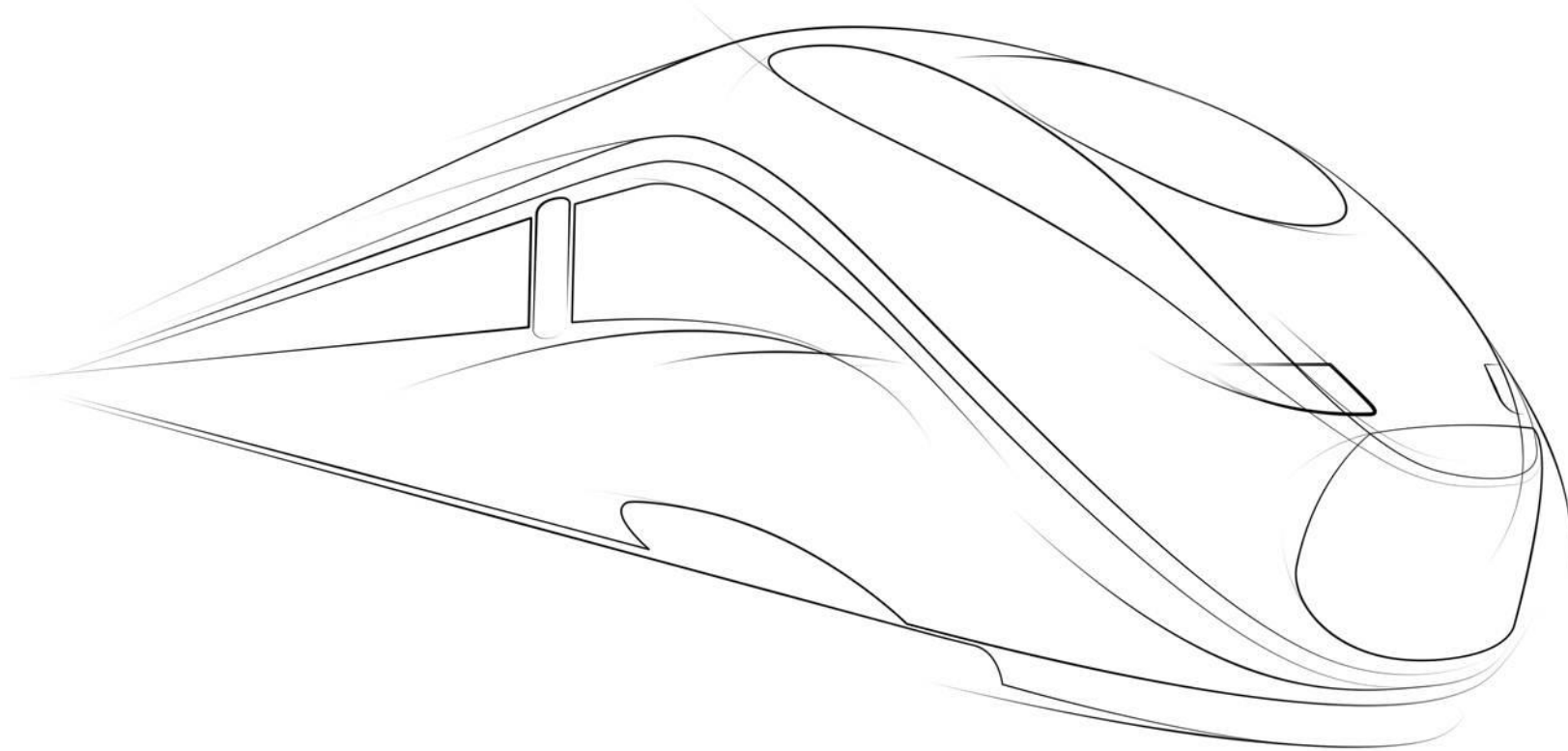


# A PASSION FOR RAILWAY SOLUTIONS



MOLINARI



**Optimization - Light weight design for rolling stock vehicles**  
**Consulting - Engineering - Analysis - Systems**

# Lightweight optimization for railway vehicles

## Benefits at a glance



MOLINARI

### Challenge

- Reduce energy consumption of rolling stock operation by reducing weight
- Maintain structural integrity and safety standards with a light weight carbody
- Optimize manufacturing process and material usage

### Your benefit

- Lightweight carbody for railway vehicle
- Carbody structure that meets standards and manufacturing requirements
- Reduced time for optimization

### Our approach

- Optimizing complete railway carbody
- Adjusted methods to deal with multiple variables beyond the software limitations
- Integration of manufacturing know-how in concept optimization

### Why Molinari

- Longstanding and strong track record
- Independent from vehicle supplier
- Skilled in working with new technology and materials
- Experienced team from concept design to detail design

# Lightweight optimization for railway vehicles

## Rationale



MOLINARI

The **weight reduction** and optimization of railway vehicles using conventional techniques has reached its limits. To achieve the **next level new approaches** already applied in the aviation industry can be used.

Weight reduction has several positive effects. Primary effects are **energy savings** and **reduced axle load**. Secondary effects can be seen in the reduction of rail damage and superstructure optimization according to the axle load.

In terms of weight distribution, a railway carriage can be divided into equipment, bogies and car body. Due to the equipment systems complexity and necessity to address the various subsystems separately and due to the bogies many and security-relevant requirements, their weight saving potential is limited.

Therefore, **car body weight optimization** becomes a **significant topic**.

For the application to the specific needs and requirements of the railway industry, **Molinari has developed a specific approach consisting of an optimization process to further optimize car bodies and structures** and the necessary **customized software tools** for effective development work, which enable us to **find the optimal solution for the forces in the given space**.

# Lightweight optimization for railway vehicles

## General Rules



MOLINARI

As a general rule, in rolling stock vehicle design the use of lightweight principles is indispensable.

The principles can be divided into:

- using of lightweight material
- function and system lightweight optimization (lightweight system configuration)
- form and shape design lightweight optimization

As specified in specific standards and directives such as DIN EN12663, EN 15227 and UIC 566, the car body is subject to various static and fatigue loads, as well as crash loads.

# Lightweight optimization for railway vehicles

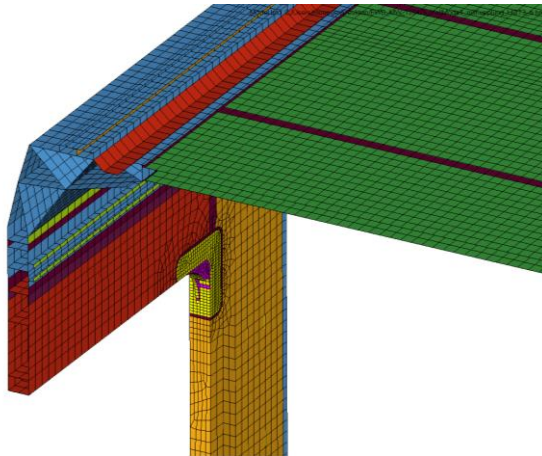
## Today's concepts



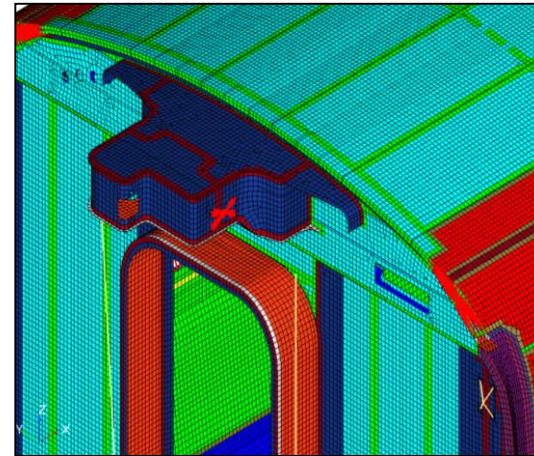
MOLINARI

Currently different concepts of car body are in use.

- Differential concept (metallic framework planked with blank sheets)
- Integral concept (locally reinforced aluminum extruded profiles welded in longitudinal direction)
- Hybrid concept (different sections uses potential of different materials)



\*Integral concept



\*Differential concept

# Lightweight optimization for railway vehicles

## Differential Optimization Process



MOLINARI

The differential body optimization process includes:

1. Space allocation model is defined and properly modelled directly in the topology optimization software
2. Boundary conditions are defined, selected loading according to the applicable standards is applied
3. Topology optimization is performed with the required constraints to reveal the main load paths meeting the criteria defined
4. Resulting topology is interpreted and translated into a framework structure
5. Size optimization is performed in order to obtain correct design dimensioning
6. Resulting framework structure is subjected to FEM analysis in order to validate the results
7. Results are used as basis for car body design development with further assistance of FEM analysis for validation

# Lightweight optimization for railway vehicles

## Integral Optimization Process



MOLINARI

The integral body optimization process includes:

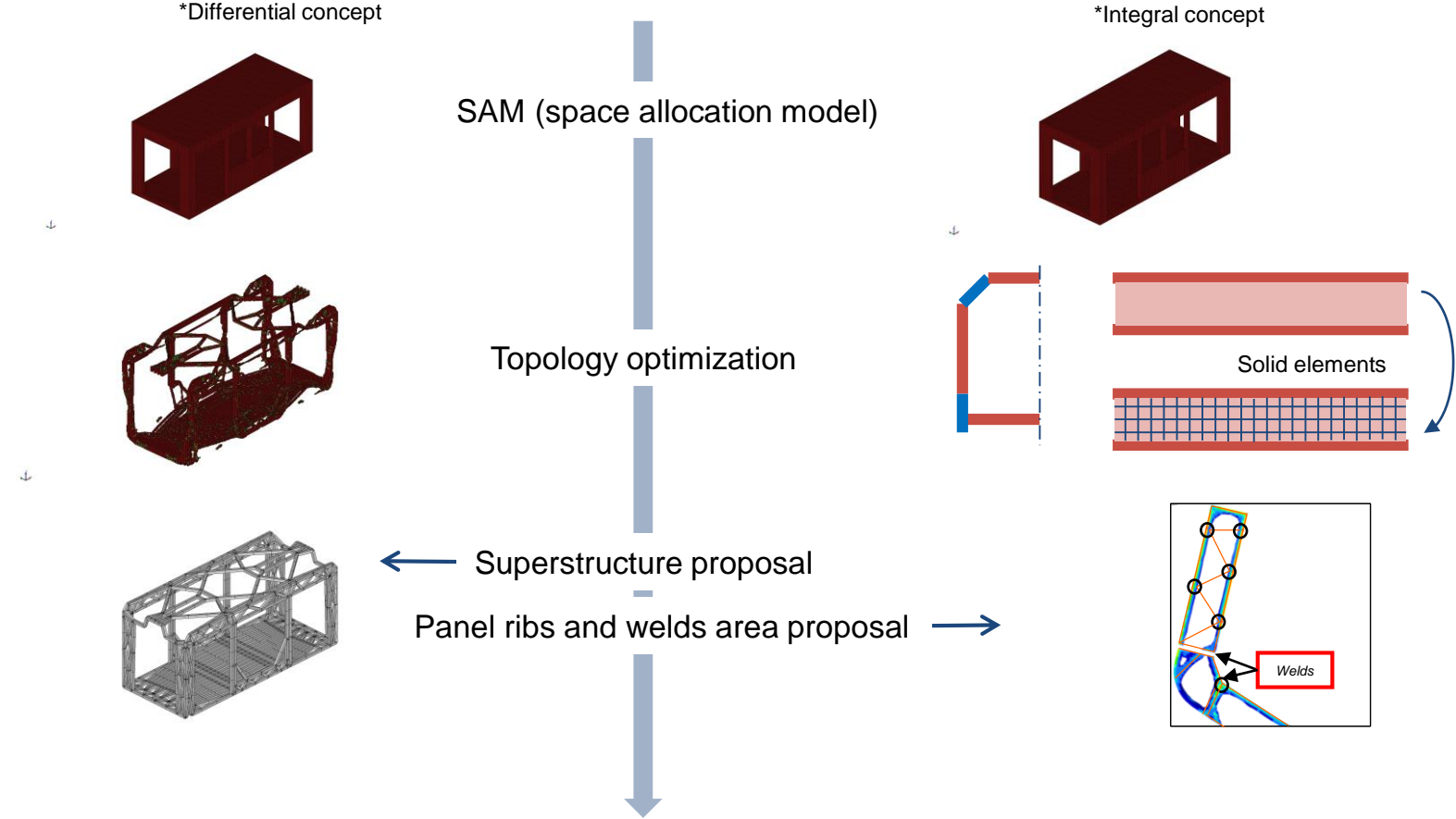
1. Space allocation model is defined and properly modelled directly in the topology optimization software
2. Boundary conditions are defined, selected loading according to the applicable standards is applied
3. Topology optimization is performed with the required constraints and in line with extruded profiles production know-how and limits, web and rib structures are revealed
4. Resulting topology is interpreted and translated into an extrusion section proposal
5. Size optimization is performed in order to obtain correct web and rib dimensioning
6. Resulting structure is subjected to FEM analysis in order to validate the results
7. Results are used as basis for car body design development with further assistance of FEM analysis for validation

# Lightweight optimization for railway vehicles

## Differential vs. integral optimization process



MOLINARI



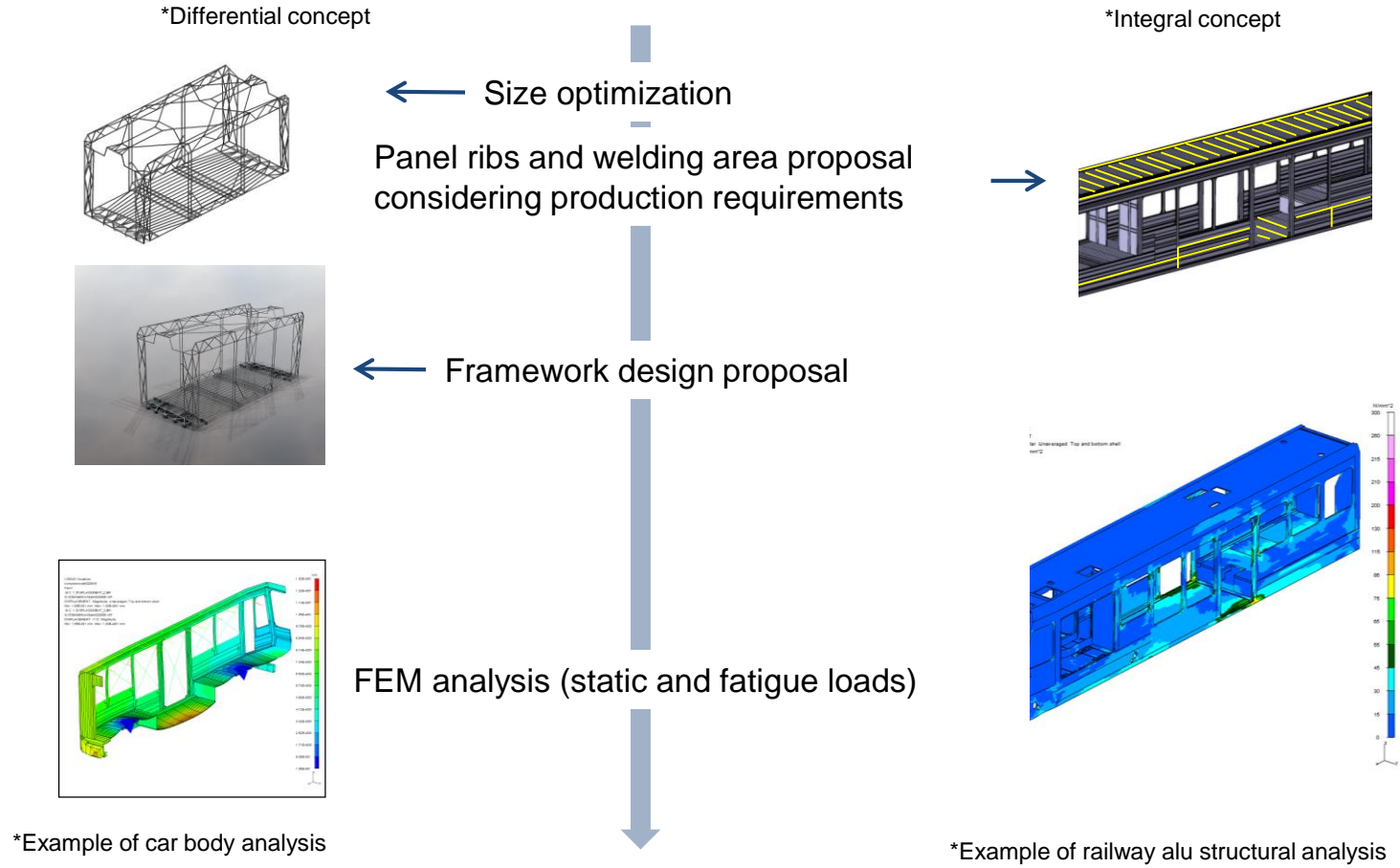


# Lightweight optimization for railway vehicles

## Differential vs. integral optimization process



MOLINARI



# Lightweight optimization for railway vehicles

## Molinari Approach



MOLINARI

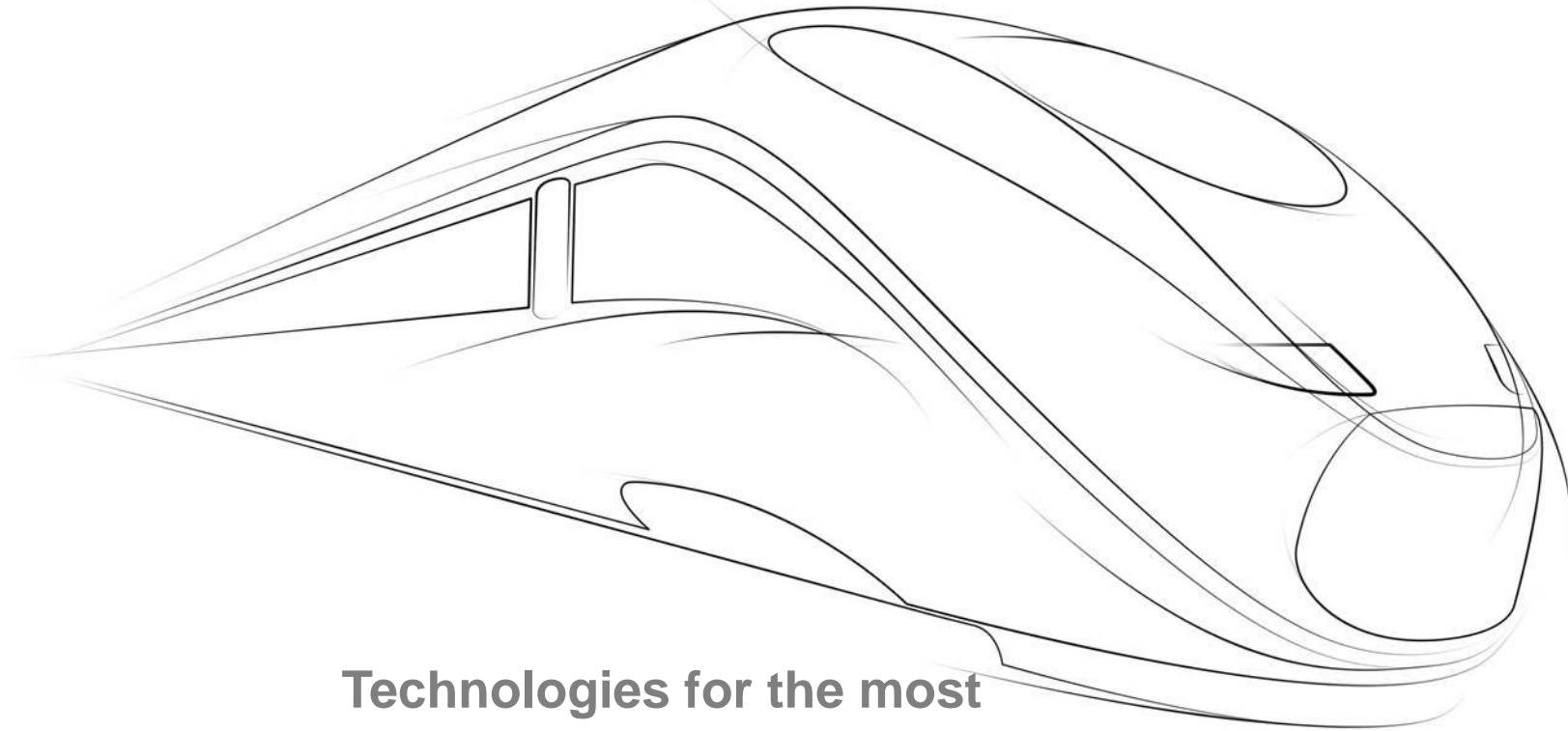
- Molinari has developed a car body optimization process using customized software tools, which can be performed on complete structures considering production requirements and using several thousand design variables
- Direct meshing method helps to substitute CAD work in early concept phases
- Timely evaluation of fatigue loads during conceptual phases allows the design to be effectively optimized during the early stages of development.
- Know how from aviation and automotive industry is transferred and used for weight optimization of rolling stock vehicles

**This method has been developed based on the extensive experience of Molinari Rail and SAS Ingenieurbüro, which is part of the Molinari Group and responsible for simulation and analysis. We are ready to discuss with you your projects and to show the benefits of our approach to cost, time and material usage. Please contact Mr. Brian Crabb at [brian.crabb@Molinari-rail.com](mailto:brian.crabb@Molinari-rail.com).**

# A PASSION FOR RAILWAY SOLUTIONS



MOLINARI



Technologies for the most  
sustainable mode of transit

**Made by Molinari**