POSSIBILITIES FOR THE USE OF METAL-HYBRID-STRUCTURES FOR VEHICLE CRASH LOAD CASES

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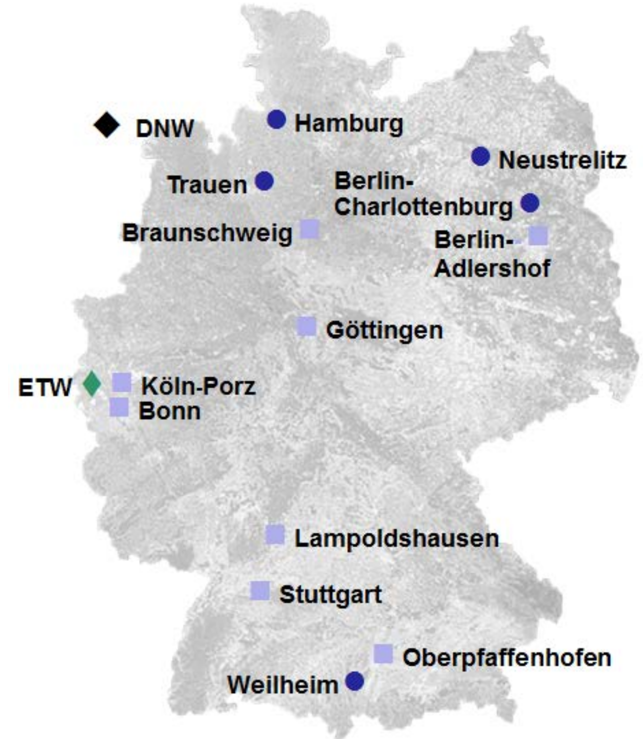
- Introduction of the institute of vehicle concepts
- Motivation and basic principle
- Simulation and Optimisation
- Possible applications

DLR – Overview

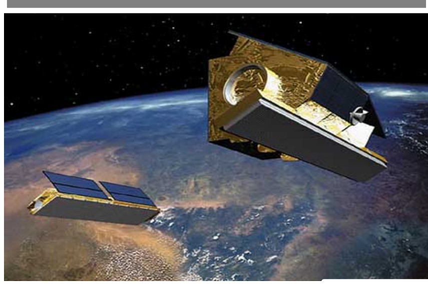
DLR's mission:

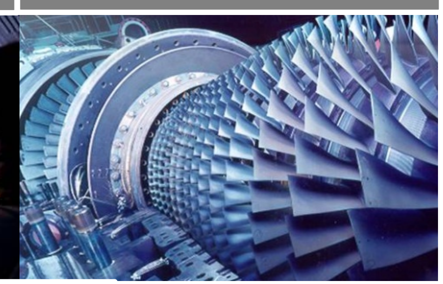
- exploration of the Earth and the solar system
- research aimed at protecting the environment
- development of environmentally-friendly technologies to promote mobility, communication and security.

7.700 employee are working at 32 research institutes and facilities in ■ 9 locations and ● 7 branch offices.



SPACE	AERONAUTICS	TRANSPORT	ENERGY



SECURITY

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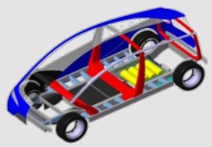
The departments of the Institute - FK

1. **Vehicle systems and technology assessment**
2. **Vehicle energy concepts**
3. **Alternative energy conversion**
4. **Lightweight and hybrid design methods**



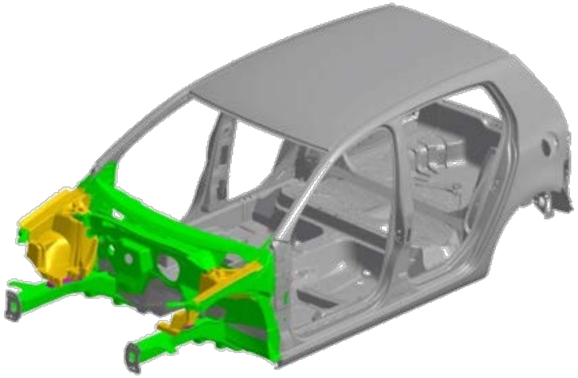
Innovative vehicle concepts for road and rail

FK designs and demonstrates innovations for the vehicle concepts and technologies of future compliant transport systems

DLR Institute of Vehicle Concepts

Lightweight & Hybrid Design Methods

- Development of resource-efficient, innovative vehicle concepts

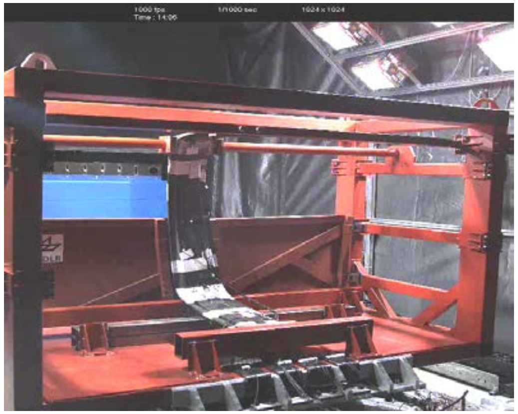


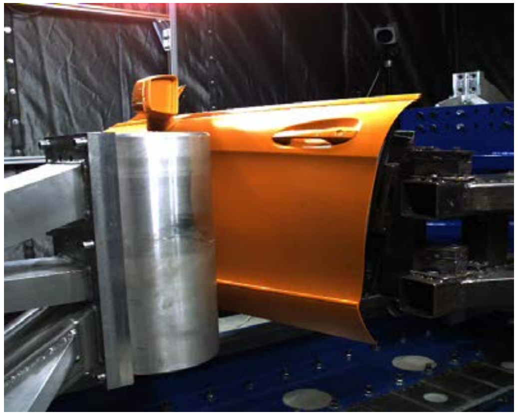
- Safe, light and cost-effective

- Adaptation to alternative drive train concepts

Lightweight & Hybrid Design Methods

Passive safety / crash simulation and testing





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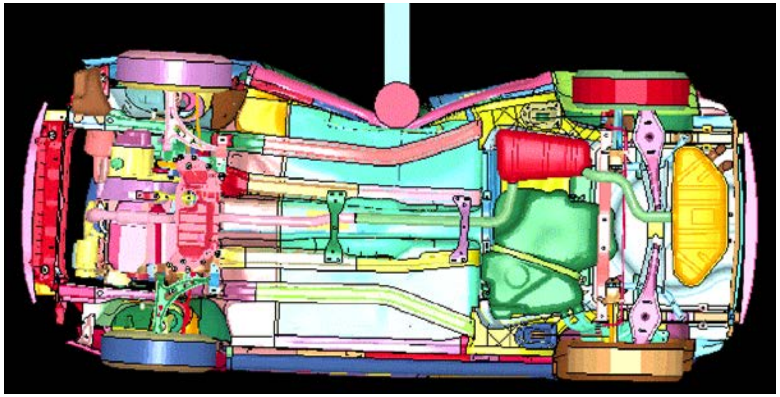
Motivation

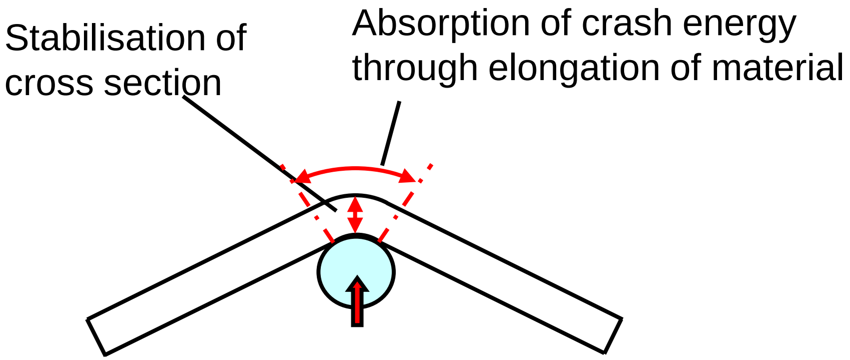


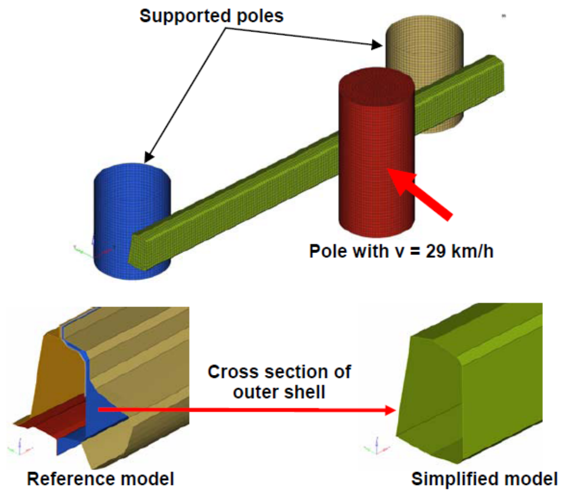
floor structure developed by DLR during SLC-project

Hollow beam made of DC 04

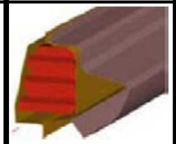
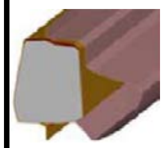
- Collapse of the rocker‘s and side piece‘s cross-section during pole-crash -> energy must be absorbed by various other components
- A stabilisation of the cross-section during bending should lead to a much higher weight specific energy-absorption of the rocker -> higher freedom of design and choice of materials for the surrounding structures, like the floor panels -> possibility of an overall weight reduction
- The storage of critical components like Li-Ion batteries in the underbody requires a low intrusion
- Demand for a simple, lightweight concept made of relatively cheap materials, adaptable to different kinds of vehicle concepts

Basic principle

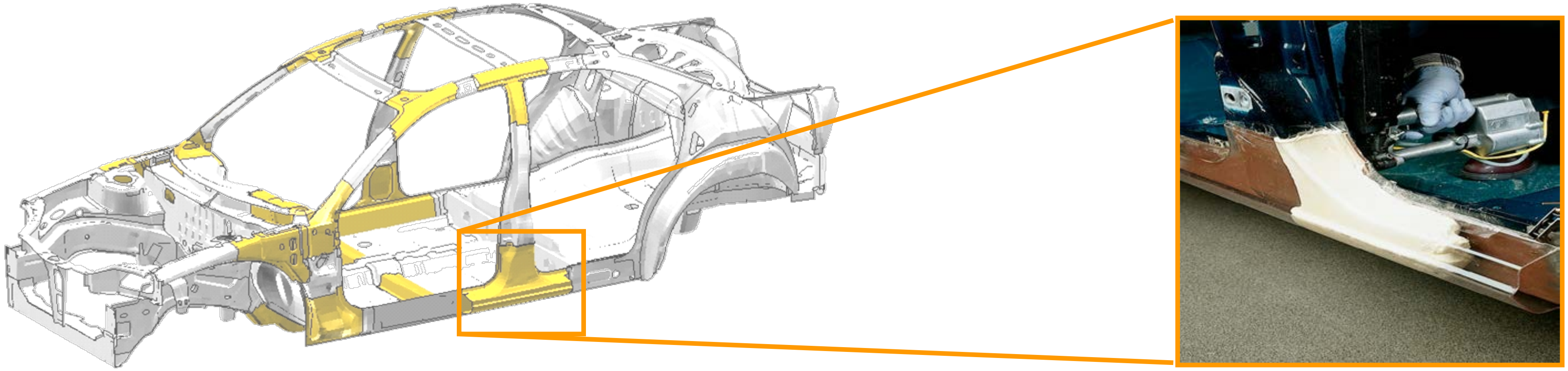




- Stabilisation of the beam by a core structure
- The core must stay intact, throughout the entire bending process, in order to increase weight specific energy absorption
- Simplified LS-Dyna-calculations showed an increase in weight specific energy absorption by a factor of about 2,5

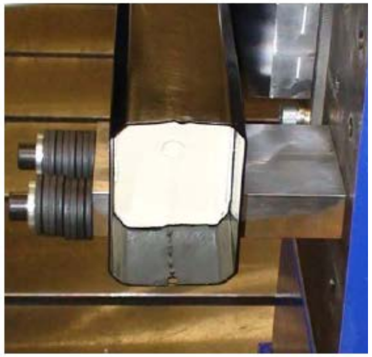
Variant	Drawing	Total mass [kg]	Material	Energy absorption [kJ]	kJ/kg
Reference		22,39	Various types of steel	4,5	0,2
Al honeycomb		15,15	Core: 1 mm Al; shell: 1 mm TRIPLEX	5,8	0,38
Foam		28,1	Core: foam 400 kg/m^3; shell: 1 mm TRIPLEX	14	0,5

Cavity filling with BETAFOAM™

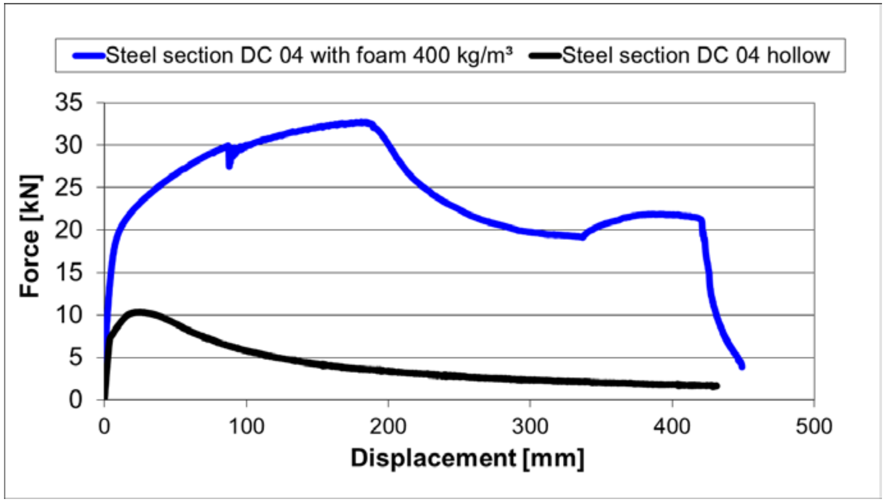


- BETAFOAM™ is a family of foam-based products
  - Two-component polyurethane foam applied as bulk
  - Fast cycle time, room temperature curing
  - Components form a rigid, closed cell foam
- Foam products range in density from 30 g/l to 400 g/l
- Higher density foams provide multi-functional benefits

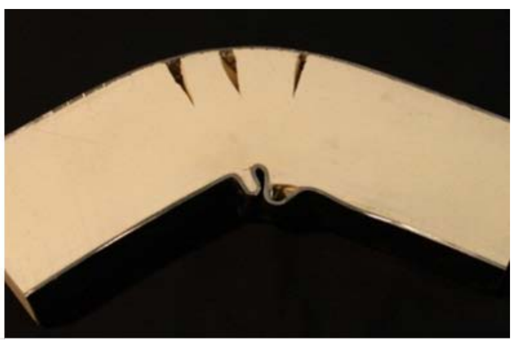
Testing performed in cooperation with DOW



DC 04 - beam filled with foam by the DOW Chemical Company
density 400 kg/m³ -> weight increase by a factor of 1,72 compared to hollow beam



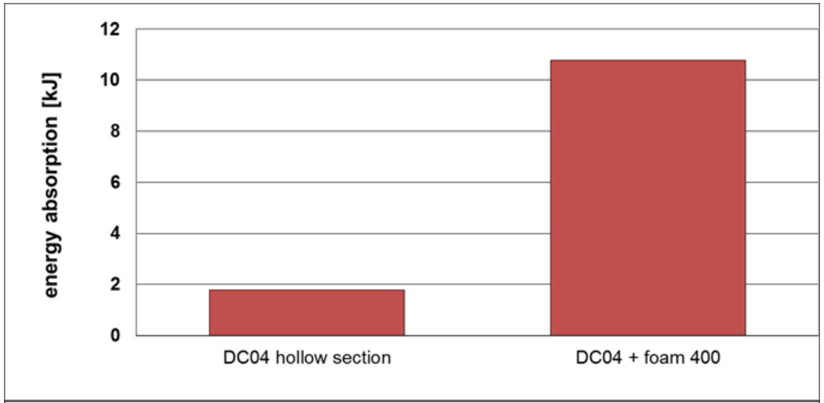
hollow beam 12,35 kg

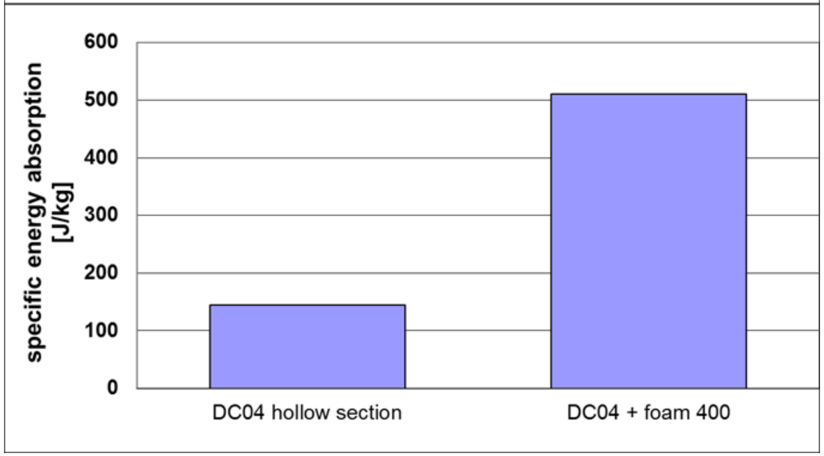


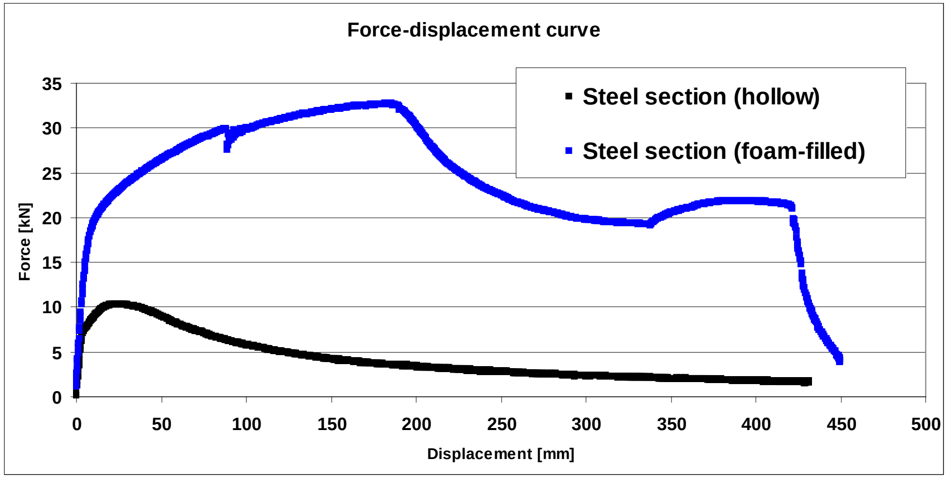
foam filled beam 21,15 kg

- 3- point bending test, distance between supports: 1300 mm
- Cross section of the beam: 128 x 90 mm
- Diameter of the pole: 300 mm
- Energy absorption = force at the pole x displacement of the pole

Testing performed in cooperation with DOW (2)

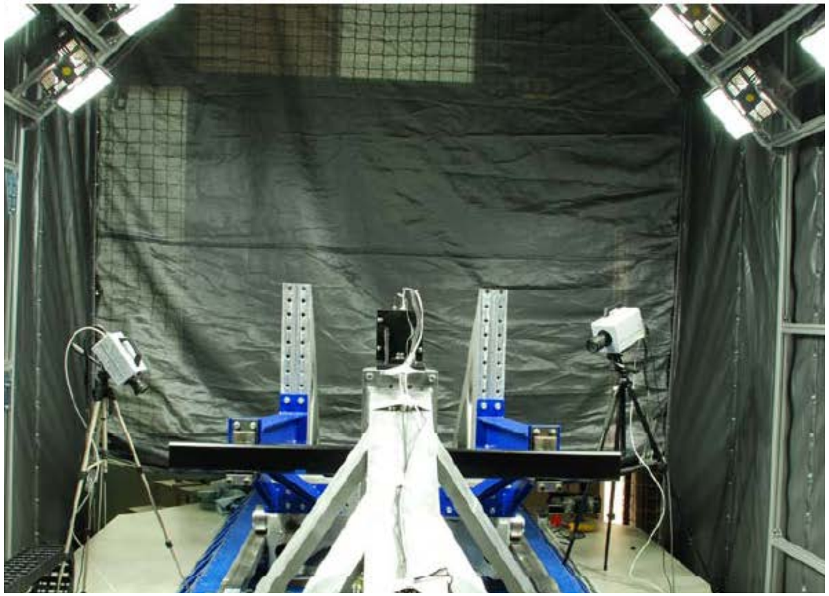


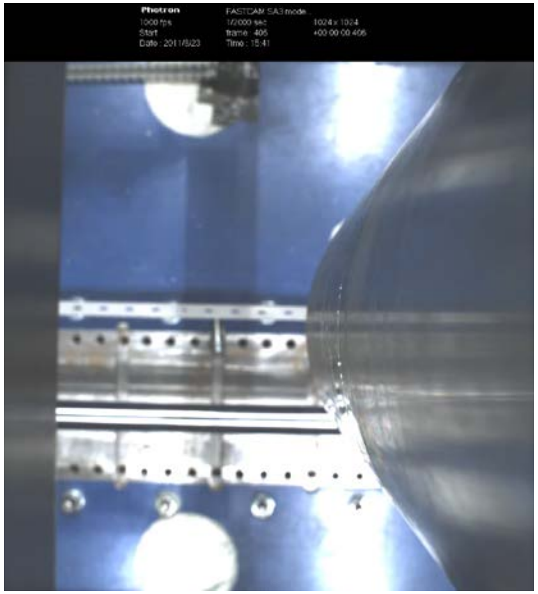


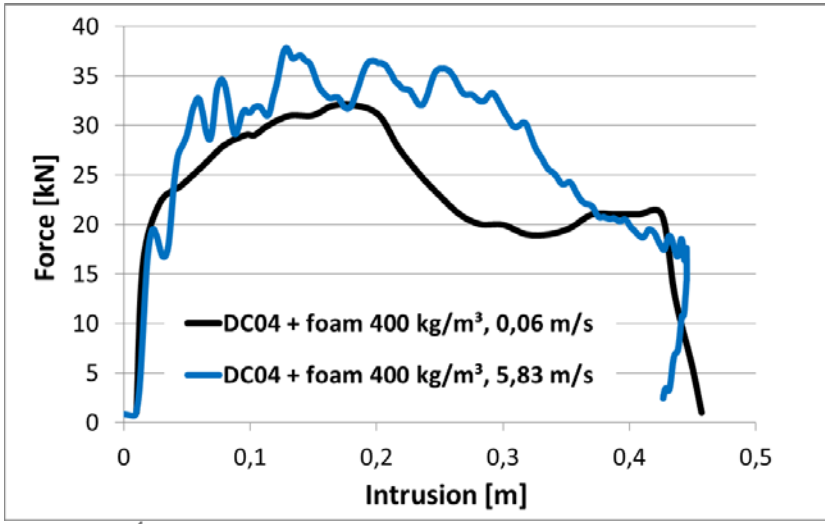


- Increase of the energy absorption by a factor of 6
- Increase of the weight specific energy absorption by a factor of 3

Dynamic Testing







- Dynamic testing results in a slightly higher force level

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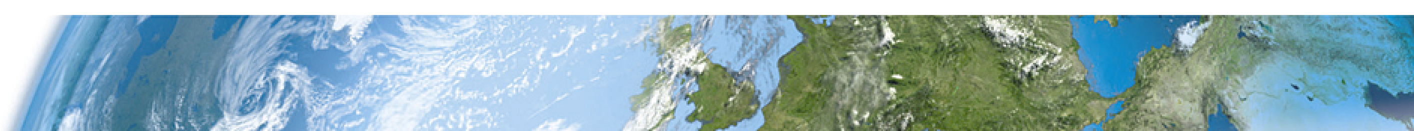
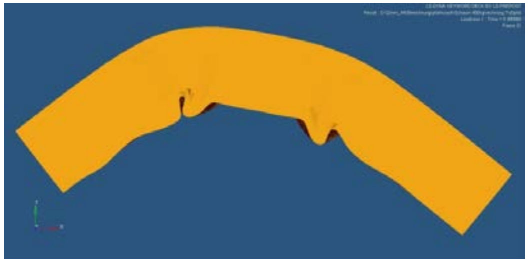
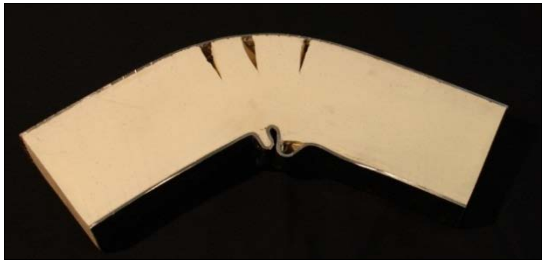
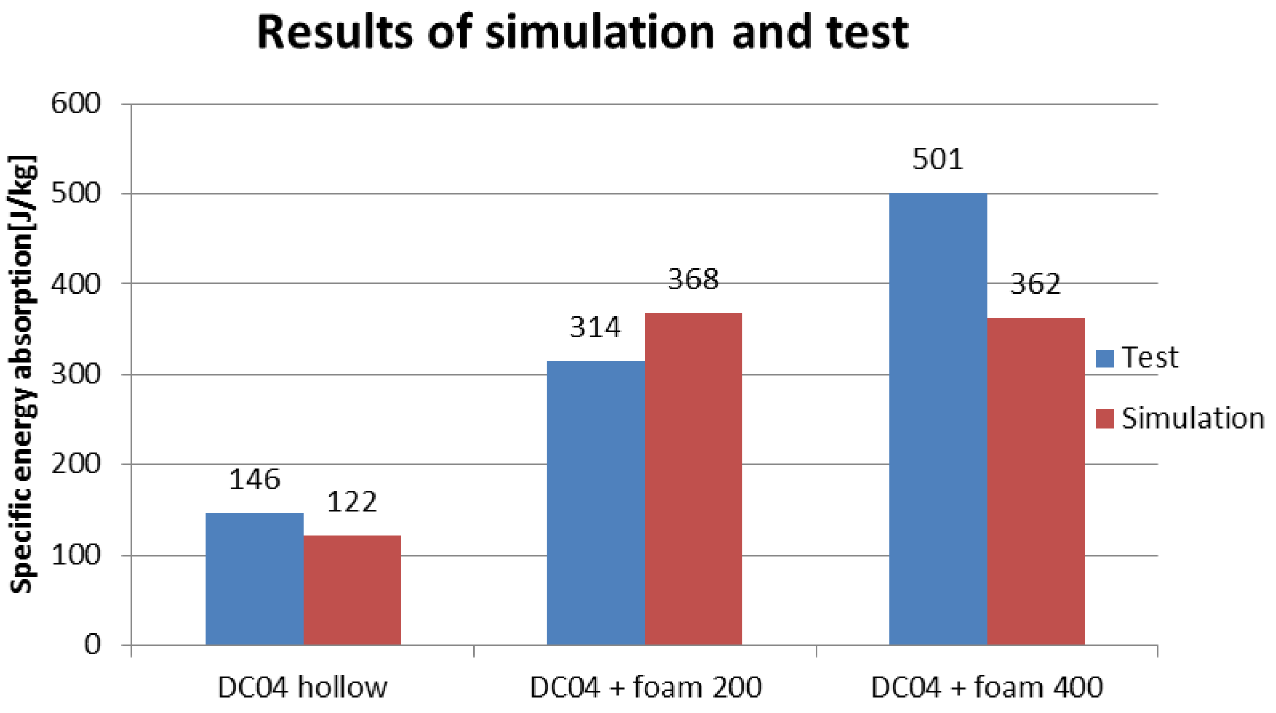


Simulation and test

Foam density [kg/m³]	Simulation	Test
200		
400		

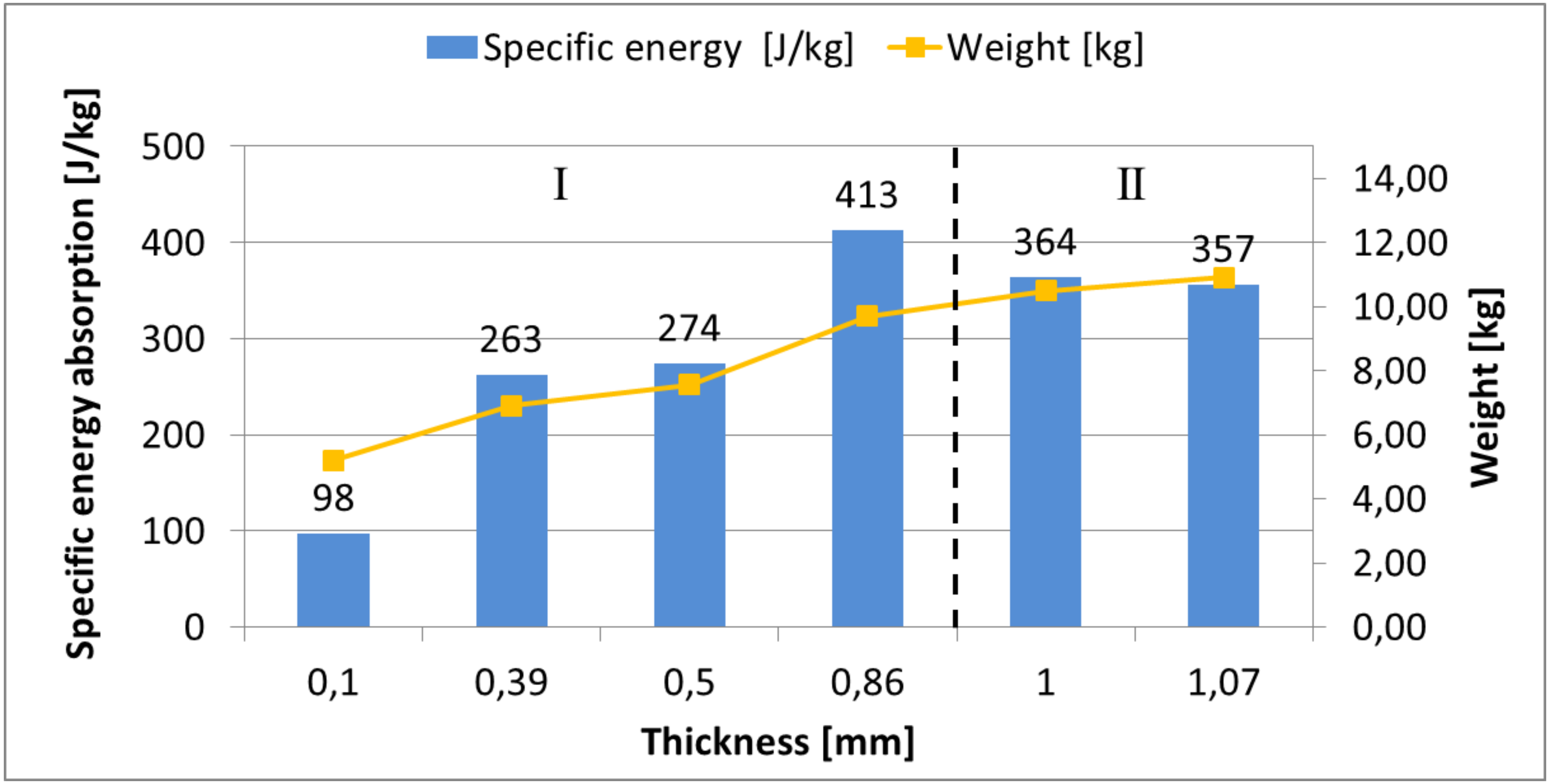
- A reduction of the core density leads to a deeper fold in the outer wall
- The tendency for folding of the outer wall can be predicted
- There are visible differences in the mode of deformation

Simulation and test



- Influence of the foam density is lower in simulation

Influence of wall thickness



- Constant foam density of 200 kg/m³
- Increasing wall thickness -> reversal point at 0,86 mm

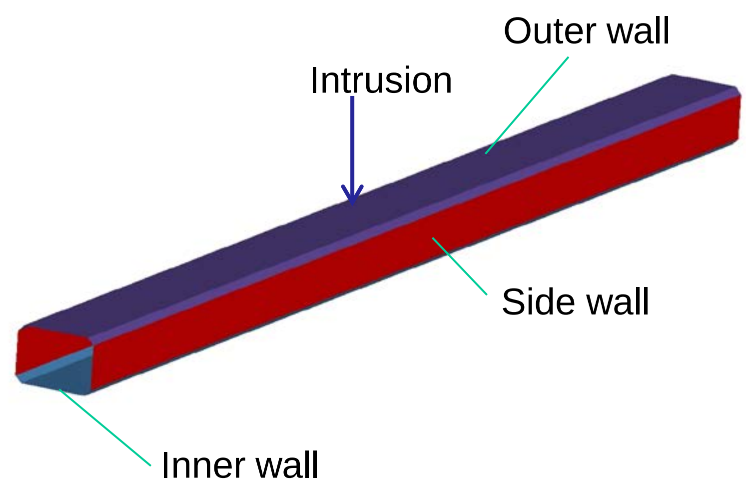
Possibilities for optimisation

Goals:

- Further increase of weight specifc energy absorption
- Reduction of the weight of the core

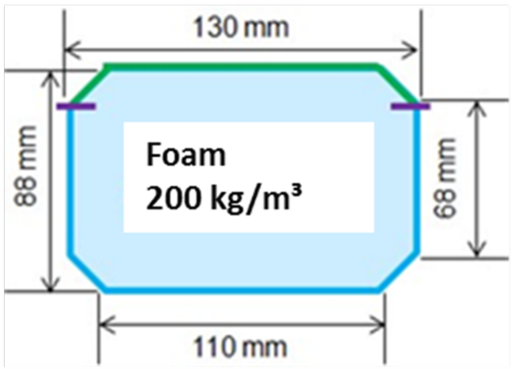
Strategies:

- Variation of the outer wall, side walls and inner wall of the beam regarding:
    - Material
    - Wall thickness

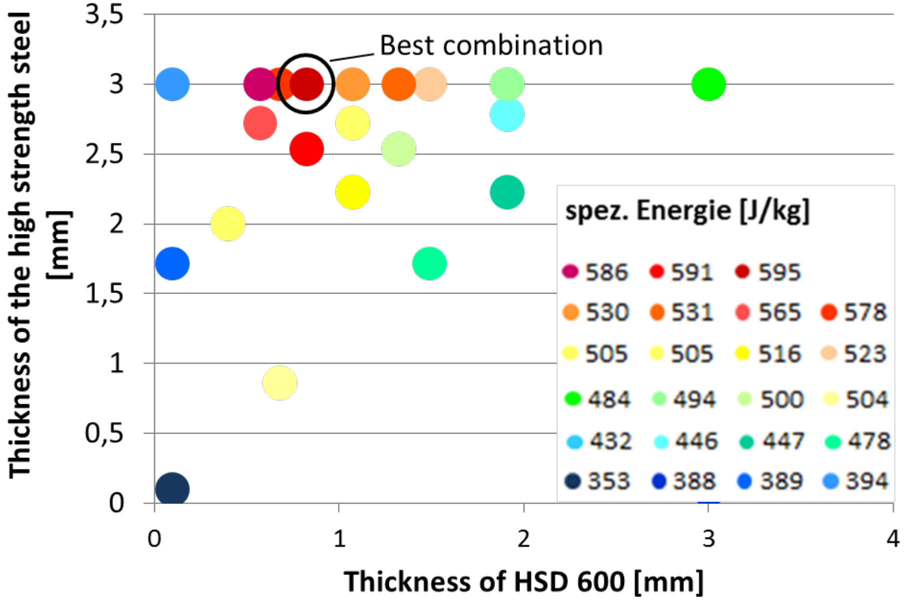


Possibilities for optimisation (2)

High strength steel, Rp_{02}= 1300 MPa



HSD® 600



- Constant foam density of 200 kg/m³
- Variation of the wall thickness of the outer and inner wall from 0.1 mm to 3 mm
- Optimisation of both parameters at the same time, with LS-Opt

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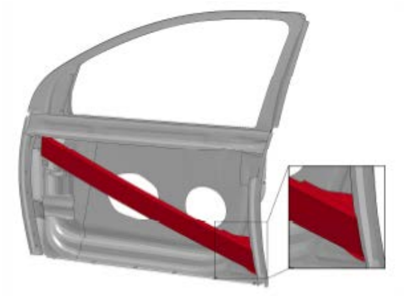
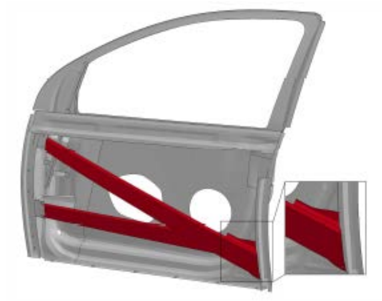
Development of a door side intrusion beam



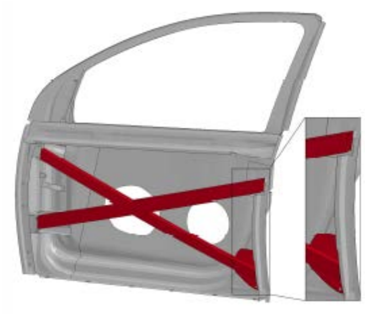
Variant 1

Beam from the hinge to the B-pillar



Variant 2

Y-shaped beams from the hinges to the B-pillar

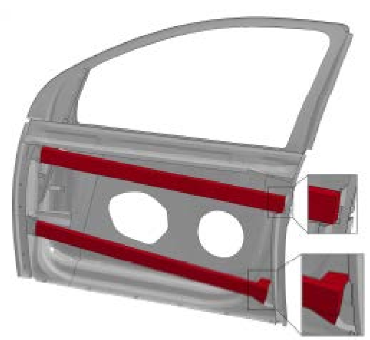


Variant 3

X-shaped beams from the hinges to the B-pillar and lock

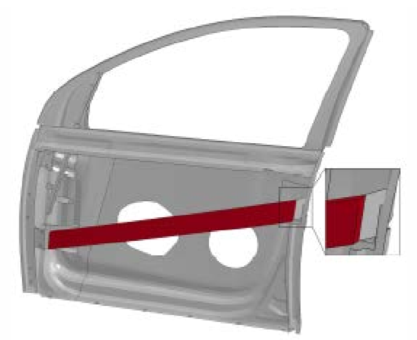
Variant 4

Y-shaped beams from the hinges to the lock



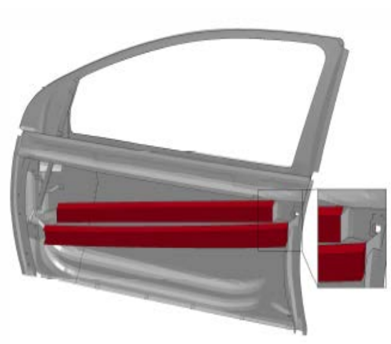
Variant 5

Two beams



Variant 6

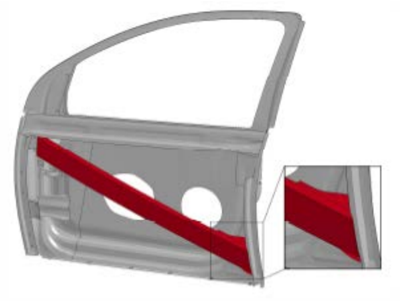
Beam from the lower hinge to the lock



Variant 7

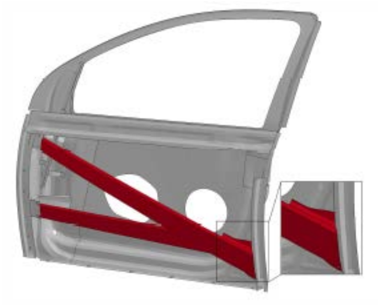
Double beam from the lower hinge to the lock

Development of a door side intrusion beam



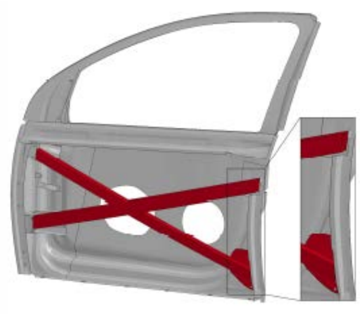
Variant 1

Beam from the hinge to the B-pillar



Variant 2

Y-shaped beams from the hinges to the B-pillar



Variant 3

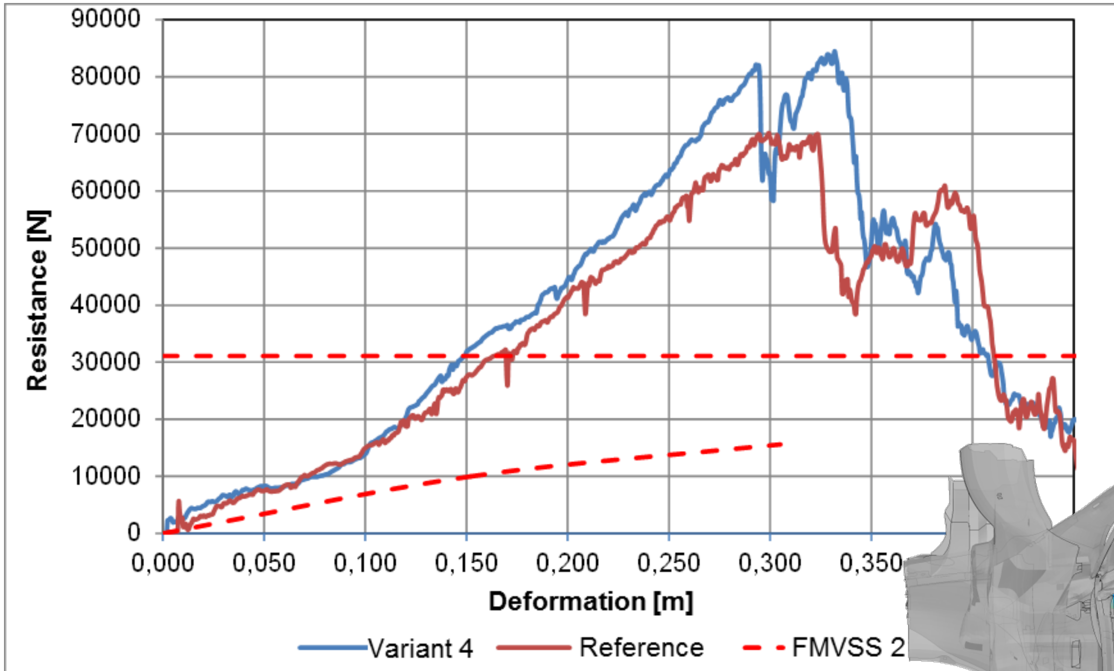
X-shaped beams from the hinges to the B-pillar and lock

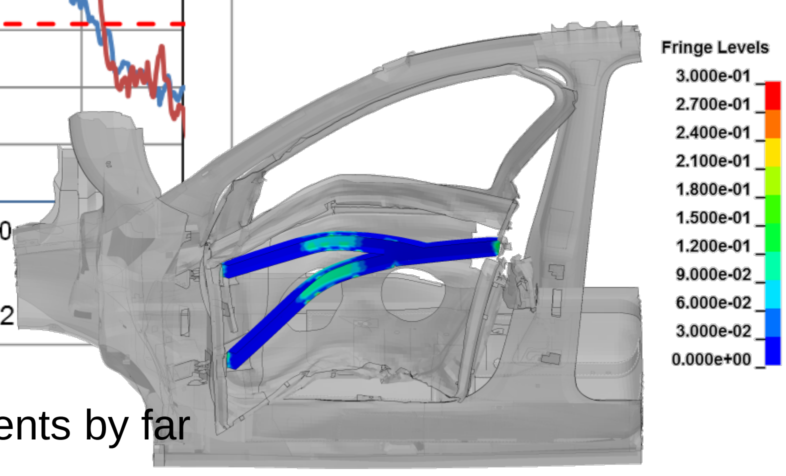
Variant 4

Y-shaped beams from the hinges to the lock

Best ratio of performance to weight

Development of a door side intrusion beam (3)

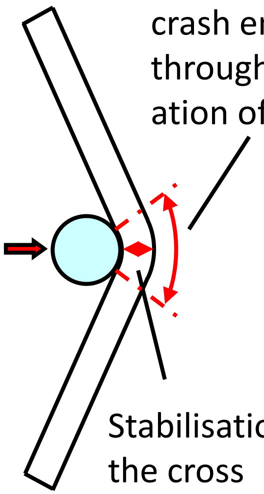




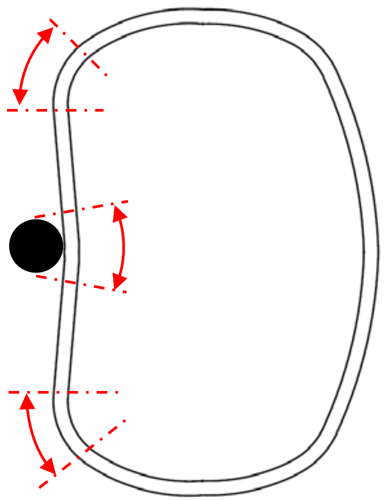
- Deformation behaviour exceeds the requirements by far
- Energy absorption 10 % higher than the reference
- Weight of the side intrusion beam reduced from 2 to 1 kg

Development of a ring-shaped frame for a lightweight car body

Absorption of crash energy through elong-ation of material



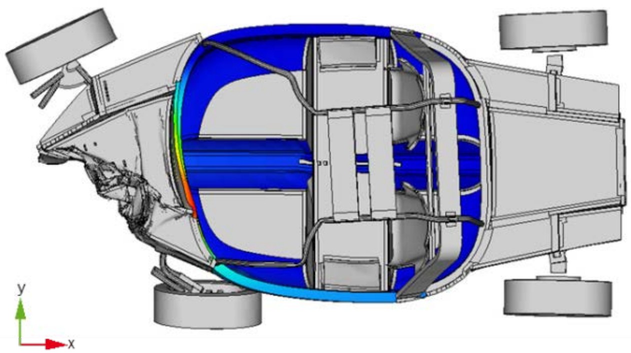
Stabilisation of the cross section



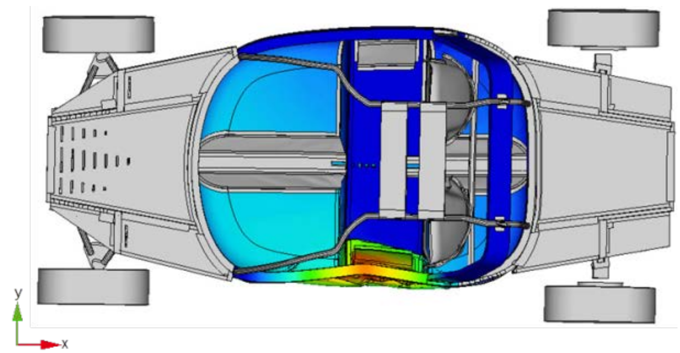
A-ring shaped structure should lead to an even better distribution of plastic strain

Application:
Ring-shaped frame of a lightweight vehicle concept
(metal-monocoque structure)

Simulation of crash tests

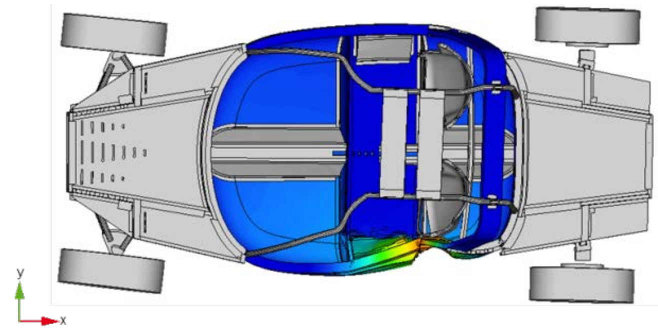


Euro-NCAP 40% overlap, offset deformable barrier



Euro-NCAP side impact

Intrusion		
Crashtest	Reference	Metal monocoque [mm]
Euro-NCAP front ODB	84	102
Euro-NCAP side impact	211	155
Euro-NCAP pole impact	381	207



Euro-NCAP pole impact

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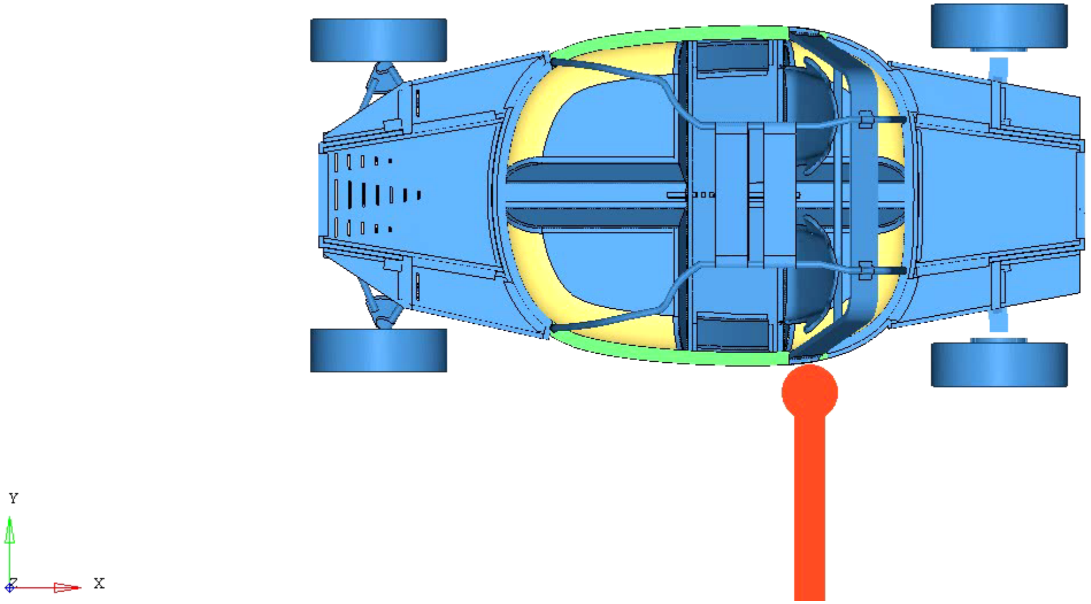
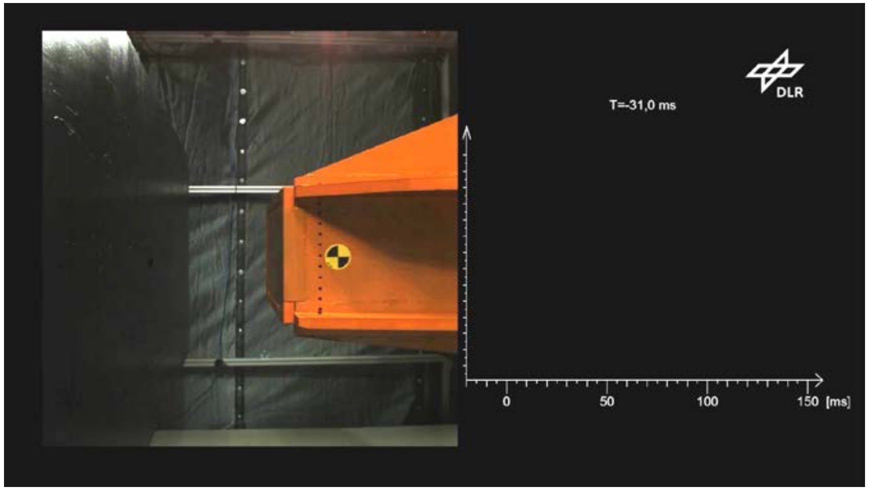
Euro-NCAP polecrash



Testing of components: Sandwich front structure



- Weight of the front structure: 12 kg
- Integration of various functions in one part:
  - Loads from the chassis
  - Support for various drive-train components
  - Energy absorption in frontal crash load cases

- Relatively uniform force-deformation-curve
- Regular folding of the aluminium layers

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Thank you for your attention!