German High Tech Champion 2012

Extreme sandwich-lightweight design with high degree of functional integration

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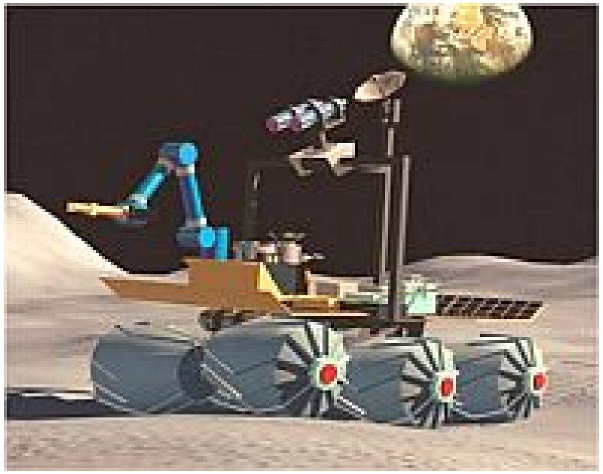
Vehicles of the German Aerospace Center

Lunar rover



Aircraft for flight testing

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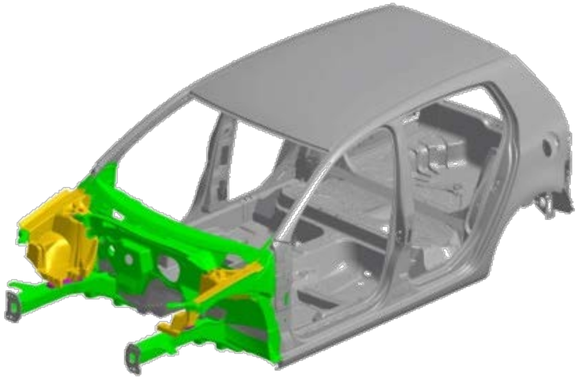
Lightweight & Hybrid Design Methods

- Development of resource-efficient, innovative vehicle concepts

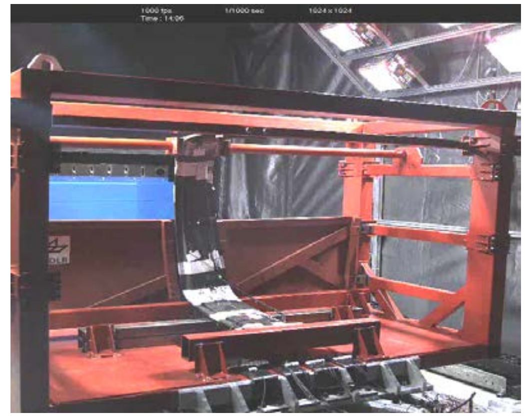


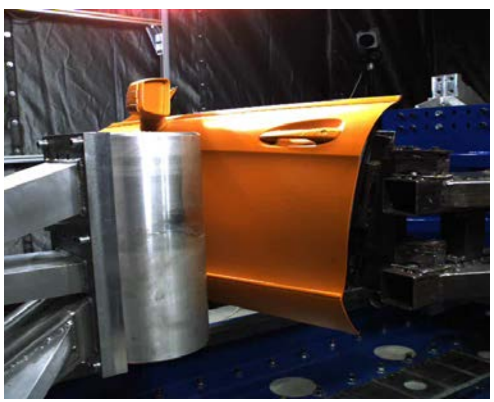
- Safe, light and cost-effective

- Adaptation to alternative drive train concepts

Lightweight & Hybrid Design Methods

Passive safety / crash simulation and testing





Motivation for lightweight design

Politics, Society / Environment und legislation

- Shortage of resources
- Climate change
- Population and mobility growth

- Decrease of consumption and emissions necessary
- Increasing demand for more efficient mobility

Source: Internet, Naisbitt

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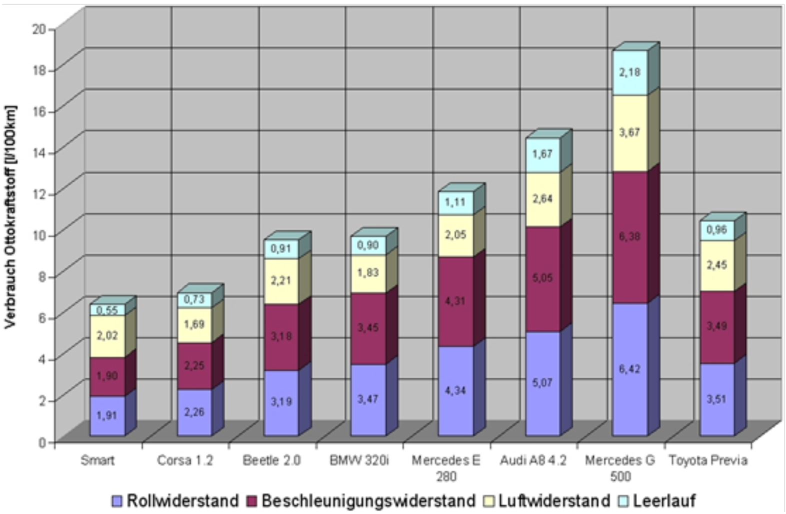
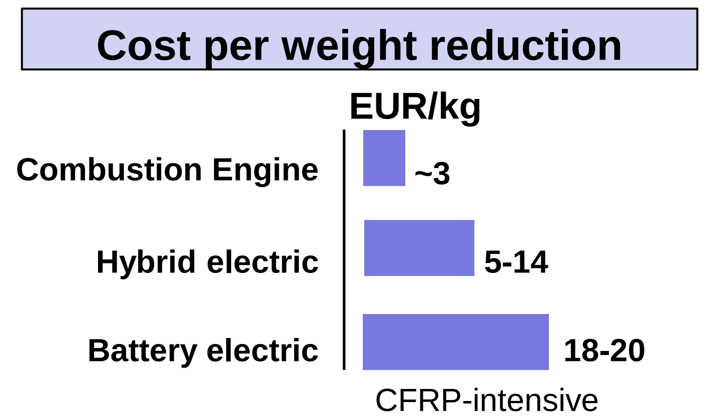
Importance of low vehicle mass



Source: Wiedemann, Jochen: Kraftfahrzeuge I



Source: based on McKinsey Study „Lightweight materials and design - a perspective across key industries“, 2012

- 2/3 of the total fuel consumption are weight-dependent
- Secondary mass reduction of the drive train and energy storage is especially important with electric vehicles

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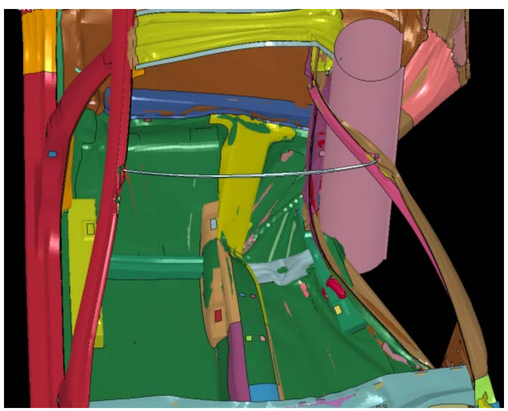
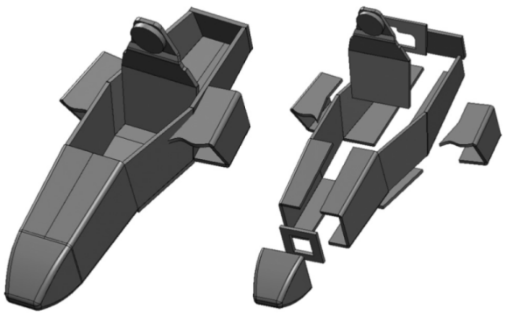
State of the art body in white construction



- Very low cost in large scale production
- Mass: around 180-250 kg for a 4 -seater
- Hollow structures, joined with spot-welds,
- Relatively complex geometry, around 200-300 parts
- High stiffness but tendency for buckling under certain load conditions

Use of sandwich parts - examples



- High stiffness, even in simply shaped parts
- Shaping of the parts is difficult
- Cost for semi-finished parts relatively high
- Crash behaviour must be examined

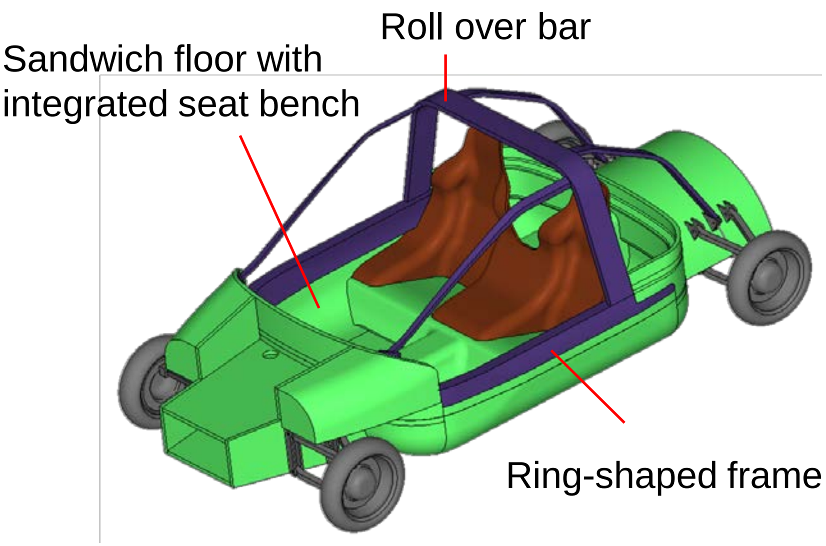
Crashbox, Schottwand und Unterboden aus *Metawell* Platten

Sources:
- H C Davies; M Bryant; M Hope; C Meiller: Design, development, and manufacture of an aluminium honeycomb sandwich panel monocoque chassis for Formula Student competition; Journal of Automobile Engineering 2011
- Metawell GmbH
- KTM Sportscar GmbH

Concept idea: Metal monocoque development

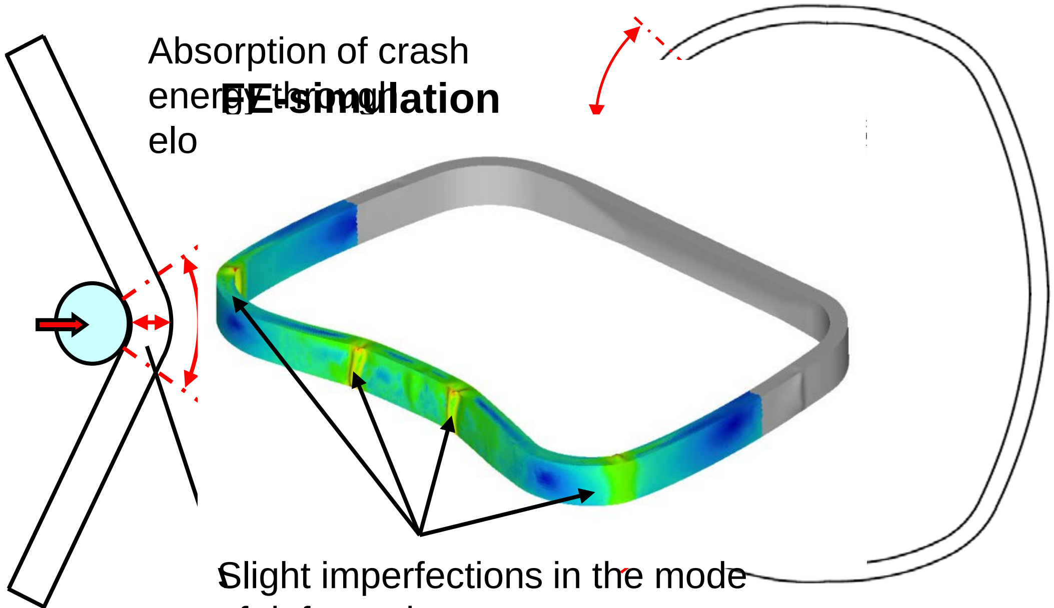
Targets:

- High crashworthiness, by use of sandwich-structures
- Low investment costs due to low number of parts
- Low initial requirements for production facilities
- Use of conventional materials (e.g. PU-foam, aluminium sheet metal)
- construction method similar to a race car
- Weight of the body in white approx. 80 kg, for a two seater



Passenger compartment structure

Mode of deformation

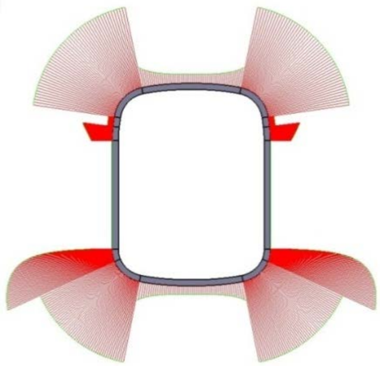


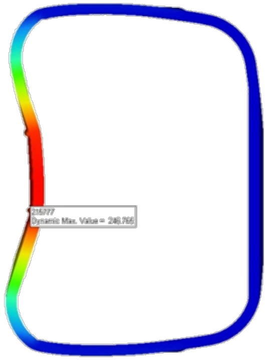
A ring-like shaped structure with a foam core should lead to comparatively low strain values, distributed over a large portion of the structure

Ring-frame optimisation

Initial design

- Mass: 23,6 kg
- Deformation under frontal load: 271 mm
- Deformation under side load: 247 mm

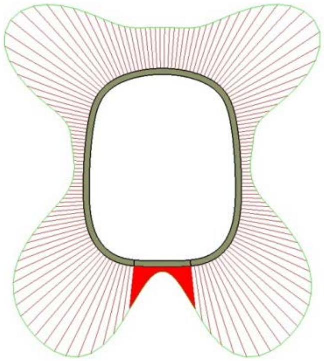


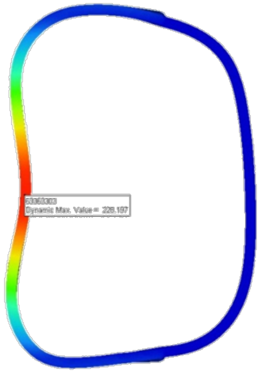


- Slight outside curvature at all locations
- Only gradual changes in curvature

Optimised design:

- Mass: 22,5 kg -4,8 %
- Deformation under frontal load: 175 mm -35,3 %
- Deformation under side load: 228 mm -7,6 %





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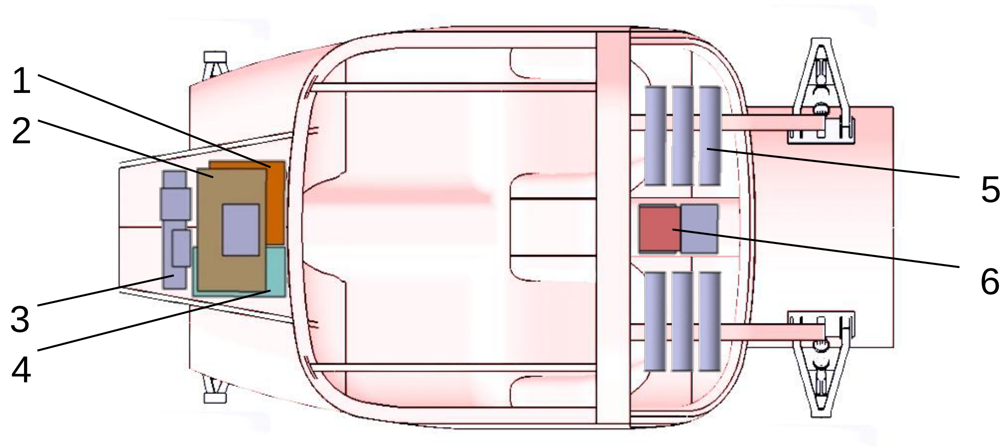
Crash-Simulation - EURO-NCAP-pole-crash

- Good overall crash behaviour under highly concentrated loads (29 km/h, pole diameter 254 mm)
- Lower intrusion than with a conventional structure, no collapse

Components for a fuel cell drive train



Body in white - top view

1 Fuel cell stacks

2 Fuel cell control module

3 Cooling module

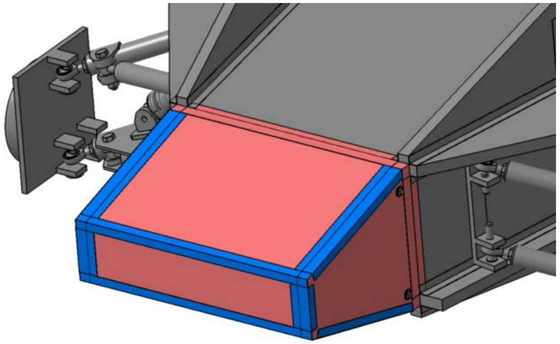
4 Air supply module

5 H_2-storage

6 Battery

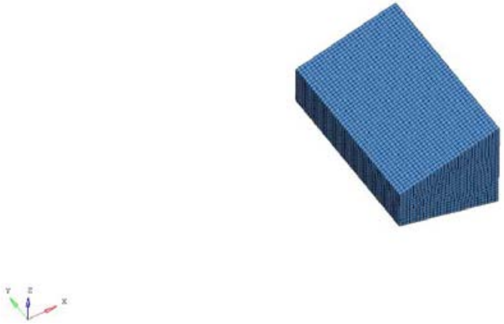
- Mass of drive train components depends on vehicle mass
  → secondary effects of body weight reduction
- Energy storage difficult in alternative drive train concepts
  → high importance of secondary weight reduction

Crashbox for AZT-testing



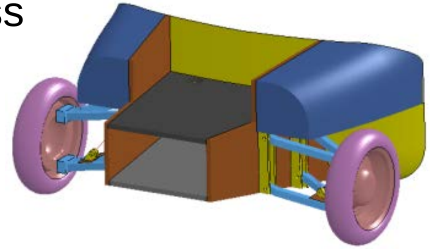
- Testing formalities:
    - Velocity: 15 +1/-0 km/h
    - 40% overlap

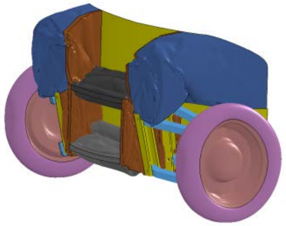
- Comparison 100% and 40% overlap:



Vehicle front structure

- Novel sandwich architecture related to automotive front structures
- Static stability (sub-frame connection)
- High safety for passengers
- Good-natured failure mechanism of the front structure
- High degree of functional integration
    - suspension/ sub-frame
    - components
    - crash performance
- Closed structures (sandwich panels)
- Segmentation of the front structure (central crashbox and sidewise structures)
- Integrated inserts in fabrication process
- Little geometrical complexity





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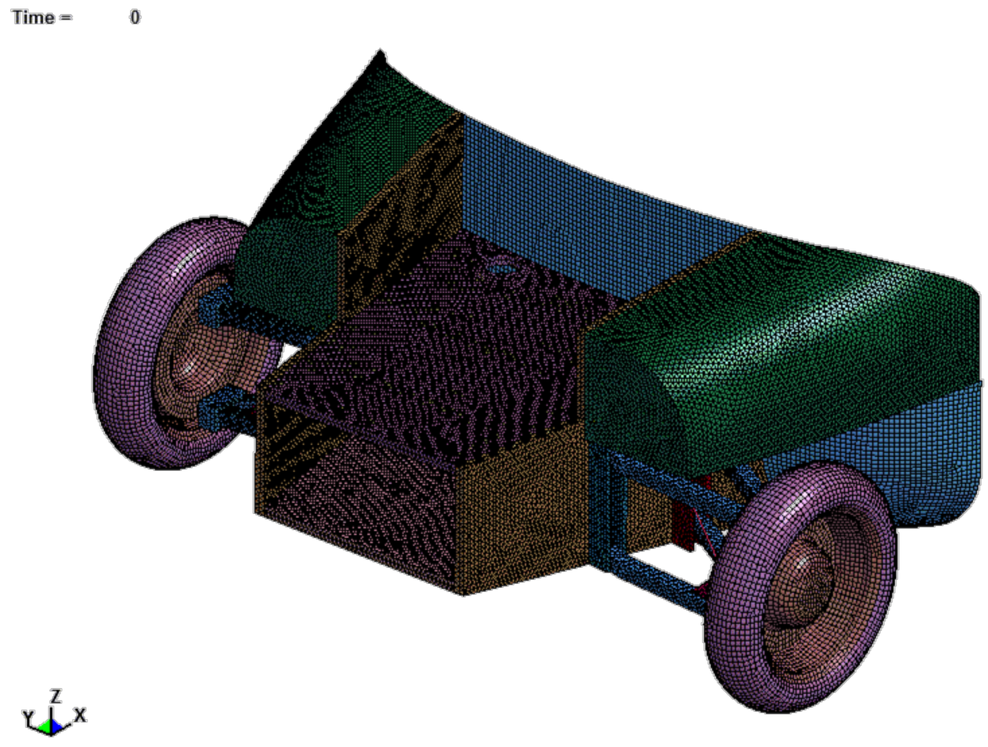
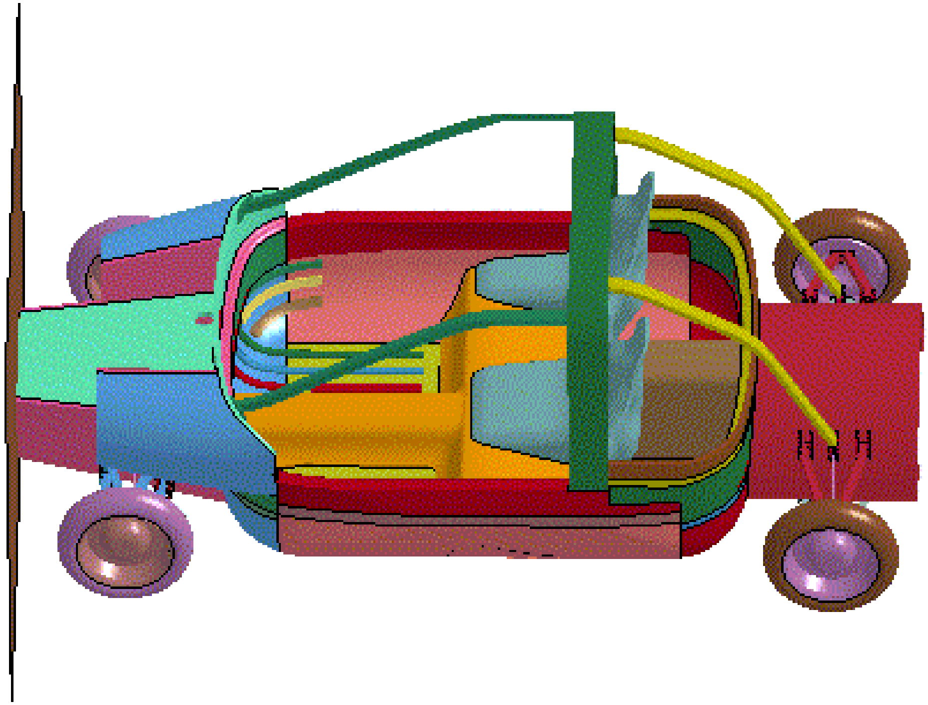
Vehicle front structure



Crash-Simulation - US-NCAP front crash



- 56 km/h
- Rigid barrier

- Damage tolerant crash-behaviour, even when overloaded, little tendency for catastrophic collapse

Summary and overview

- Implementation of an overall sandwich car body concept
- Low mass (80 kg)
- High degree of functional integration
- First successful execution of numeric simulation
    - US-NCAP frontal
    - Pole-crash
    - Component test
- Good-natured failure mechanism

Challenges

- Validation of assembly concept
- Validation of the suspension concept
- Crash testing on the dynamic component testing facility
- Validation of assumpted framework conditions in simulation
  - Material behaviour
  - Numerical settings
- Manufacturing concept (prototype and small series)

Future prospects

- Design of the external shell
- Driveable demonstrator
- Crash testing (components and complete car body)
- Shape and topography optimization
- Aerodynamic investigation (with partners)
- Investigations of structures with high fatigue strength
- Investigations in additional crash scenarios
- Systematic examination of crash behaviour of sandwich structures

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Thank you for your attention!

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