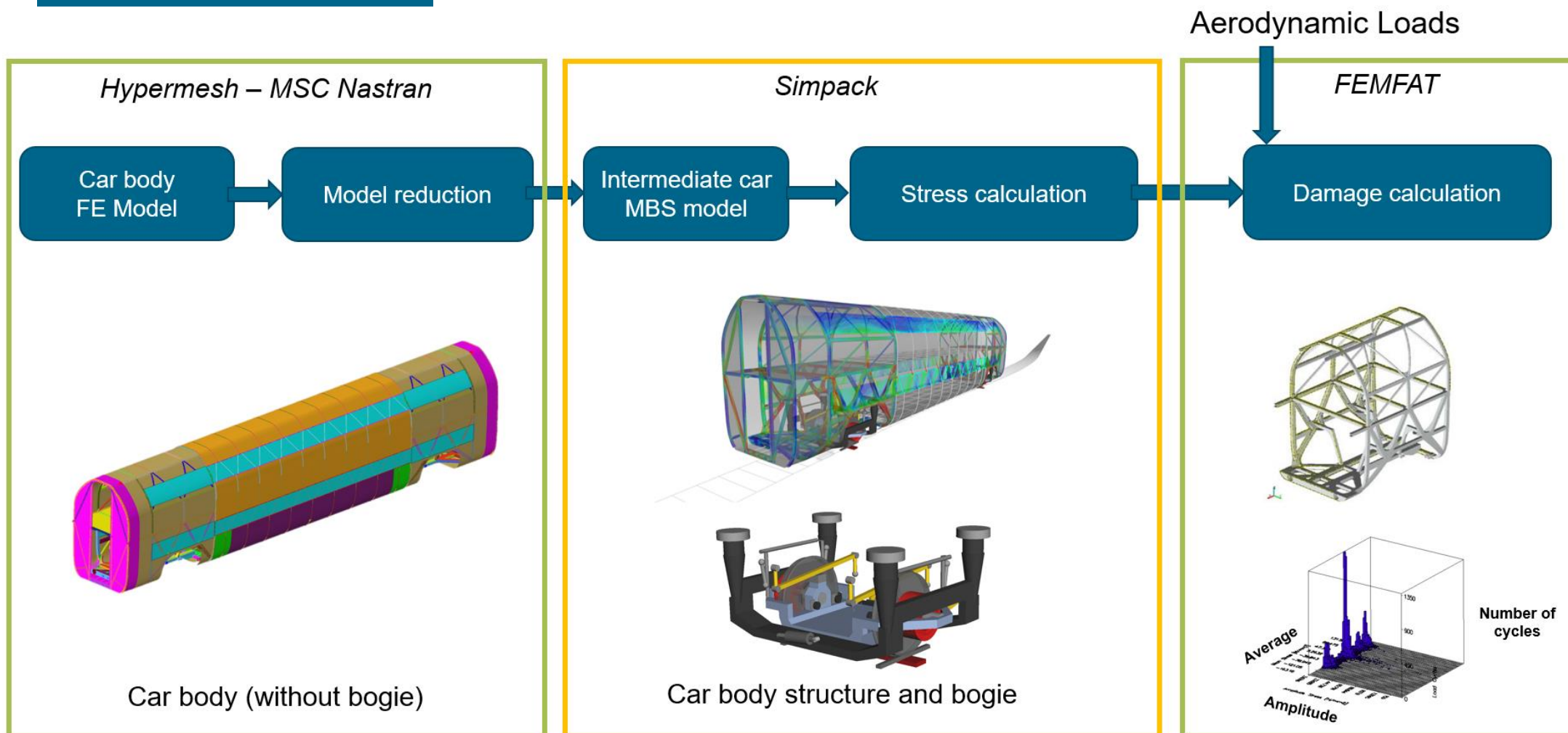


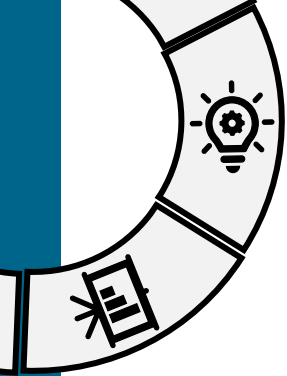
Our solution



Our solution

Workflow



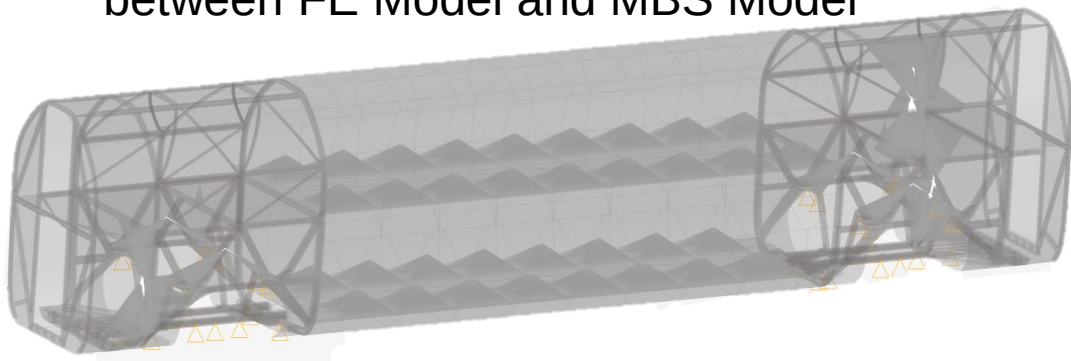


Our solution

FEM Models

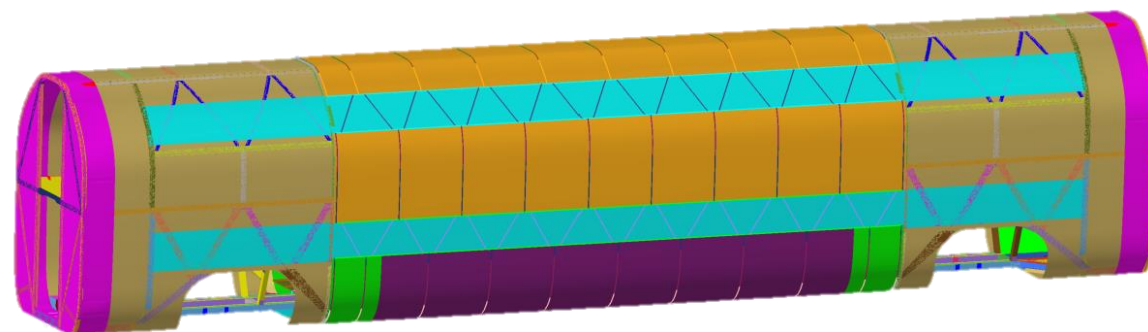
Vehicle dynamic loads

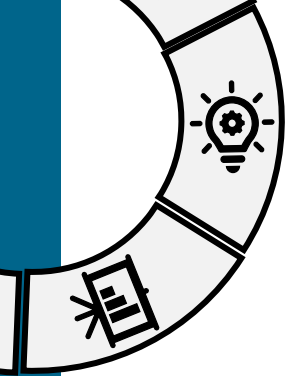
- Modal reduction with **Craig-Bampton** method
- Definition of the **interface nodes** between FE Model and MBS Model



Aerodynamic loads

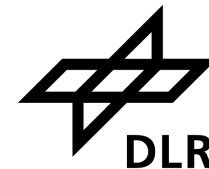
- Unit loads (1 Pa)
- Computation of the aerodynamic loads following EN 12663-1 and EN 14067





Our solution

MBS Model

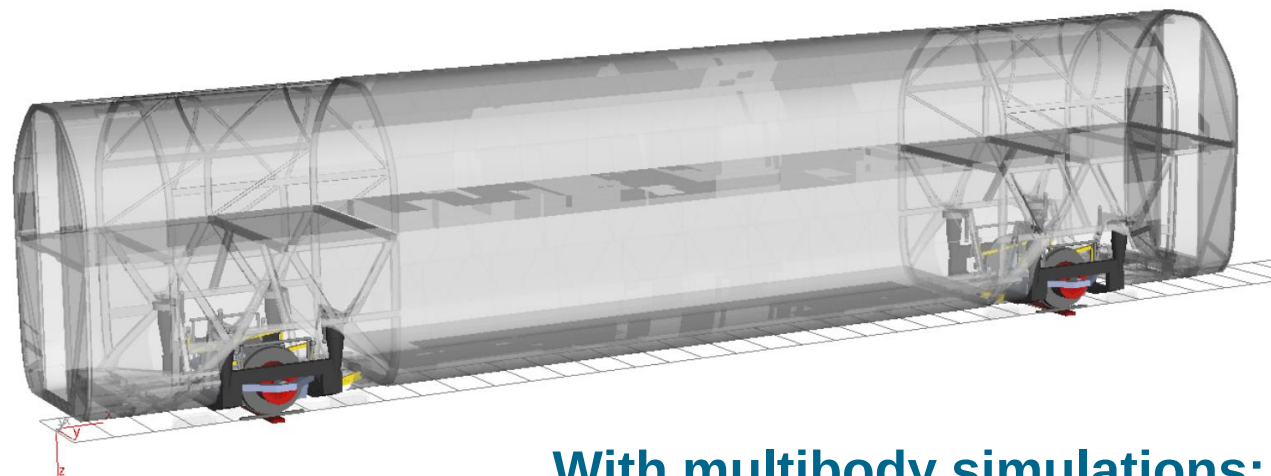


Scenarios:

- Double Switch at 40km/h
- S-curve, radius 6000m at 400km/h
- Ingolstadt-Nuremberg 320km/h

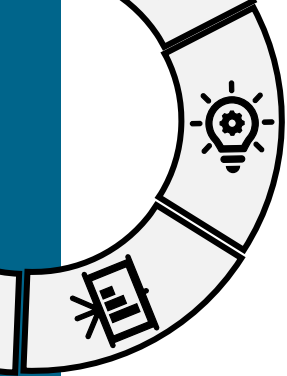
All: with(80% loaded) and without(tare) passenger

Hierarchical, modular MBS Model:



With multibody simulations:

- **Dynamic Simulations** following the scenarios
- Computation of the **loads** induced by the bogies
- Computation of the **stresses** in the structure
- Creation of a *.max file for FEMFAT



Our solution

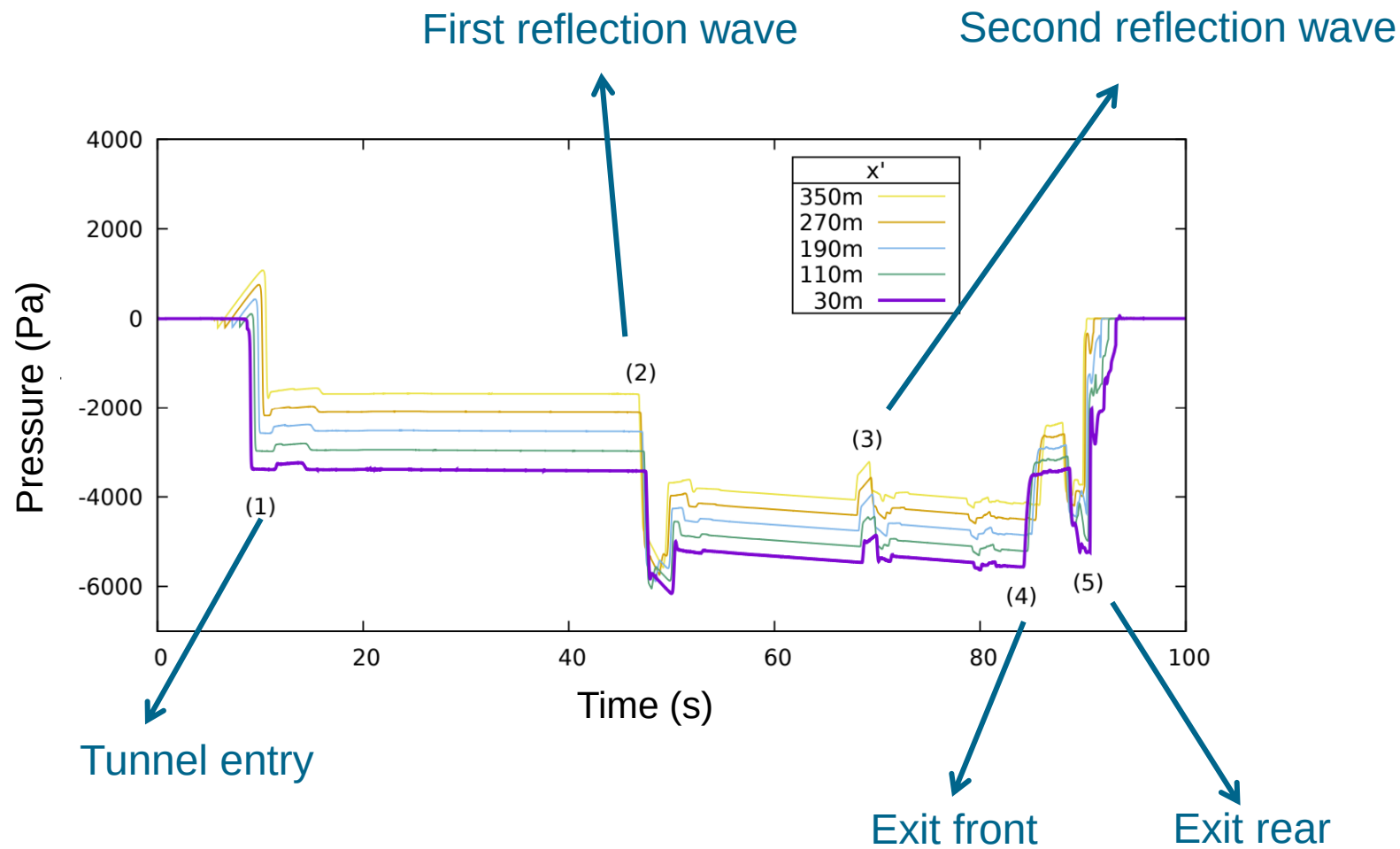
Aerodynamic loads

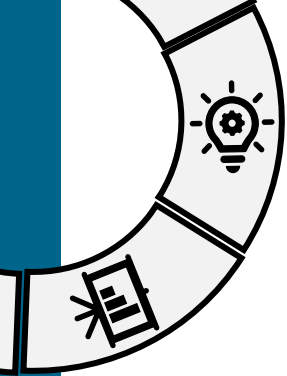


Scenarios:

- Trains crossing
 - Open track
 - At the middle of a tunnel
 - Before the tunnel exit
- In a tunnel (Katzenberg tunnel)

Example of the pressure on a train driving into a tunnel:





Our solution

FEMFAT Model



Modules used:

→ FEMFAT MAX

- Importation of the *.max file from Simpack
- Importation of the *.asc file from aerodynamic loads computation

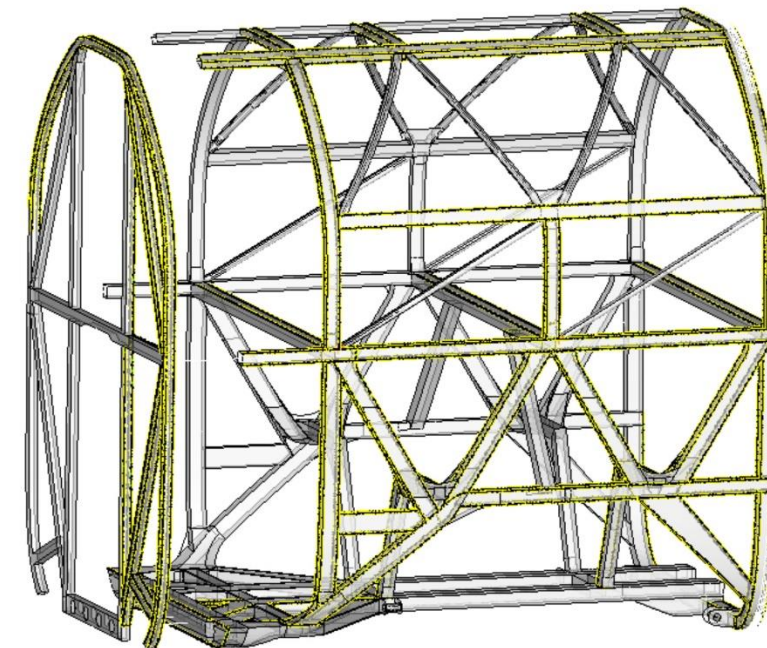
→ FEMFAT WELD

- Around 600 welds

→ FEMFAT Visualizer

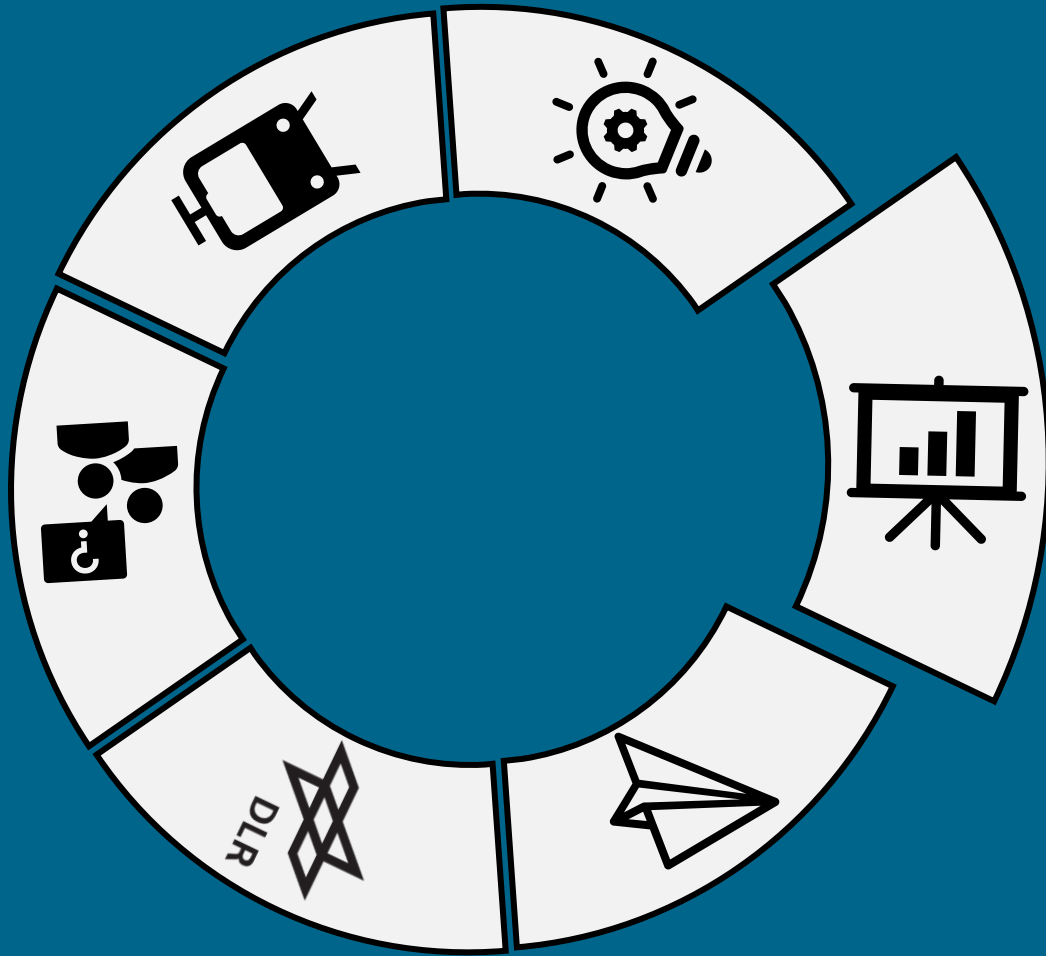
Material:

- Aluminum AlCu4SiMg
- DVS 1608



For improved simulation efficiency:

→ Welds only defined on the half of the structure (symmetry)



Results



Results

Process

1. Creation of the FEMFAT Model (welds, material...)
2. Importation of the *.max file
3. Simulation runs with dynamic loads
4. Creation of the second model with unit loads
5. Importation of the *.asc file containing aerodynamic loads
6. Simulation runs with aerodynamic loads
7. Combination of the results files (*.fps) with different simulation scenarios

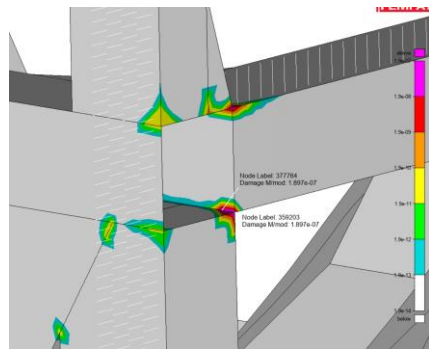


Results

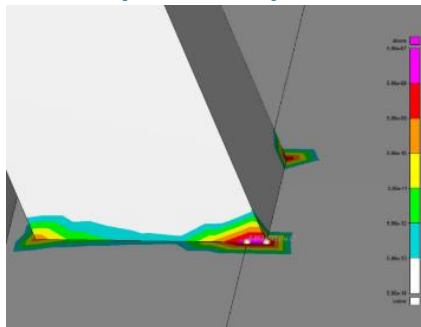
Damage



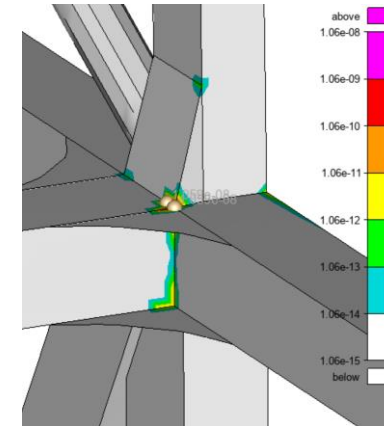
S-Curve at 400 km/h (loaded)



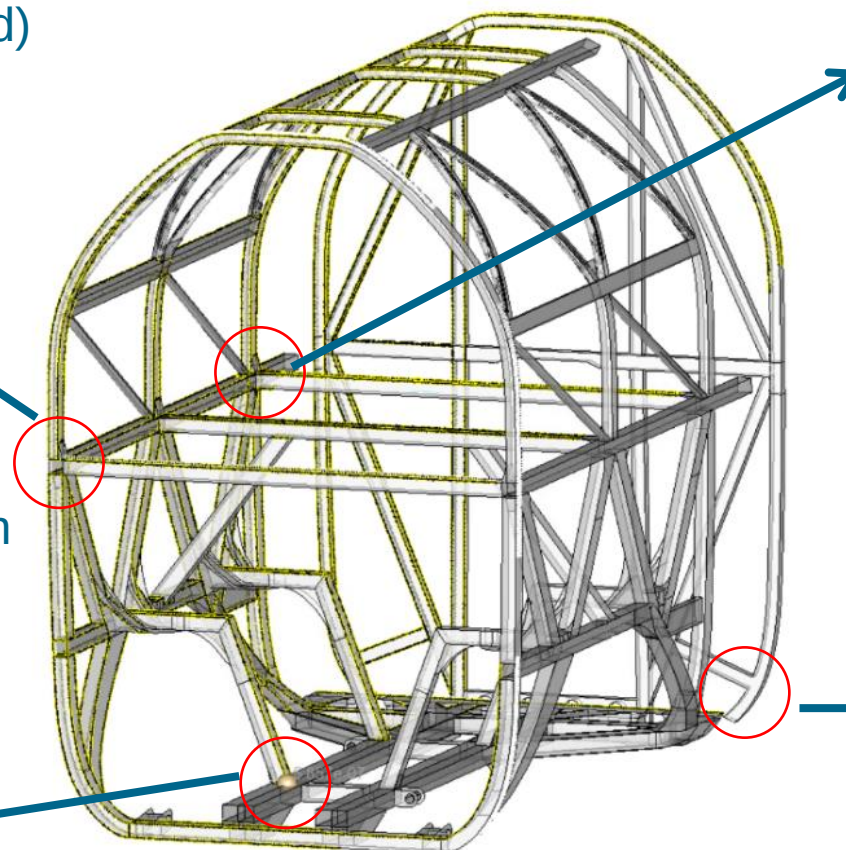
Ingolstadt-Nuremberg at 320 km/h (loaded)



Double switch at 40 km/h (tare)

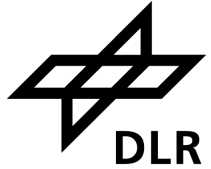


Trains crossing in a tunnel at 400 km/h



Results

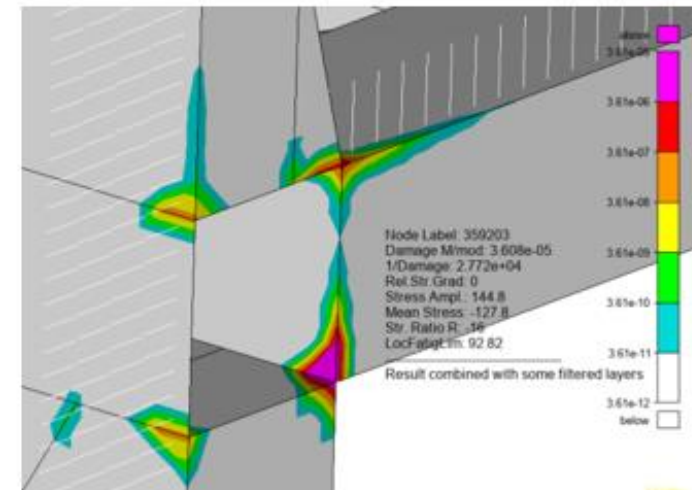
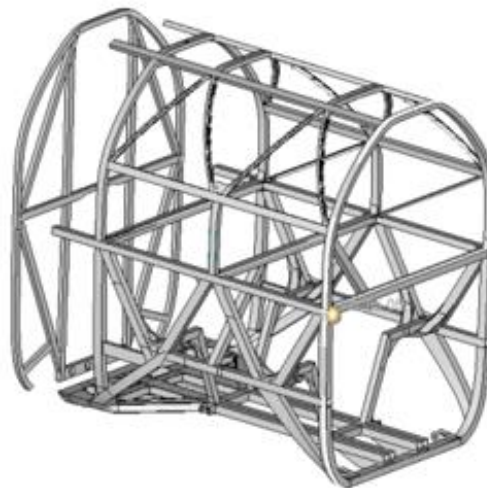
Combination of scenarios

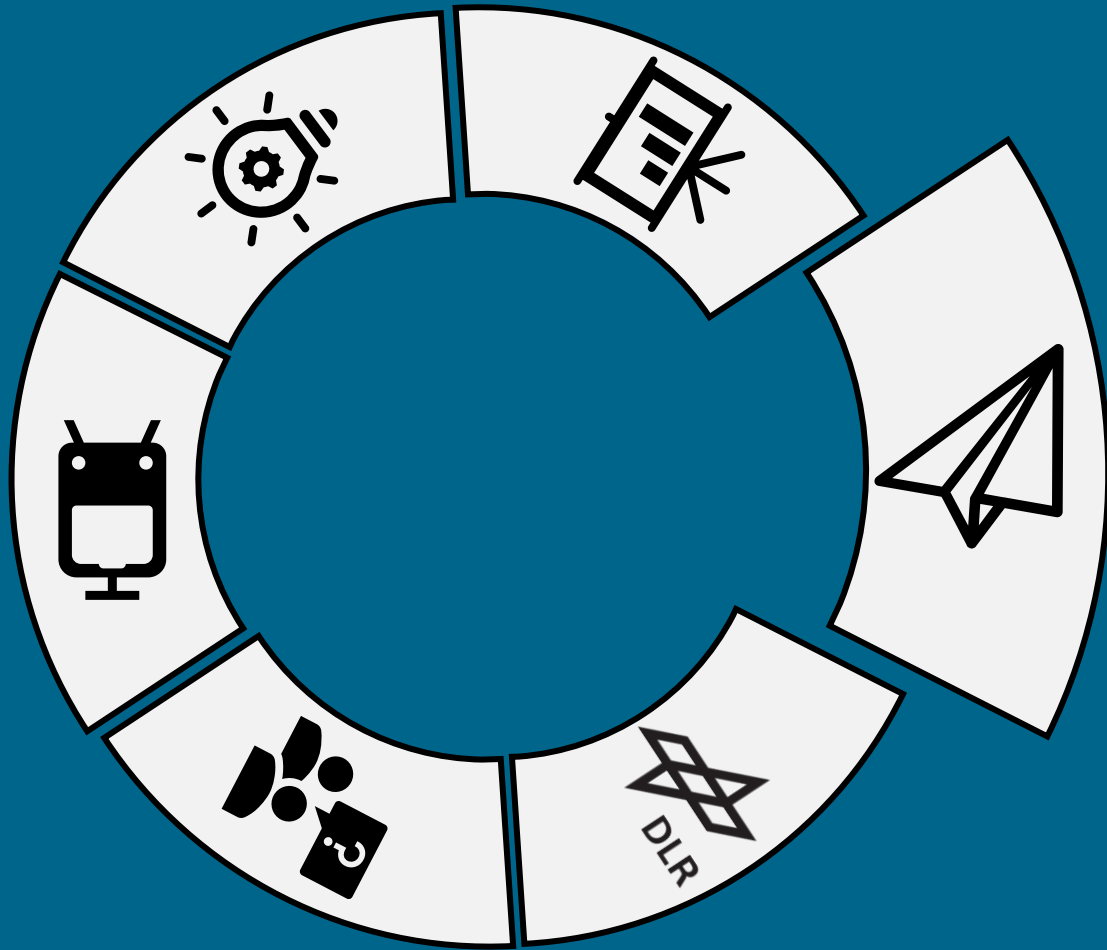


Scenarios:

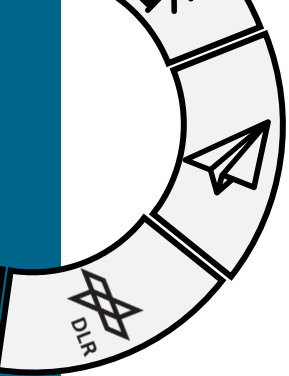
- High-speed line, Ingolstadt-Nuremberg at 320 km/h & trains meeting on open line
- High-speed line, Ingolstadt-Nuremberg at 320 km/h & two trains meeting in the middle of a tunnel
- S-curve at 400 km/h & passing the Katzenberg Tunnel
- S-curve at 400 km/h & two trains meeting in the middle of a tunnel

Results with all scenarios:





Summary and outlook



Summary and outlook



Summary

- Successful workflow
 - ✓ Simulation-based design process for metallic structure
- “Universal method” → can be applied on different models

Outlook

- Validation of the method
- Try the method with last software edition (Simpack and Optistruct compatible?)
- Verification for combination of material (composite/metal)

Thank you for your attention!
Are there any questions?

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Dr. Ing Gerhard Hippmann

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+49 711 6862-8261

