Lightweight Design: Construction Methods and Vehicle Concepts

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DLR

Agenda

I. DLR

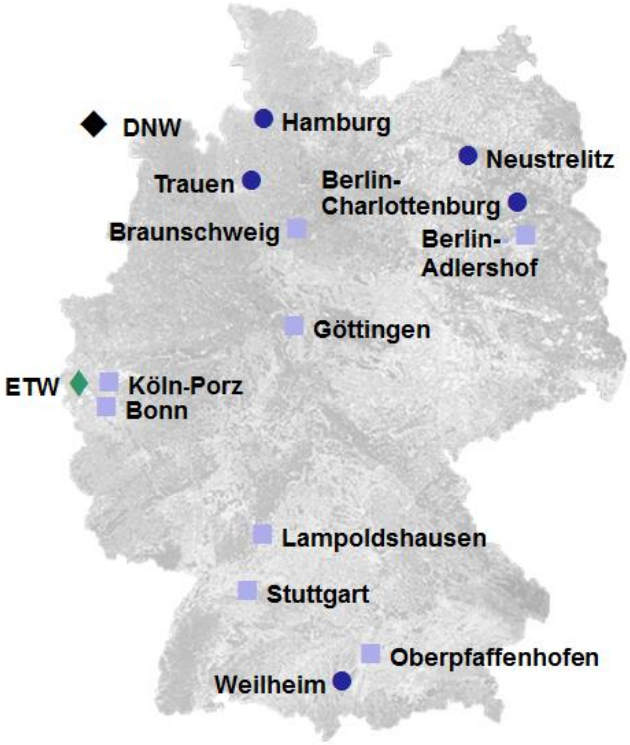
1. The growing importance of lightweight design
2. Methodical approach in the development process
3. Lightweight design strategies
4. Concepts for current and future cars
5. Summary

DLR – German Aerospace Center

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

Source: DLR

DLR – German Aerospace Center

Institute of Vehicle Concepts:

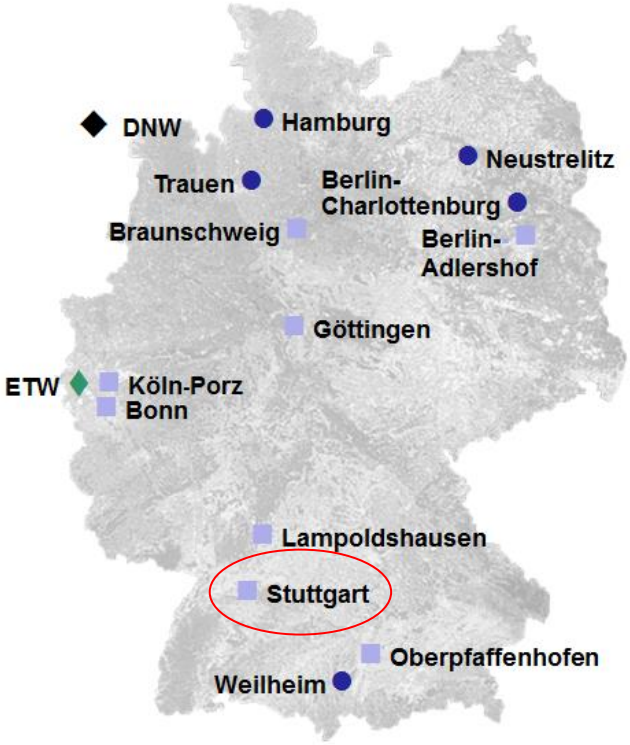
- 72 employee

Vehicle systems and technology assessment

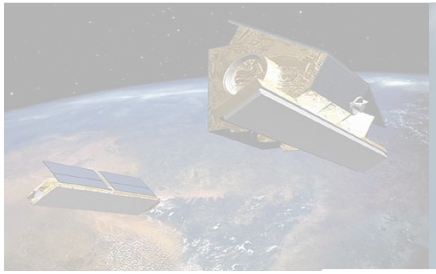
Vehicle energy concepts

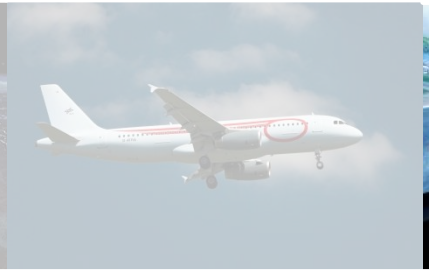
Alternative energy conversion

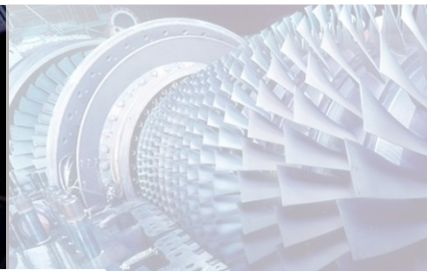
Lightweight and hybrid construction



SPACE | AERONAUTICS | **TRANSPORT** | ENERGY







SECURITY

Source: DLR

Megatrends

- We are reaching the limits of oil extraction
- Climate change is taking place
- Growing population, concentrated in big cities and conurbations
- Demographic trend

Source: www.br.de Jakarta

Source: DLR

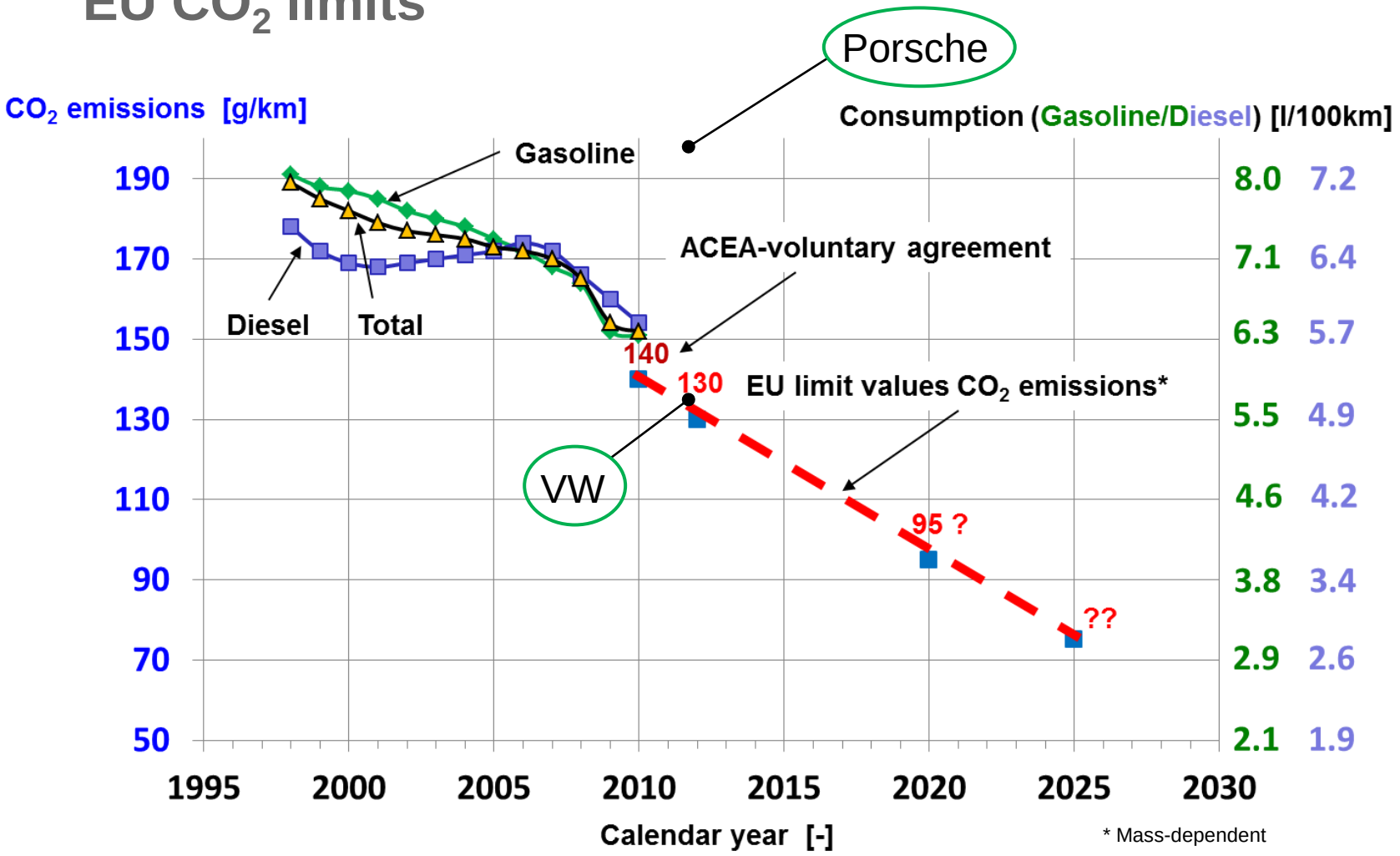
Vehicle concepts

- Lower energy consumption
- Reduced CO_2 emissions
- Alternative and regenerative energy sources
- Automated driving / connectivity
- …

Source: DLR

Source: DLR

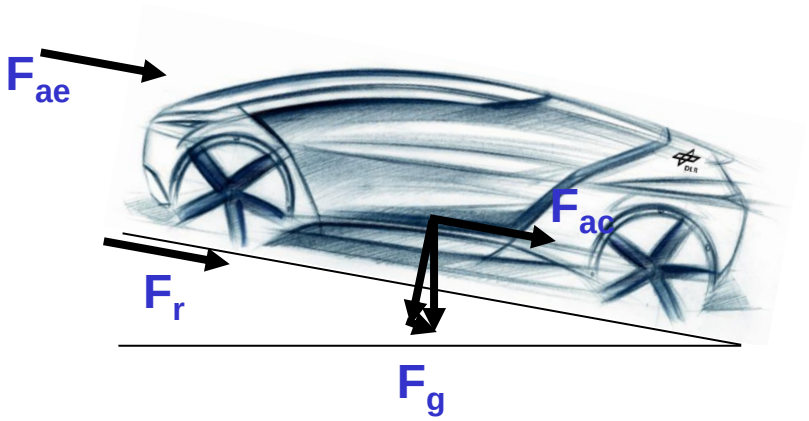
CO_2 emissions in new vehicles in Germany and EU CO_2 limits



Source: KBA; DLR

Driving resistances and consumption

$$\sum \mathbf{F}_r = \underbrace{b \cdot (m_t + \sum m_{rot})}_{F_{acceleration}} + \underbrace{m_t \cdot g \cdot f_r \cdot cos(\alpha)}_{F_{rolling}} + \underbrace{m_t \cdot g \cdot \sin(\alpha)}_{F_{gradient}} + \underbrace{\frac{\rho}{2} \cdot c_d \cdot A \cdot v^2}_{F_{drag}}$$



Total driving resistances

-1 ‰-Point ➡ -0.10 l/100km -2.5 g CO_2/km

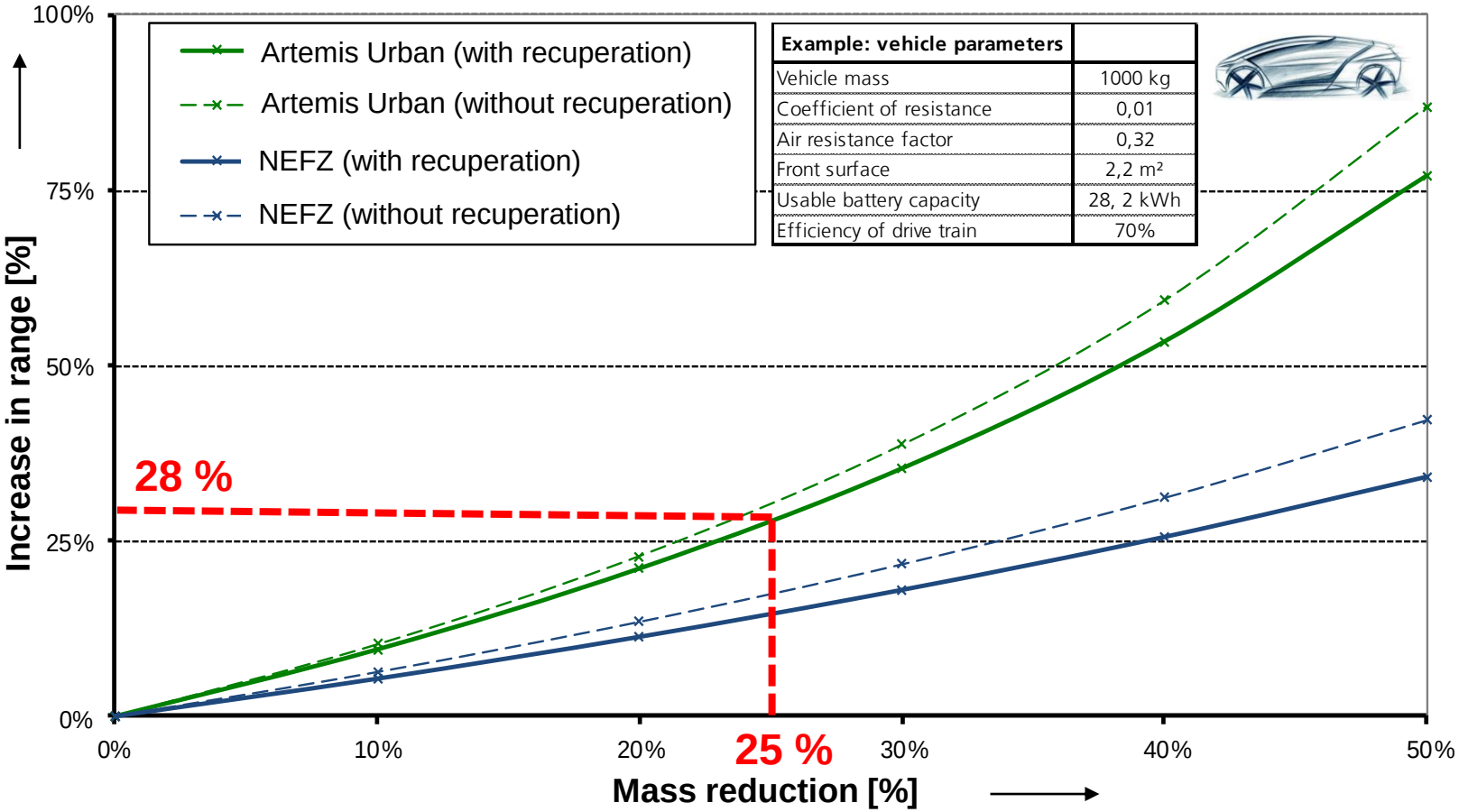
-10 c_d-Points ➡ -0.04 l/100km -1.0 g CO_2/km

-0.08 m² ➡ -0.04 l/100km -1.0 g CO_2/km

-100 kg ➡ -0.30 l/100km -7.5 g CO_2/km

Source: DLR; Daimler

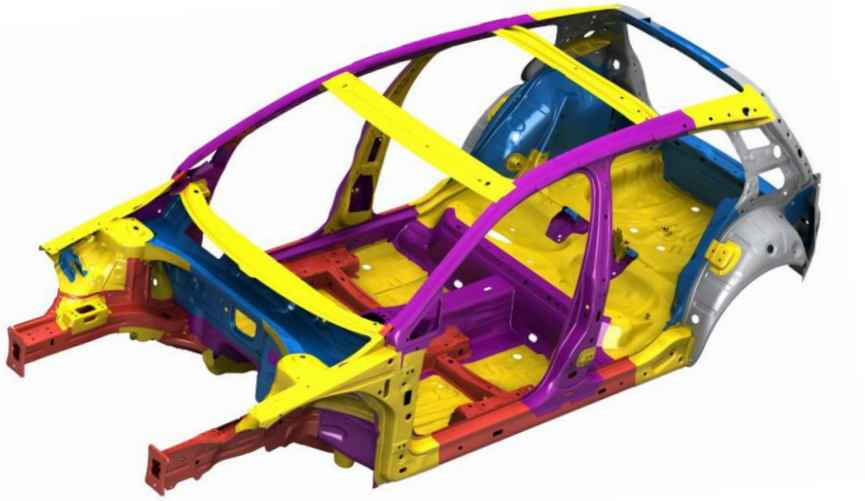
Extension of range with small electric vehicles



→ **25 % mass reduction can achieve 28 % increase in range**

Source: DLR

State of the art vehicle Golf 7



Weight saving:

- weight reduced about 100 kg
  - Electrics - 6 kg
  - Drive train - 40 kg
  - Chassis - 26 kg
  - Body - 37 kg

Lightweight design measures:

- High-strength and higher-strength types of steel, reduced sheet thickness (TRB)
- Only using material where it is needed
- Optimal geometry of profiles and surfaces

→ **Holistic, methodical approach in the product development process to achieve the CO_2 limits**

Source: VW

From the chain of effects of the traffic system to the methodical development process

Demand for mobility
- CO_2
- Legislation
- Energy prices
- …

Transport system
- Requirements
- Target function
- …

Vehicle concepts and architecture
- Simulation
- Optimization
- …

Technology
- Structural components
- Crash components
- Energy converters
- …

methodical development process

Lightweight design by requirement for electrical vehicles

Lightweight requirement

Lightweight concept

Lightweight materials

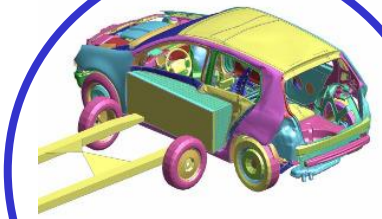
Lightweight shape

Lightweight design strategies

Source: DLR

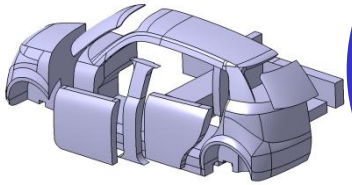
methodical development process

Methodical Development Process
Vehicle lightweight design concept



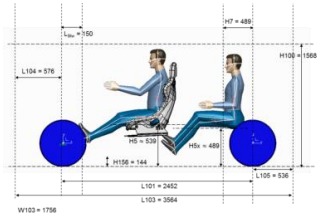
design and simulation

conceptual structure- variants suitable for any material

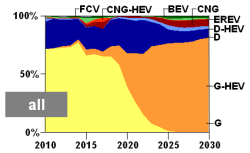


CAD- designed spacemodel and topology optimization

vehicle- and lightweight design-concept



vehicle concept/ measure concept / package



requirements/ market/customer

Source: DLR (Münster)

From the chain of effects of the traffic system to the methodical development process

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- Requirements
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Vehicle concepts and architecture
- Simulation
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Technology
- Structural components
- Crash components
- Energy converters
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methodical development process

Lightweight requirement

Lightweight concept

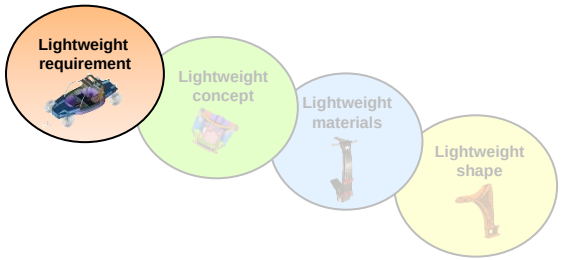
Lightweight materials

Lightweight shape

Lightweight design by requirement for electrical vehicles

Lightweight design strategies

Source: DLR



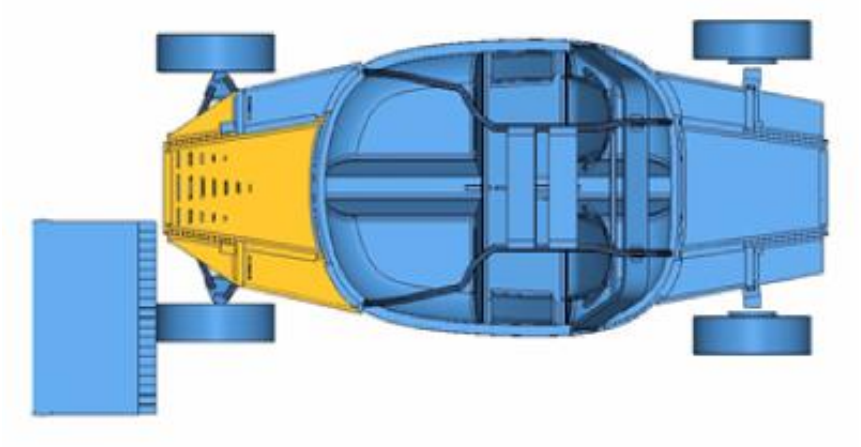
Lightweight requirement

Objective:

- light vehicle with high crash performance (L7e)

Solution:

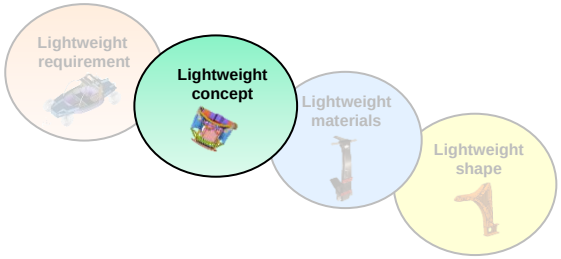
- Body structure in sandwich architecture
  - Skin layers aluminium alloy
  - Foam core polyurethane
- Joining process
  - Crash-stable structural adhesive
  - Welded parts



BIW < approx. 80 kg

Euro-NCAP frontal crash → intrusion approx. 102 mm

Source: DLR (Kriescher, Brückmann)



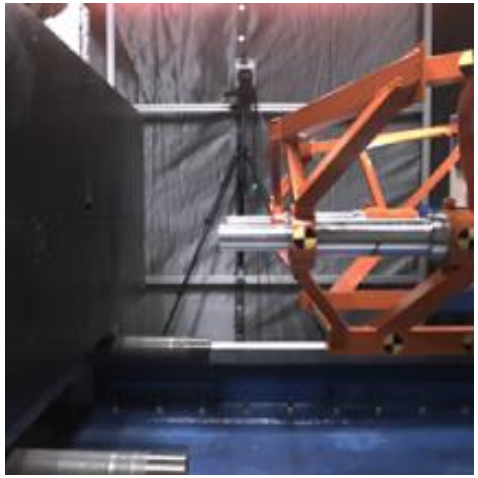
Lightweight design concept

Objective:

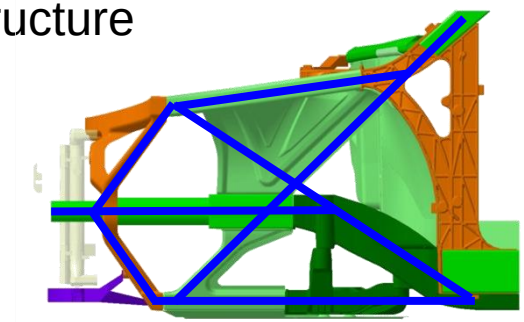
- Crash modular, adaptable vehicle front

Solution:

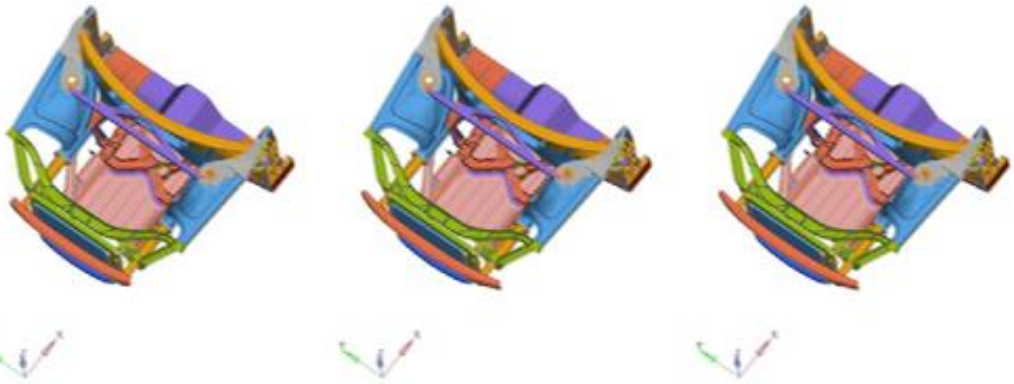
- Energy absorbed through cutting



- Three-dimensional, reinforced light front vehicle structure



- Peeling pipes for adjustment of energy

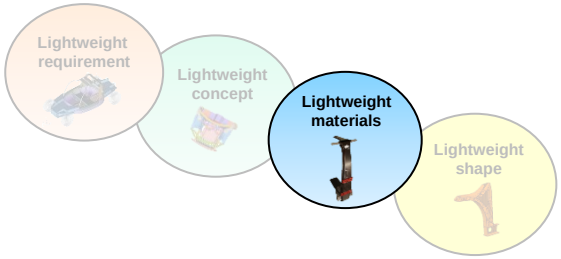


„weak“ „medium“ „strong“

Approx. 20% lighter than steel reference structure

Source: DLR (Beeh)

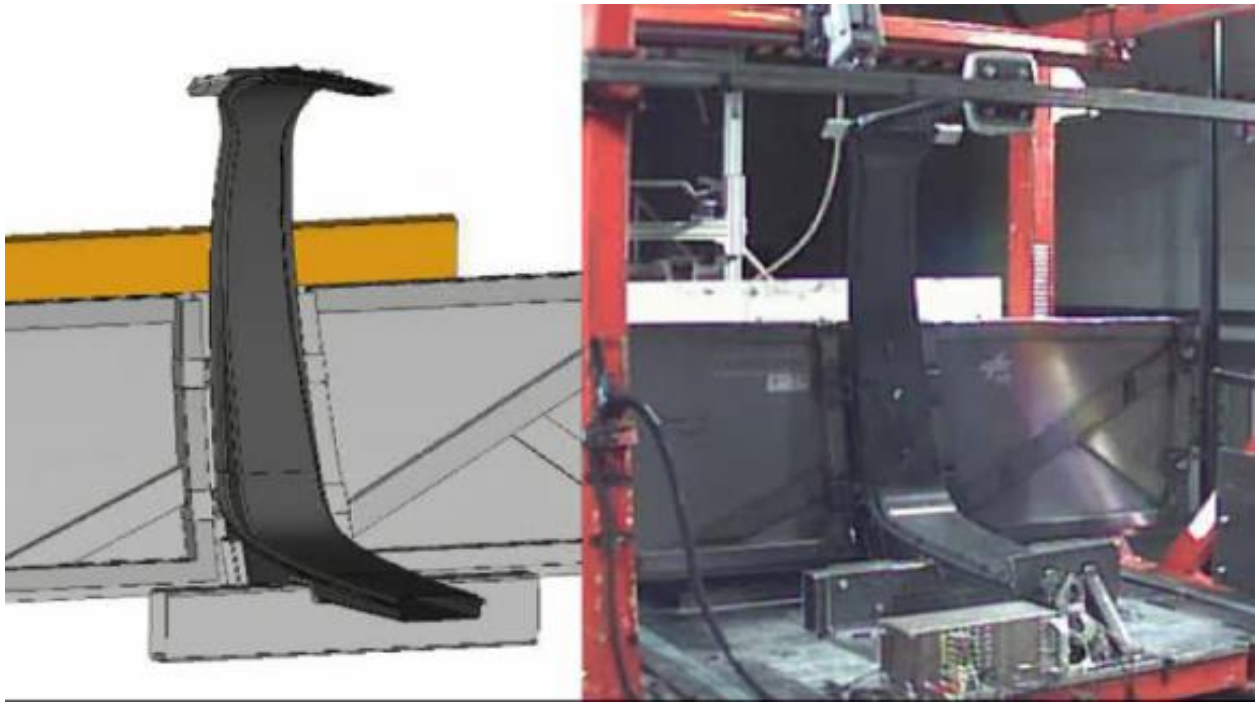
DLR



Lightweight material design

Objective:

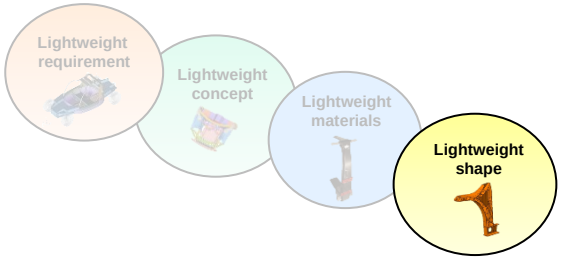
- Light CFRP B-pillar



Solution:

- Layer structure (0/90/±45)
- Manufacture using VARI procedure
- Internal reinforcement with additional Omega profile

Source: DLR



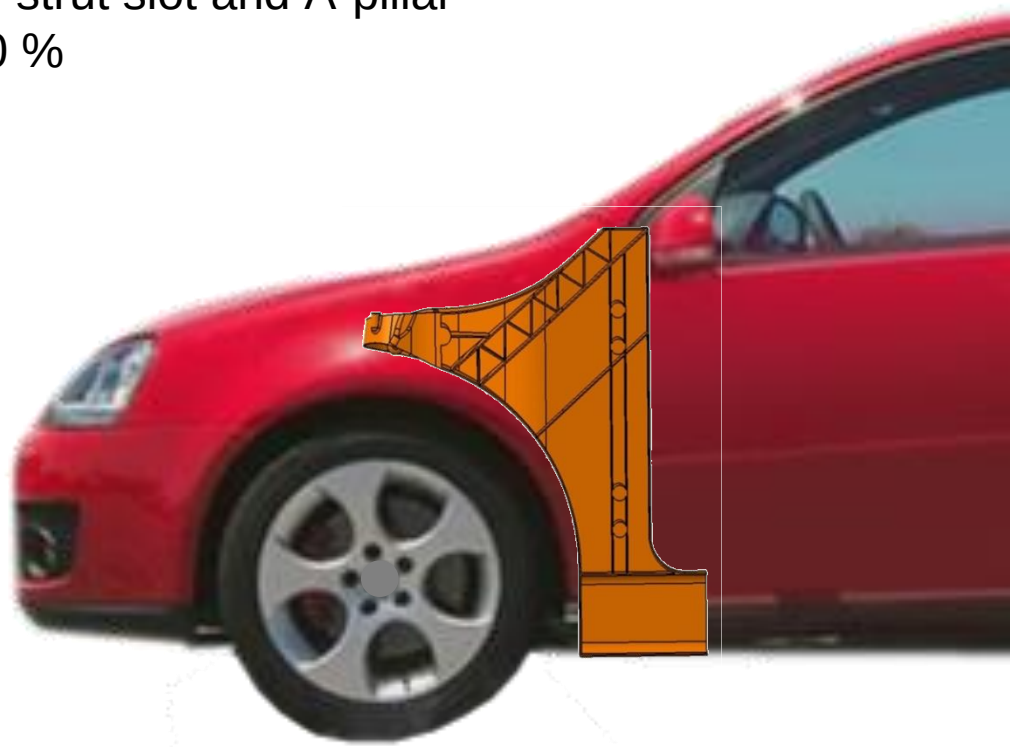
Lightweight shape

Objective:

- A lighter and more cost-effective cast A-pillar node

Solution:

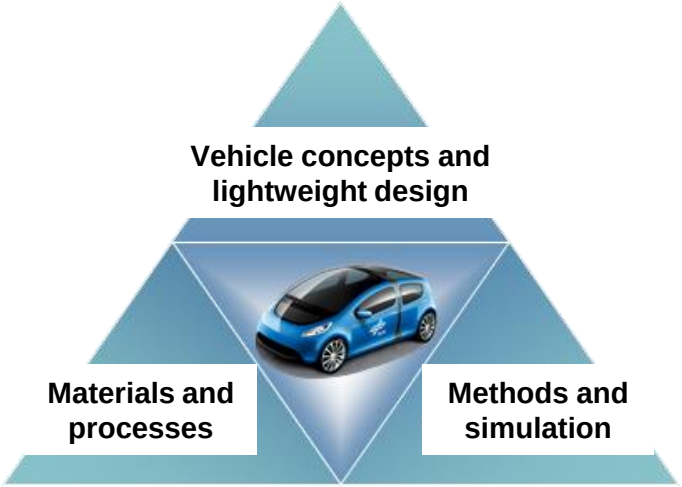
- New design with magnesium alloy
- Integration of suspension strut slot and A-pillar
- Weight saving approx. 50 %
- Component weight 6 kg



Source: DLR (Beeh)

Summary

- CO_2 limits and gradual electrification are reinforcing the trend towards lightweight construction in vehicle design
    - Compensation for extra weight of new components
- Gradual electrification as a chance for:
    - new vehicle concepts, lightweight design concepts and a push for lighter materials
- Focus for research and development:
    - Holistic, methodical approach in the product development process



Source: DLR

Thank you for your attention!

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