



## **Cluster 3**

# **Materials & Manufacturing**

**Less weight – less cost – less  
CO<sub>2</sub> – more dynamic – more  
efficiency**



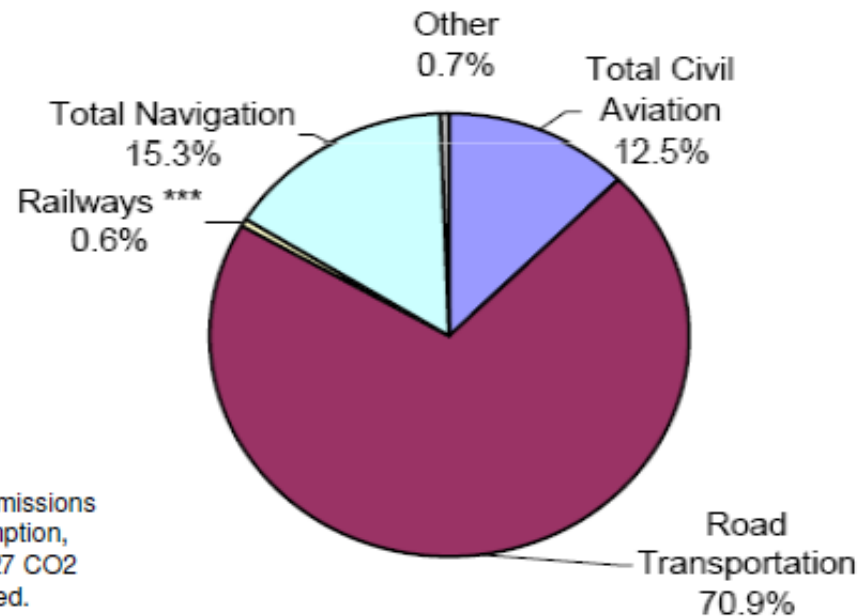
## **NoAE**

**Let us define projects, to find solutions for issues, we can´t solve alone!**

**Let us look into the entire mobility industry to learn from each other!**

## Drivers for weight saving

- Transport responsible for 23%\*\*\* of EU-27 CO<sub>2</sub> Emissions and is expected to become 50% in 2050.
- The largest share of this comes from Road Transportation



\*\*\* Excluding indirect Emissions from Electricity Consumption, otherwise, 27% of EU-27 CO<sub>2</sub> emissions is often quoted.

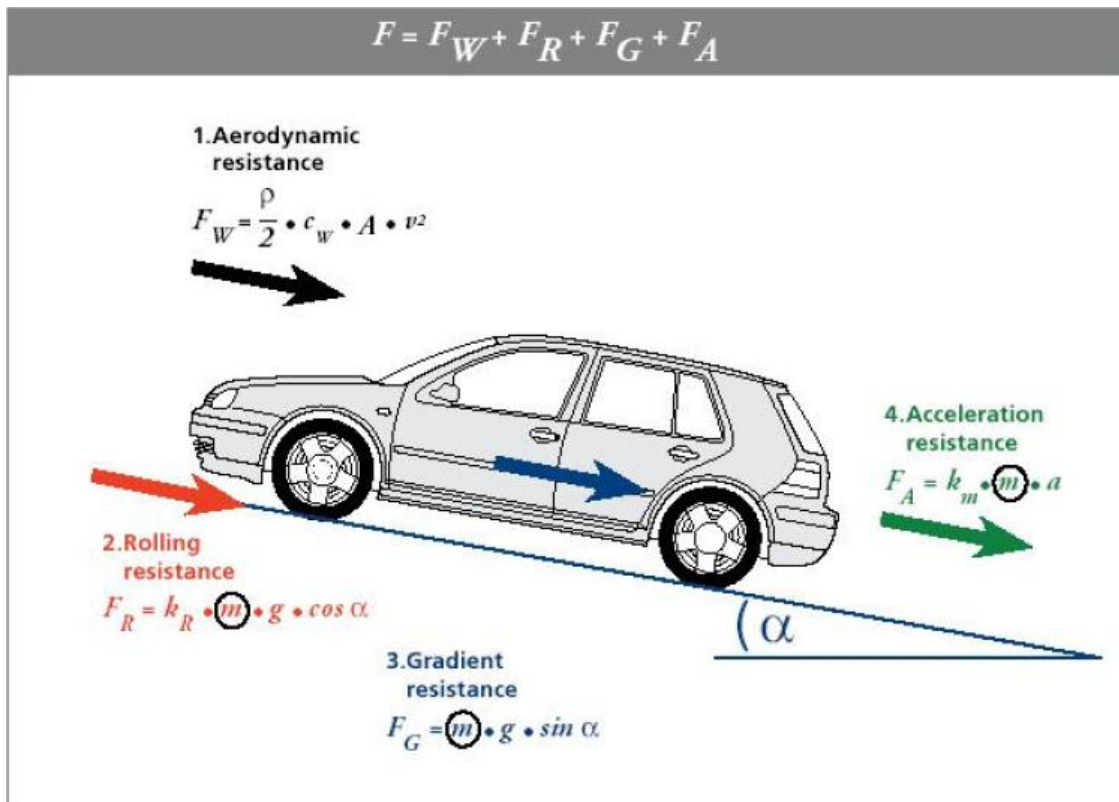
Source [http://ec.europa.eu/energy/publications/doc/statistics/ext\\_co2\\_emissions\\_by\\_sector.pdf](http://ec.europa.eu/energy/publications/doc/statistics/ext_co2_emissions_by_sector.pdf)

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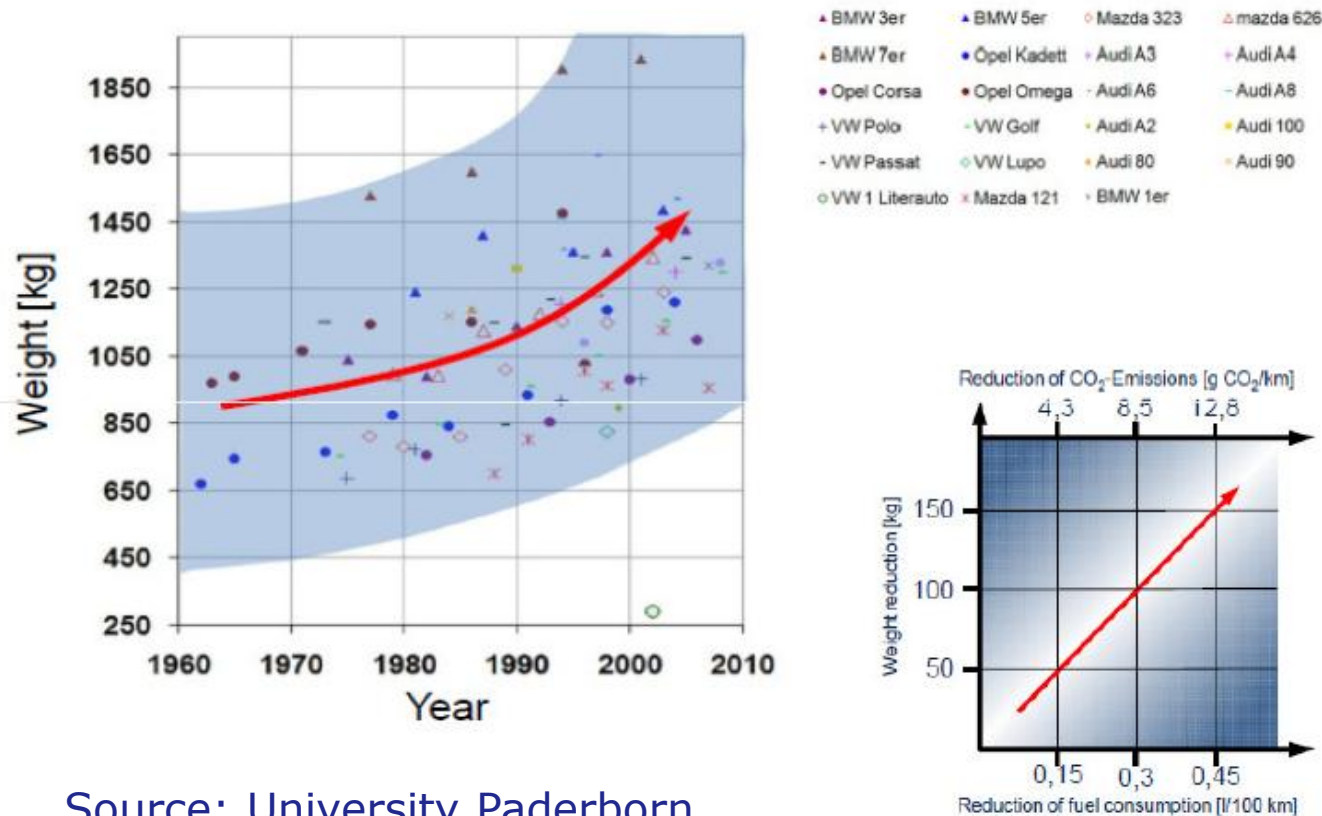
Reduction of the vehicle weight is a must

Vehicle weight is directly proportional to the energy required to move the vehicle, except for aerodynamic resistance

Reducing the mass is very efficient for reducing the fuel consumption

100kg weight reduction saves 0,25 – 0,35 l/100km

## Motivation for lightweight design



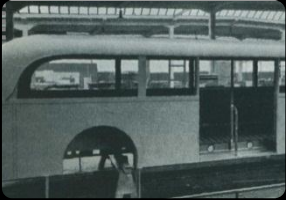
Safety and comfort  
overcompensated the  
lightweight design efforts  
in car body development

Source: University Paderborn

# •Lightweight design history in Europe

•1937

•Mg Bus trailer



•1999

•AUDI A2 with the 2nd ASF generation



•2007

•BMW M3 CFRP roof – the beginning of the carbon fibre wave



•1993

•Audi A8 with an aluminium space frame (ASF)



•2001

•VW 1ltr car  
•Mg structure with CFRP panels



•2009

•More and more multimaterial designs.  
•AUDI A6, Q5 ...  
•BMW  
•Daimler Benz  
•Porsche  
•.....





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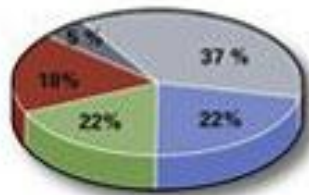
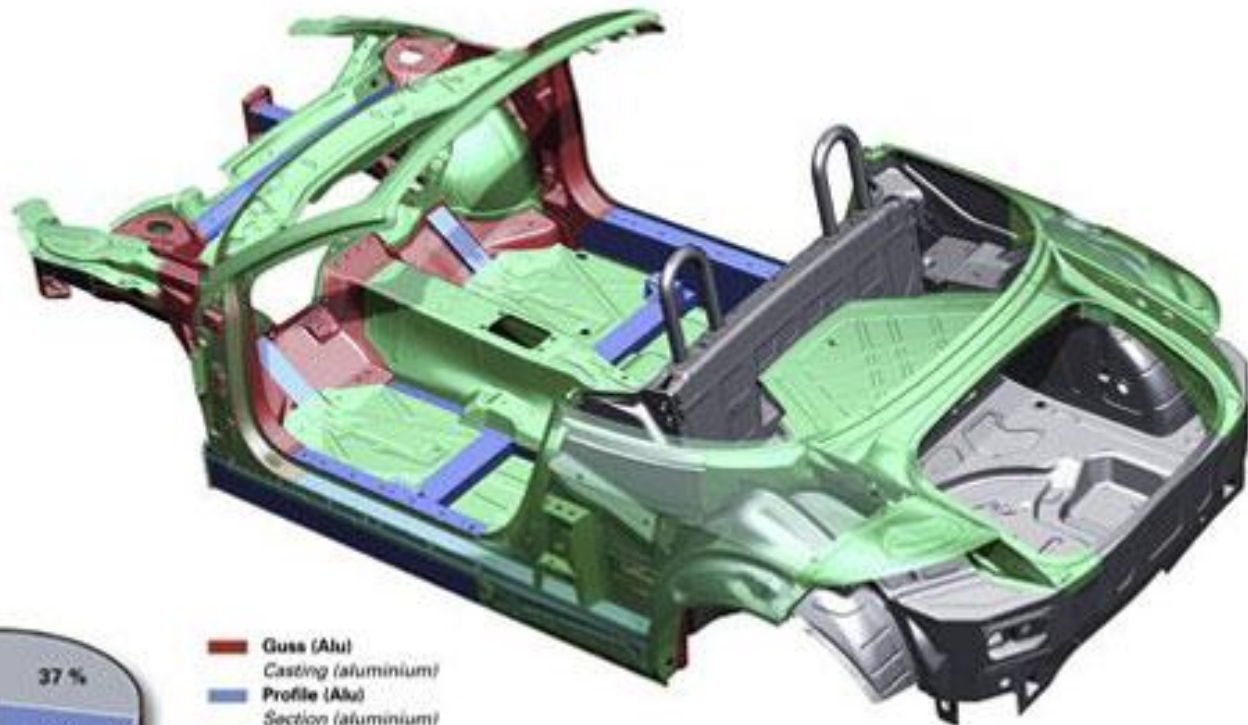
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## Audi TT Roadster

### Rohkarosserie

Structure  
11/06



- Guss (Alu)  
Casting (aluminium)
- Profile (Alu)  
Section (aluminium)
- Blech (Alu)  
Sheet (aluminium)
- Blech (Stahl)  
Sheet (steel)
- Profile (Stahl)  
Section (steel)

Source: AUDI



## Lightweight-design pressure around the world



### **NA**

**legal regulations  
support lightweight  
design more than in  
EU**

**Suppliers have to  
achieve -50%  
weight on part level**

### **EU**

**center of lightweight  
design based on new  
materials**

### **A/P**

**clever and pragmatic  
lightweight design  
with proven  
materials**

**first innovations  
coming from China  
in western markets**





## Specifica of mobility markets



### **Automotive:**

- enormous volume
- missuse cases
- big players



### **Railway:**

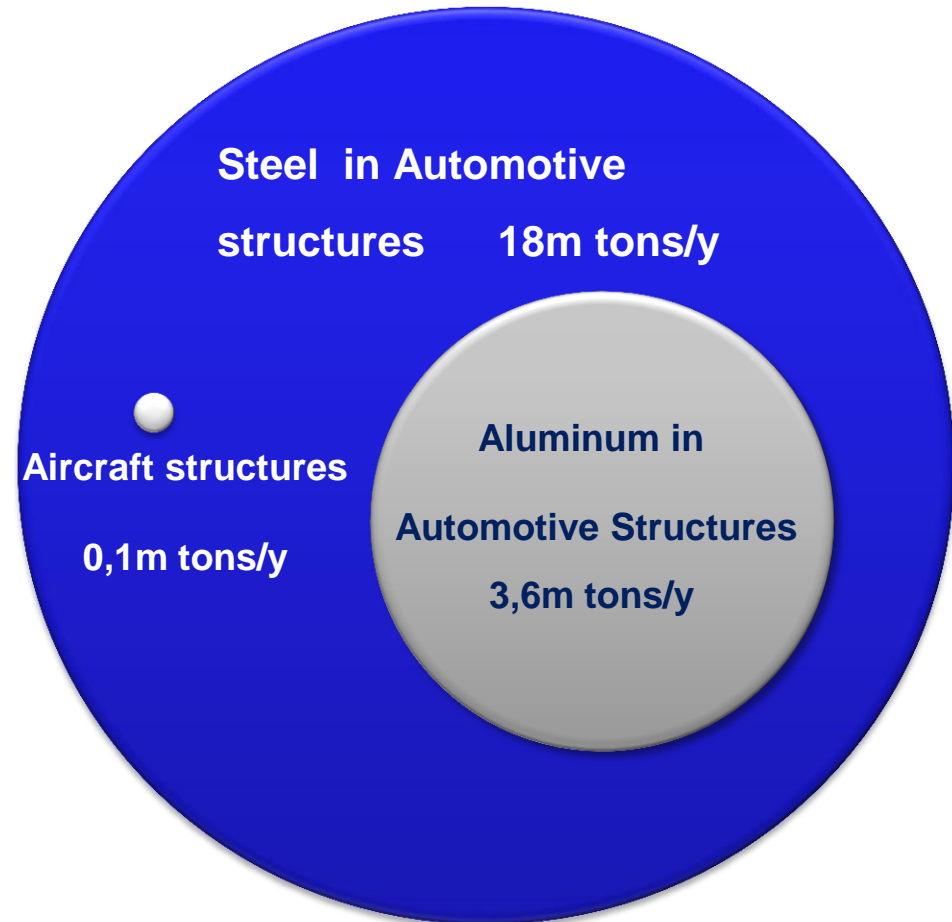
- robustness
- straight lines
- higher level of market-concentration



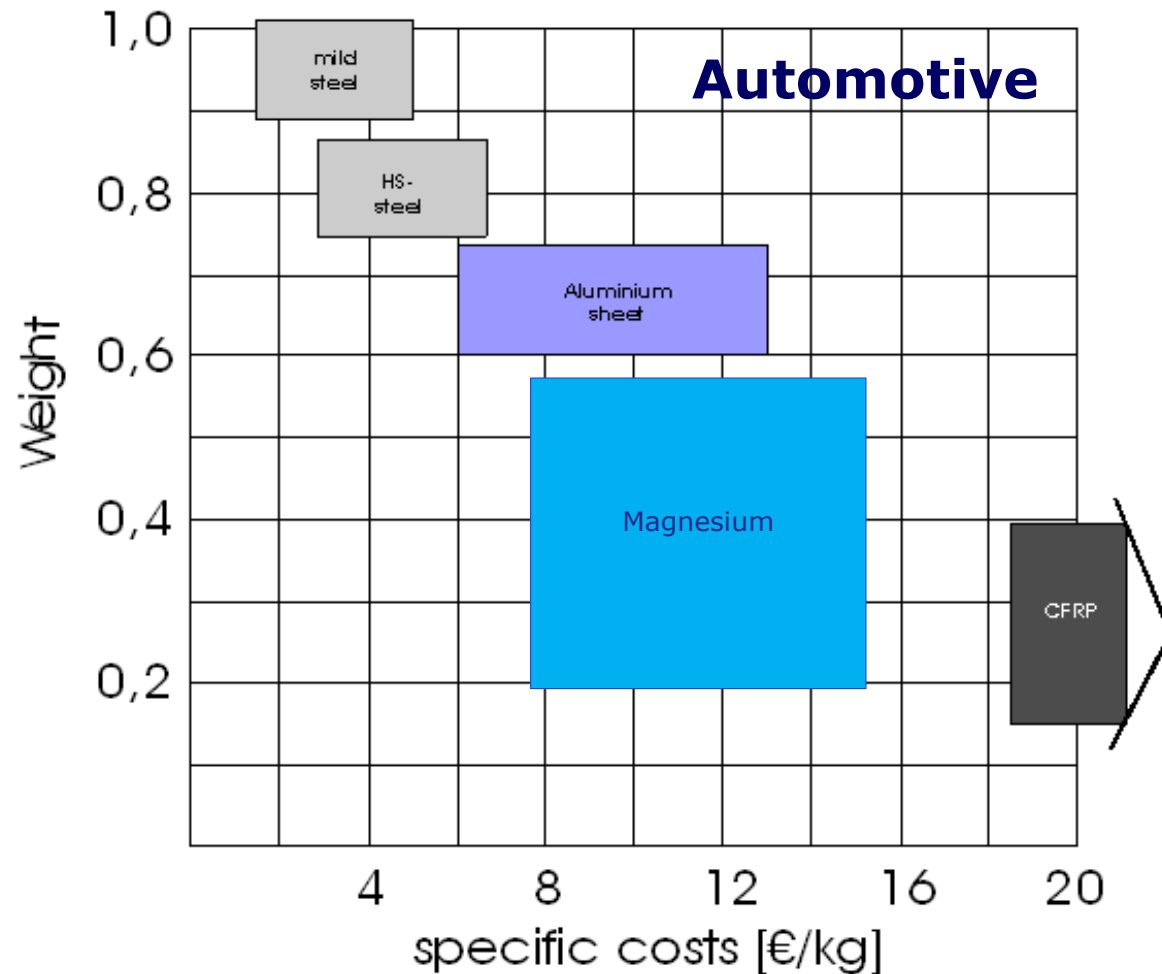
### **Aircraft:**

- 100% under control; no undetected misuse
- high entry barriers
- few players

## Specifica of mobility markets



## Specifica of mobility markets



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## Workshops No. 3 MATERIAL & MANUFACTURING

Time	Acitvitiy	presenter
10.30 – 10.35 am	Opening Workshop 3 „Material & Manufacturing“	Mr. Anderseck, Prospecting Partners Member of the Jury
10.35 – 10.50 am	New Materials: Synergies Automotive, Aircraft und Railway	Mr. Dr. Kirschfink, Lufthansa Technik, Member of the Jury
10.50 – 11.10 am	Project.Proposals iMaut: 3 Projects	Carlos Moliner Martin Pohl
10.10 – 11.20 am	Project-Proposal „iMDP“	Mr. Anderseck
11.20 – 11.45 am	Project-Generation Base1: 10 Innovation winners Base2: ideas and needs from the auditorium	Moderation Prof. Grienitz and Mr. Anderseck
11.45 am – 12.00 am	<b>Activity plan</b>	Prof. Grienitz and Mr. Anderseck

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- Reserve



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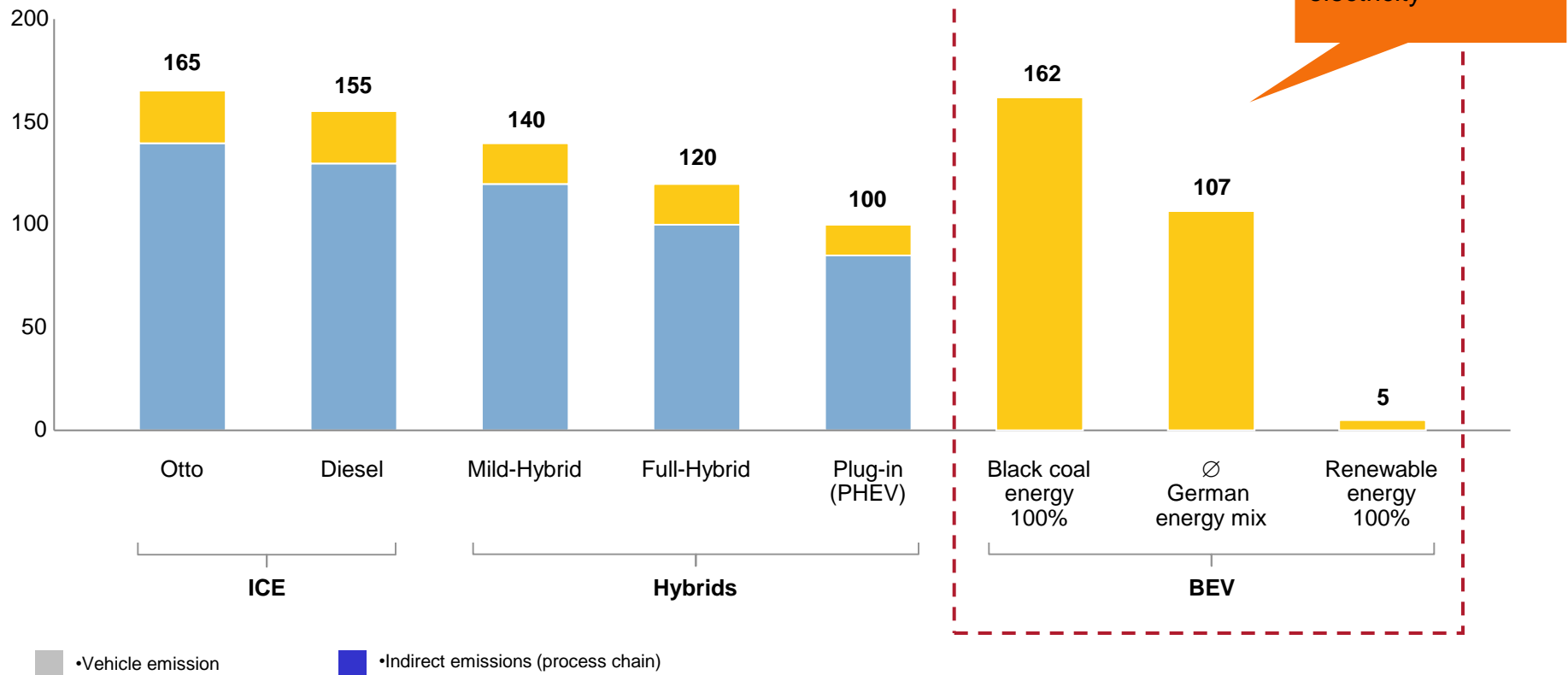


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## Electric cars are only as green as the electricity they run on

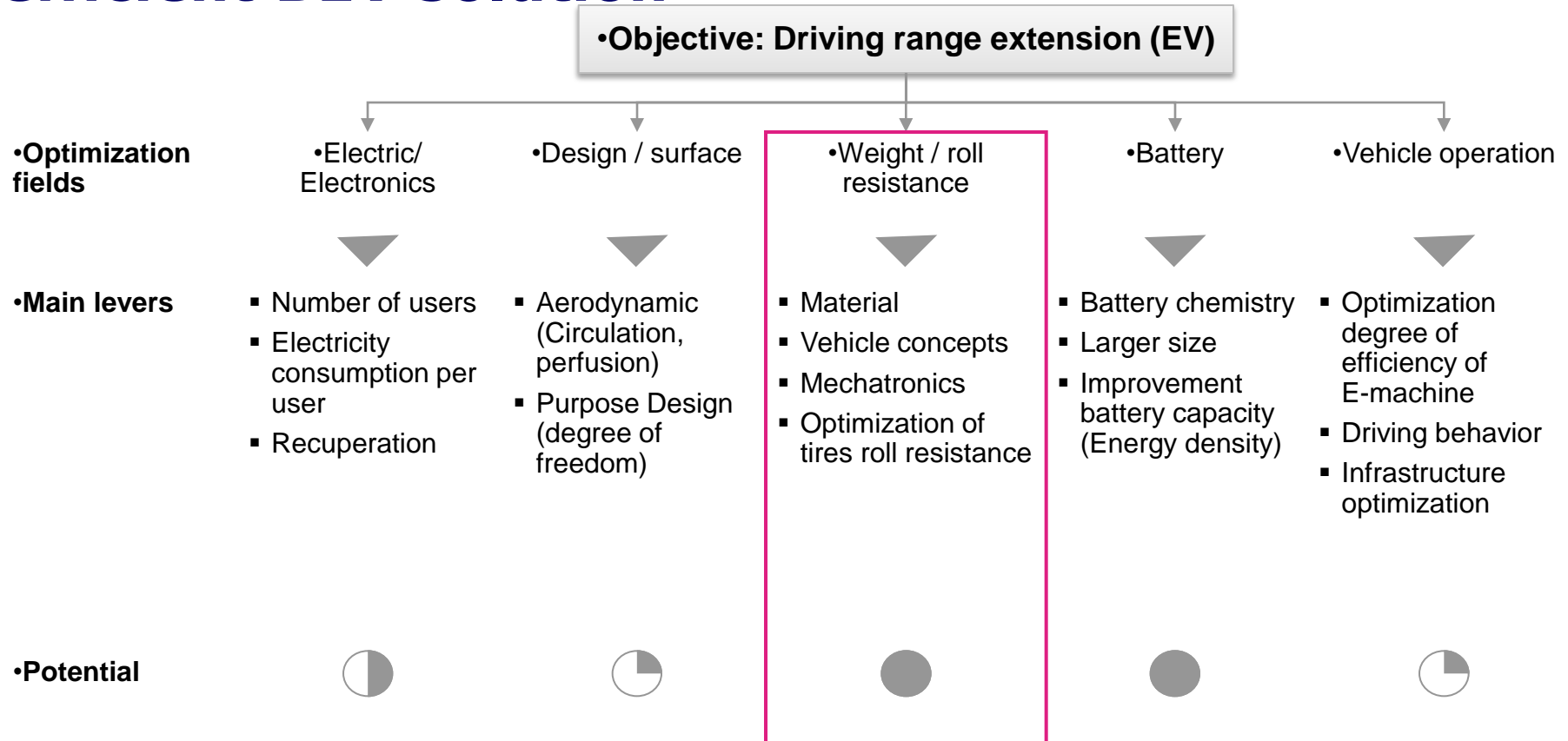
- CO<sub>2</sub> emissions by power train technology (Well to wheel perspective)
- In g CO<sub>2</sub> per km, lower medium segment example, Germany



• Source: UBA, BMU 2008, WWF 2009



## Lightweight as important lever for a cost efficient BEV solution



► **Light weight technology is strongly gaining importance as competitive advantage, especially in topics such as fuel efficiency and fleet emission for ICE as well as driving range for BEV**



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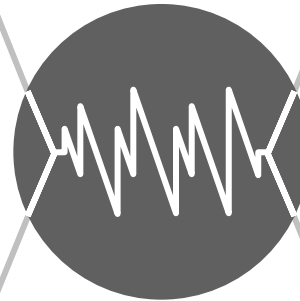
•What material ?

## •Metals

- Steel
- Aluminium
- Magnesium

## •Plastics

- Thermoplastics
- Organosheets
- GFRP
- CFRP
- Nano-material



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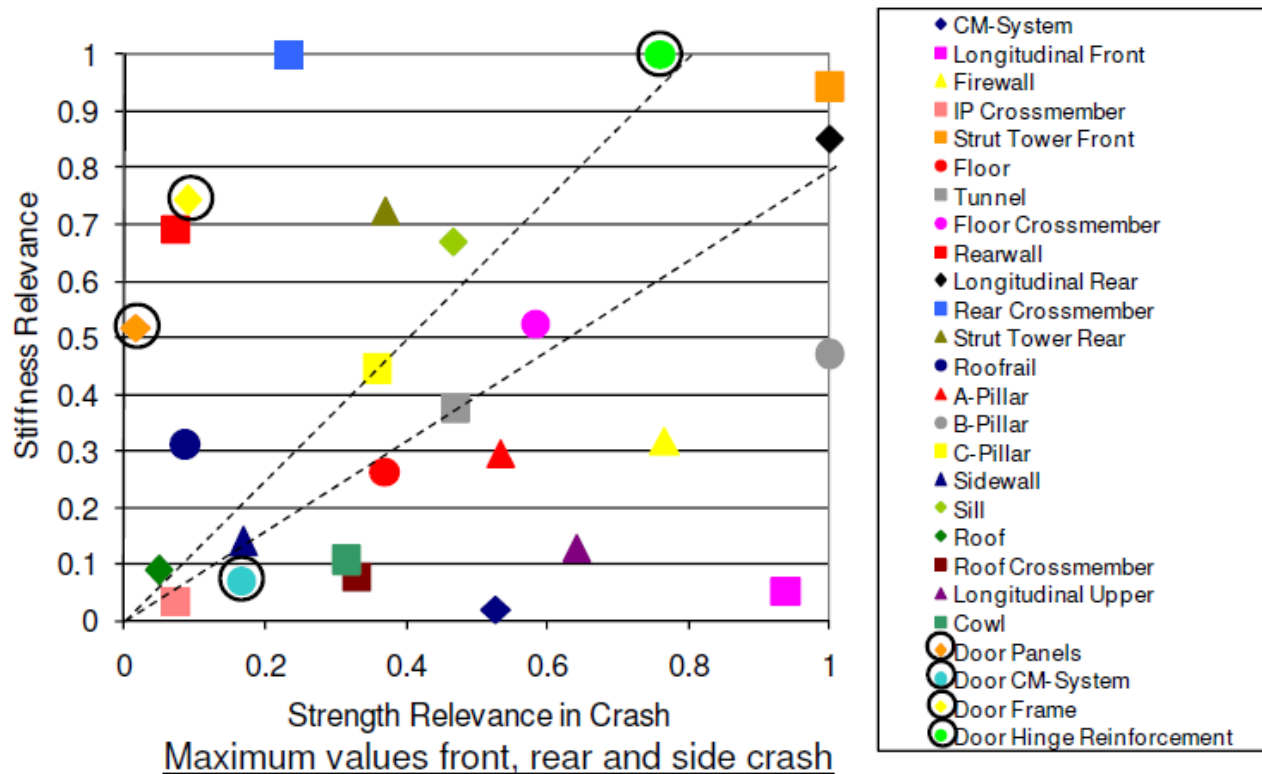
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Trend: Material competition  
• What material should I choose?

## Strength and stiffness relevance for typical car body components (ika, 2009)



• Source: IKA, 2009

• Strength and stiffness relevance for typical car body components:

• For most of the components, strength is still not the limiting factor. Many parts are primarily stiffness-determined

• Components with high stiffness relevance are not suitable for efficient lightweighting by using steel grades with high yield strength

• Using aluminium in a stiffness determined component can reduce the weight by 30-50%

• Using Magnesium MnE21 in a stiffness determined component can reduce the weight by 50 – 75%

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- Trend: Material competition, wide range of properties available

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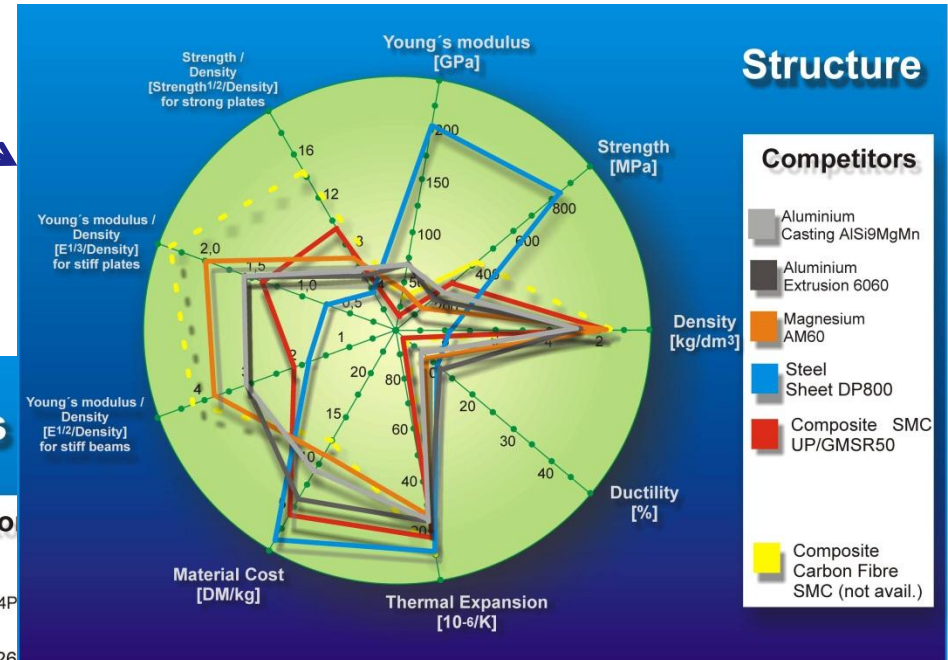
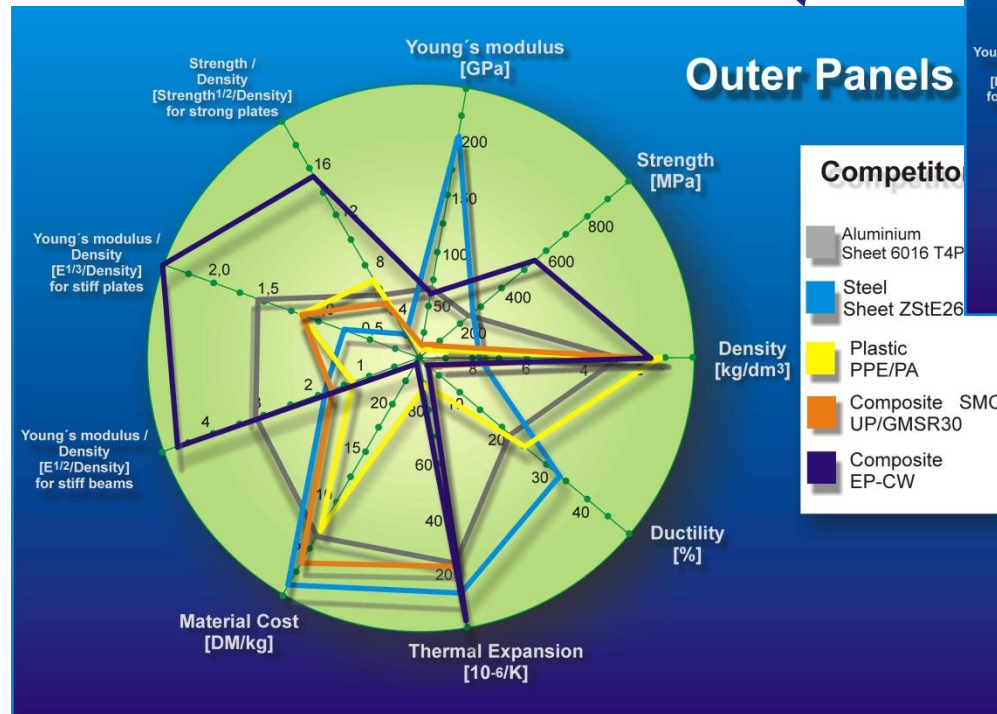


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- Competition of Structural parts
- Competition of Outer Panels



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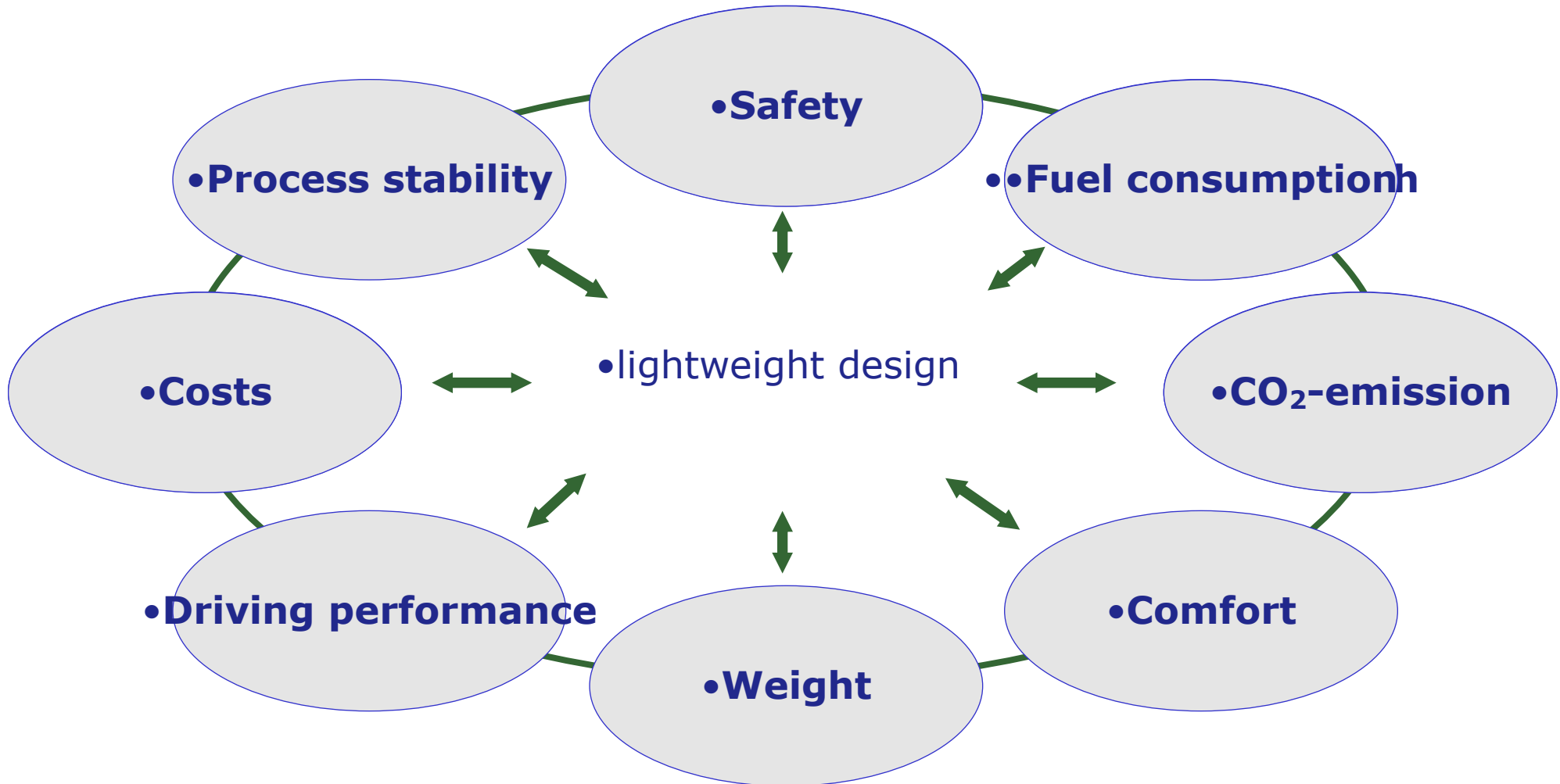
- Trend: Material competition, challenge to balance the car behavior

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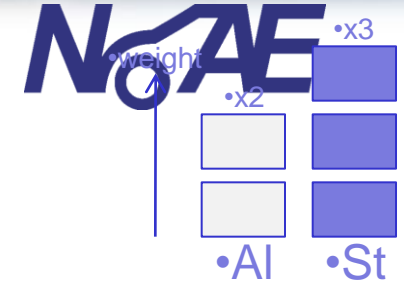
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## Material Competition: Aluminium

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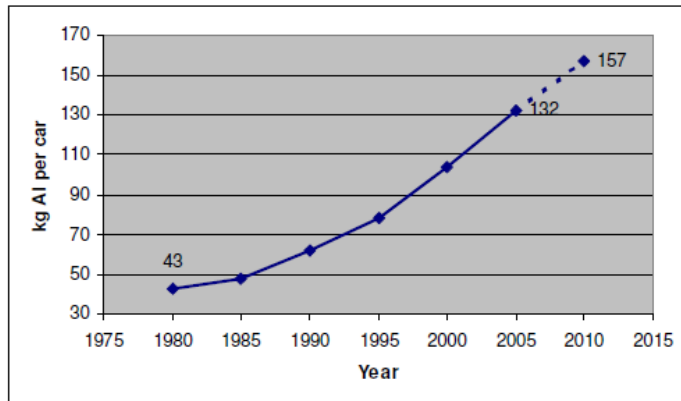


## Aluminium is an important automotive material

### Aluminium-intensive cars:

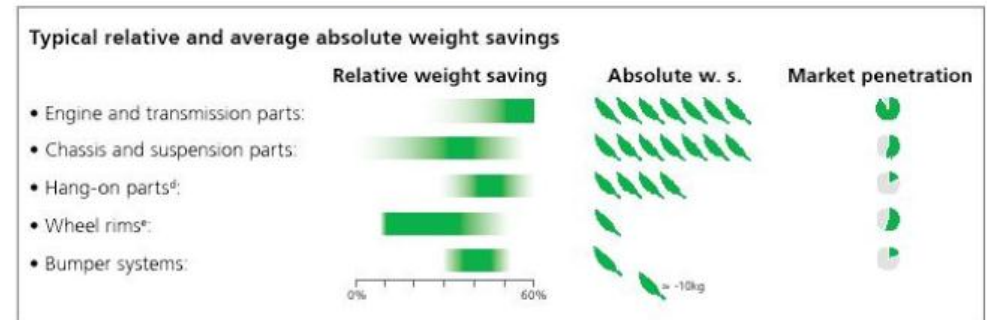
- > 450 kg upper class models
- > 300 kg middle class models

Average aluminium content in European car models:



## Lightweighting with aluminium – today

- Primary weight savings, typical values:



Secondary weight savings typically 0 – 50% extra

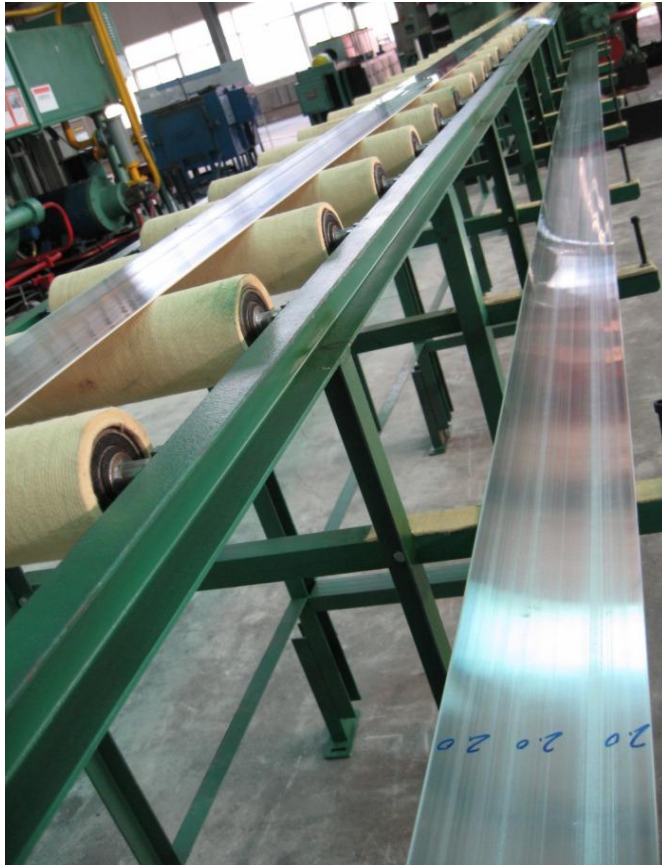
- Significant growth potential, in particular for aluminium sheet, exists in car body applications:
  - Closures (doors, hoods etc.)
  - Structural applications
  - but also in chassis and suspension



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## Magnesium: Castings, Extrusions, Sheets

- Ministerium für Wirtschaft, Energie, Bauen, Wohnen und Verkehr des Landes Nordrhein-Westfalen
- EnergieRegion.NRW Cluster Nordrhein-Westfalen
- Mg2: new light weight material for mass market production with a new process route



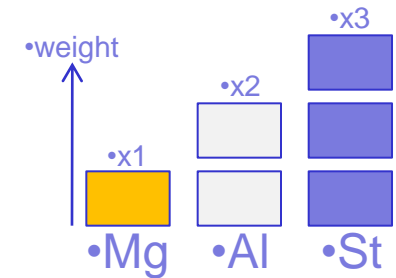
•Sheet manufacturing in China



•Bumper



•Porsche console cover



•Samples to show deforming capability

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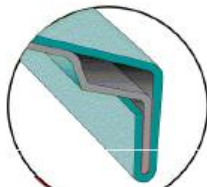
- Process Innovations are key for the usage of new materials

OEM , Plattform

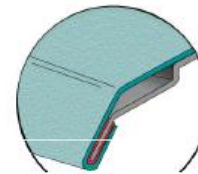
**Jaguar, XJ350**

Application description

Aluminium Hem Flange Bonding - all closures

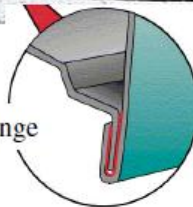


Deck hem flange



Hood hem flange

Door hem flange



- No distortion
- Less than 30 seconds cycle time
- Aluminum
- High Oil compatibility

3M Product

SA 5027

**3M**

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• Trends: Process innovations

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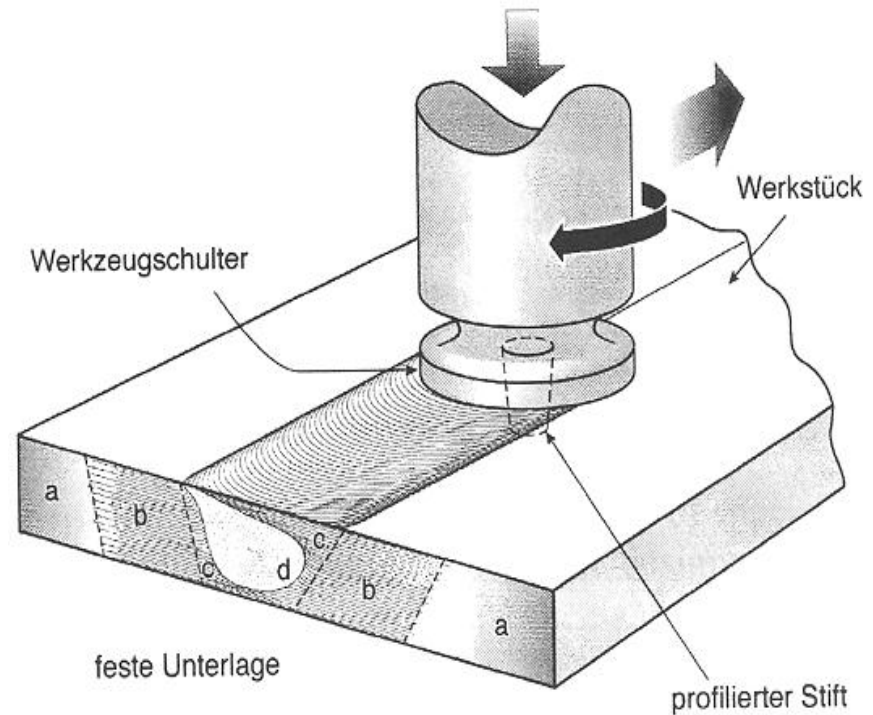
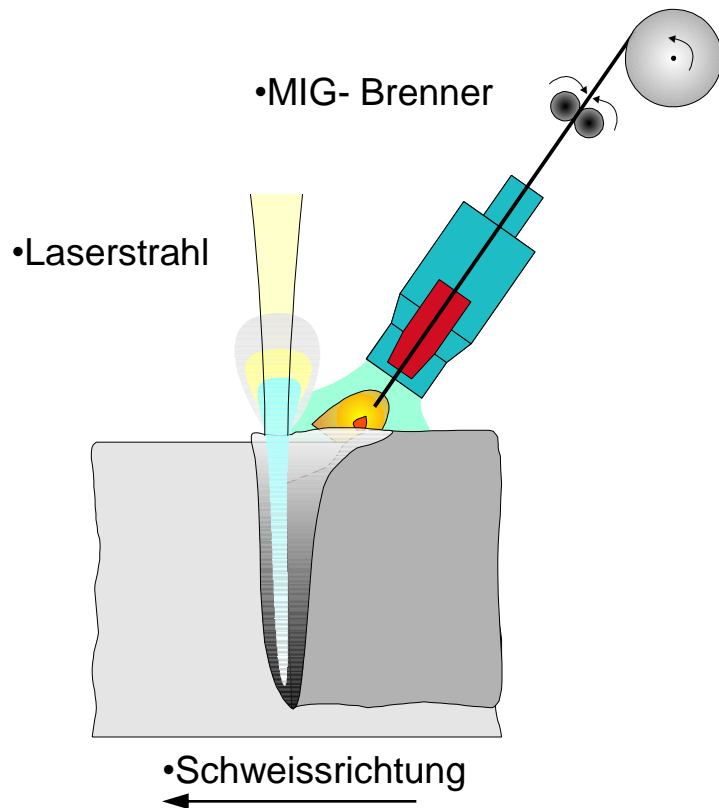


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• New materials need new or improved joining technologies

• CMT, Laserhybrid, ... Welding processes • Friction- Stir- Welding



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## •Complex material behavior is changing the design process

### •Knowledge

- To become a multi-material engineer is a big challenge
- The experience in steel is existing
- The aluminium knowledge is available
- The carbon fibre knowledge is concentrated at some locations
- The magnesium knowledge is in the growing phase
- Where are the engineers familiar with all these materials?

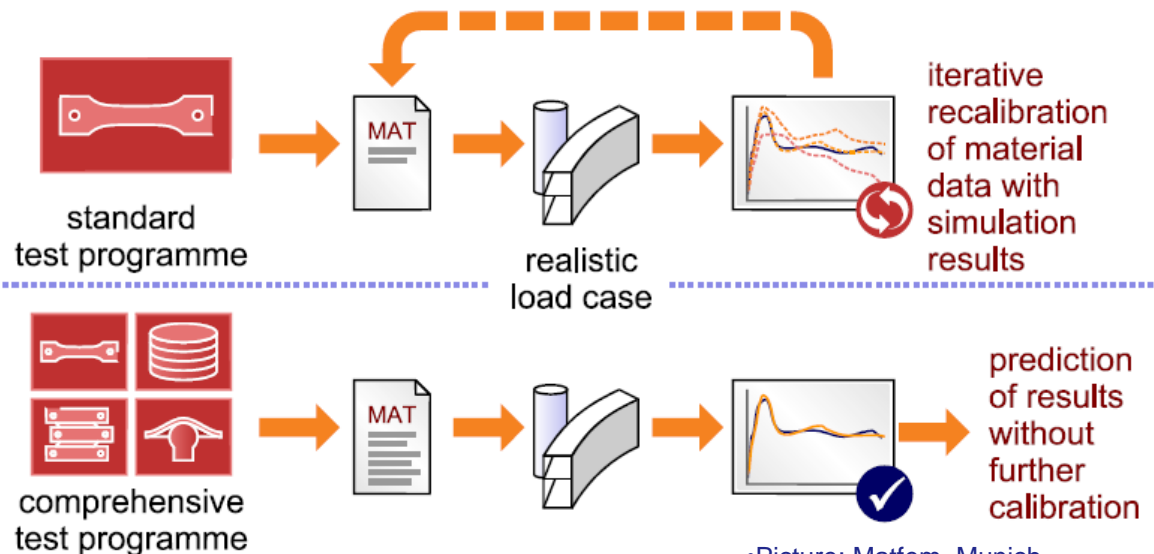
### •CAE

- All modern lightweight materials do not have an isotropic behavior!

### •Testing

- many testing methodologies were developed, to test steel

#### Predictive Simulation





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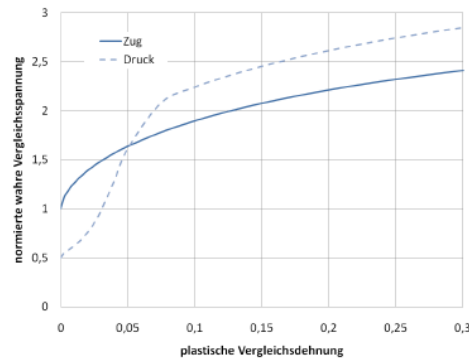
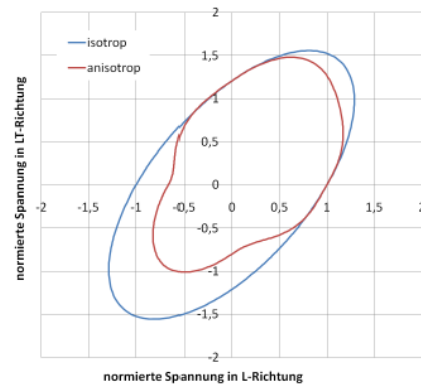


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- Effective lightweight design is not isotropic

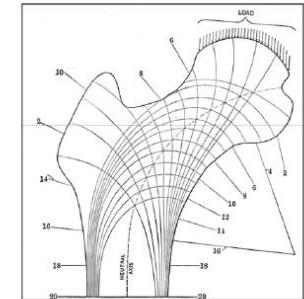
Fließort (für  $\epsilon_{eq}=0.03$ ) und asymmetrische Verfestigung für MnE21-Profil



•Picture: Matfem, Munich

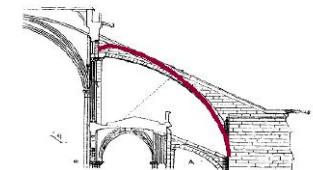
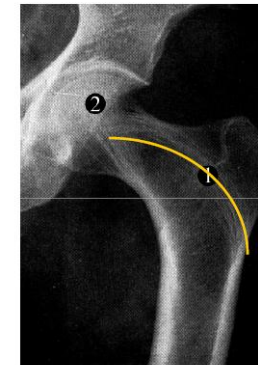
- Flow characteristics of a magnesium alloy

Trapecular (Spongiosa)



Cortical

- Structure of a human bone



- transferred into a church architecture of the 16th century



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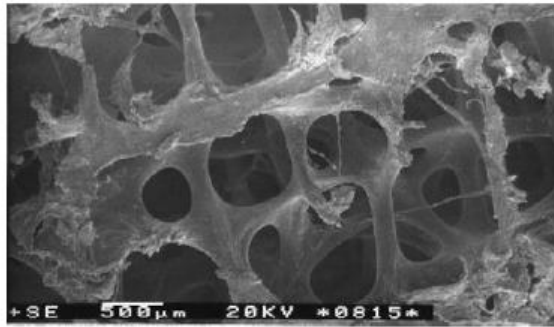
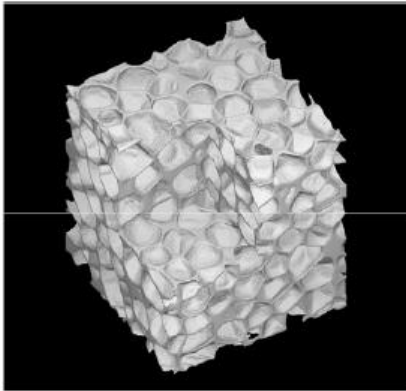
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## •Bionic principles

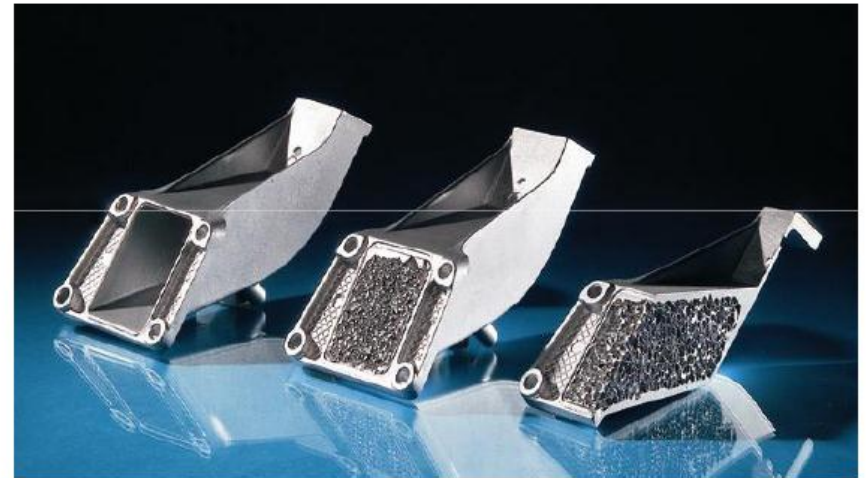


## •metal-foam

## bone-structure

•Picture: Prof. Wellnitz, Ingolstadt

## •Prototype of an engine support



•Picture: BMW

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**Trend: Car architecture**

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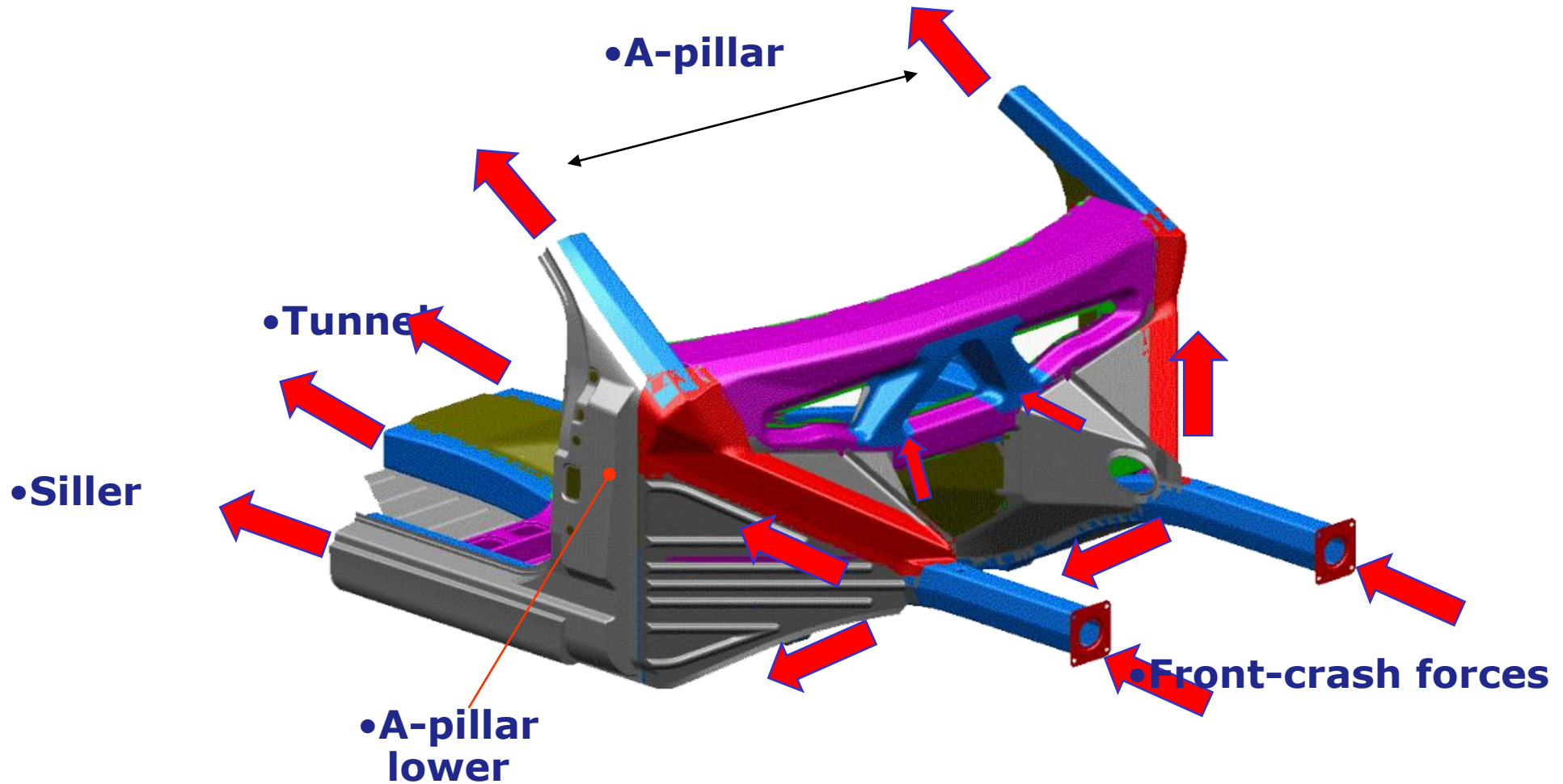


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• **Architecture and crash performance**

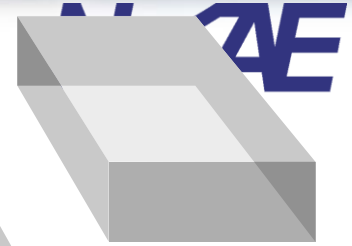


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- CO<sub>2</sub> regulations and e-mobility is leveraging lightweight design
- Weight saving targets in Europe are at a level between 50 to 250kg
- The European OEM 's tried out a lot of lightweight approaches
- Actually we realise a lot of multimaterial design in premium cars
- CFRP has an important role for luxury cars
- Suitable lightweight design for mass market cars
- needs a lot of efforts
- The new alloy MnE21 can be a part of
- a solution for mass market cars
- in China e-mobility is important part of the mobility in mega-cities
- Therefor China has a strong need for lightweight design .
- for e-mobility lightweight design is necessary for achieving a cost effective car. Secondary savings are much higher compared to combustion engines

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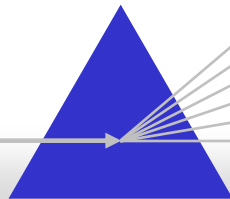


## 3 Criteria for customer value in the automotive industry

### What has to be fulfilled by a new material?

- trust
- price markup between 3 and 5 €/kg weight saving is in discussion
- high weight saving potencial
- simple car integration
- sourcing guarantee
- CAE capabilities
- global availability
- supplier configuration acceptable
- testings ok
- package ok
- production stability ok
- CO2 emissions ok
- many different semi finished products needed
- joining technologies must be available

•new material



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## 3 Criteria for customer value in the automotive industry

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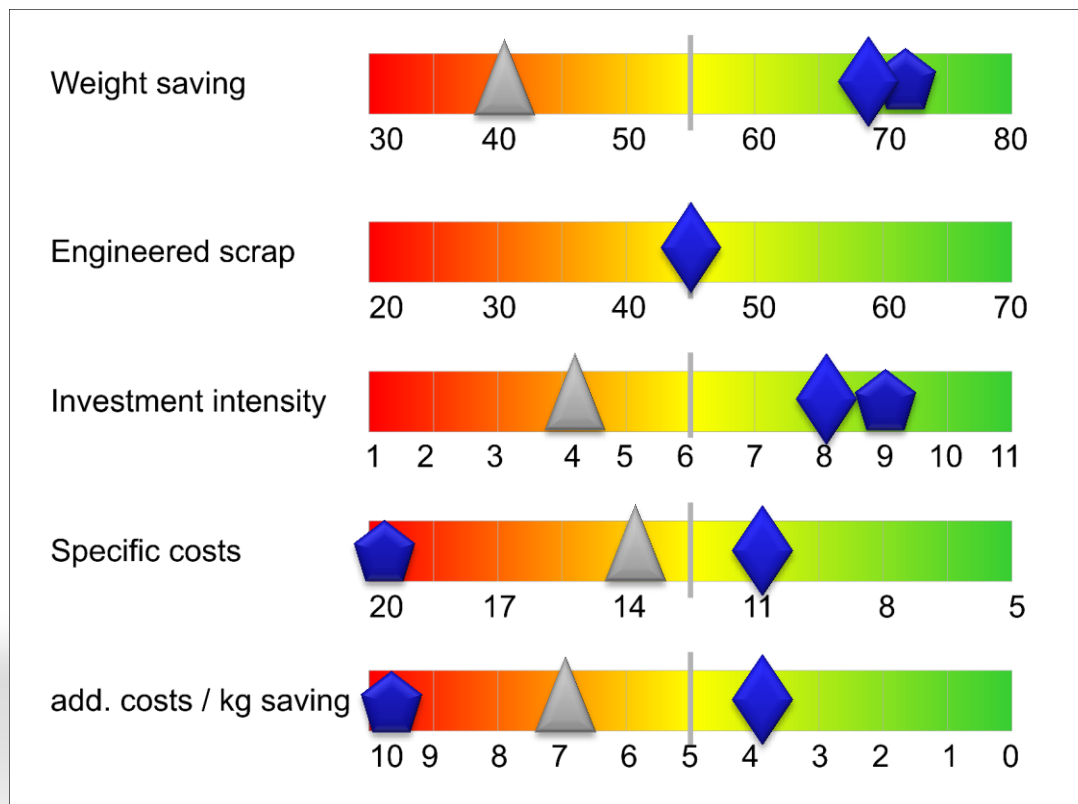


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### Performance indicators of magnesium applications



•MnE21 sheet warm-in-warm process



•Aluminium sheet



•CFRP part

(1) Weight saving [%]  
Green: 65% - 75%

(weight of steel or aluminum component compared to MnE21 part)

(2) Engineered scrap rate [%]  
>50%

(component weight / blank weight) only interesting for warm-in-warm process

Green:

(3) Investment intensity [-]  
Green: >10

(lifetime revenue / capital employed for this component)

(4) Specific costs [EURO / kg]

(part costs / part weight)



## **Cluster 3**

# **Materials & Manufacturing**

**Less weight – less cost – more  
dynamic – more efficiency**