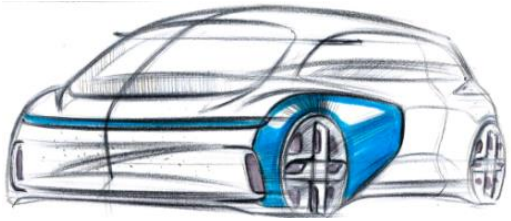


Next Generation Car – Fahrzeugkonzepte, Fahrzeugarchitekturen und Strukturbauweisen für die zukünftige Straßenmobilität

Next Generation Car – vehicle concepts, vehicle architectures and structural design for future road mobility

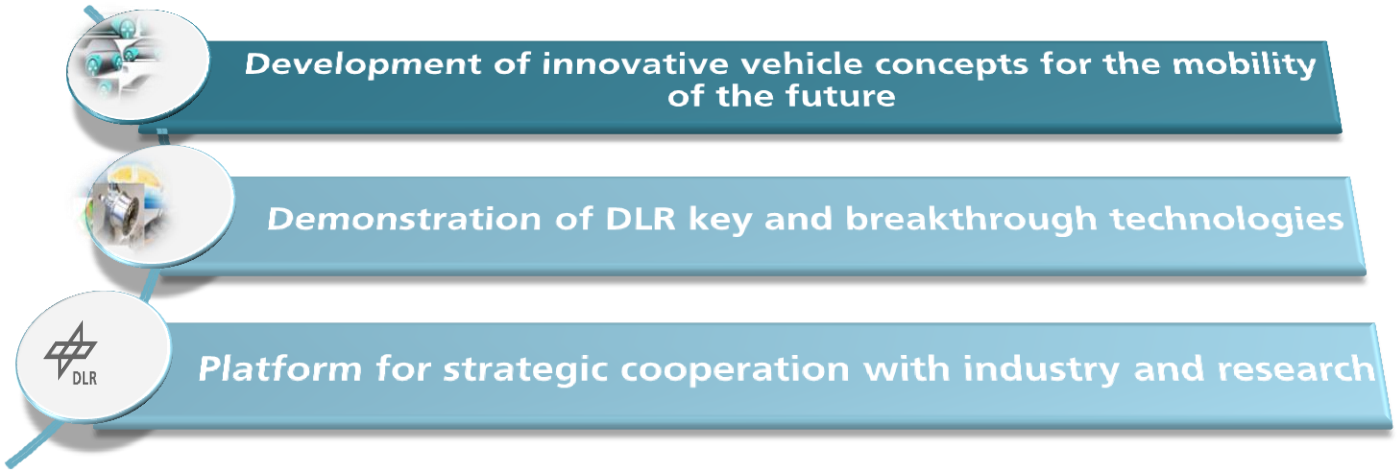
7. Tagung für neue Fahrzeug- und Werkstoffkonzepte
Werkstoff plus Auto, 15.02.2017, Stuttgart

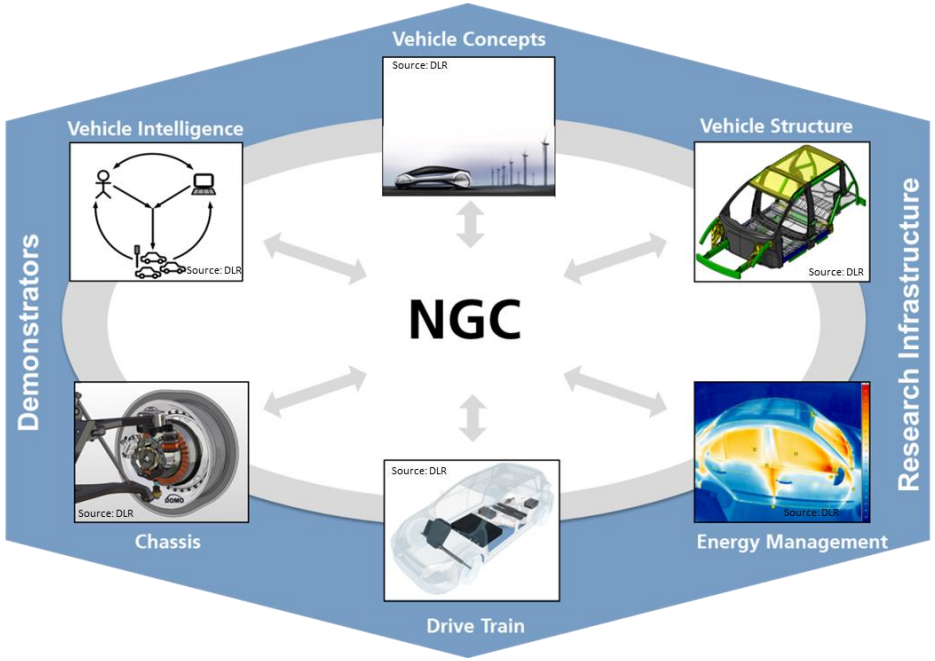
Ge. Kopp, M. Münster, M. Kriescher,
M. Ruff, S. Vohrer, Gu. Kopp

DLR Next Generation Car
Meta Project

DLR Meta Project - *Next Generation Car*

Multiplier for DLR system and technology competence by networking and integrating research institutes, infrastructures and demonstrators



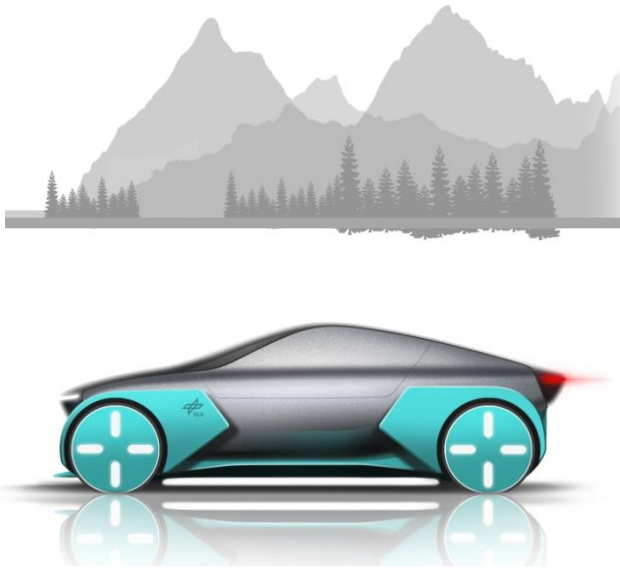


DLR

DLR Next Generation Car

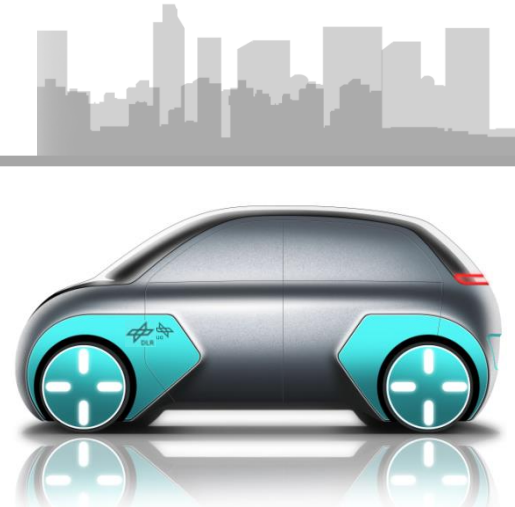
Vehicle concepts and property fields

Save Light Regional Vehicle (SLRV)



Cost-effective, very light and safe vehicle, class L7e

Urban Modular Vehicle (UMV)

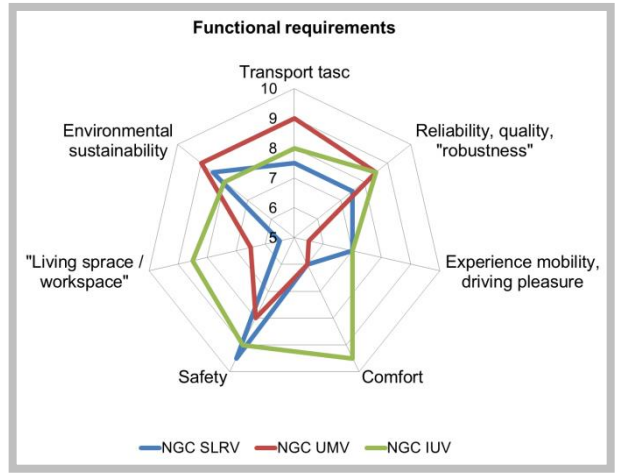


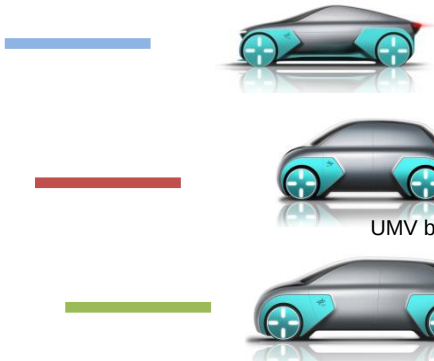
Electric, intelligent, modular

Interurban Vehicle (IUV)

Comfortable fuel cell vehicle with CFRP body

Property Fields*





UMV basic

* compared to vehicles of the same class

Challenges, trends and vehicle innovations (extract)

Globalization

Urbanization

Knowledge Culture

Mobile Commerce

Mixed Mobility / Multimobility

Housing structures, Infrastructure

Connectivity

Industry 4.0

Digitalization

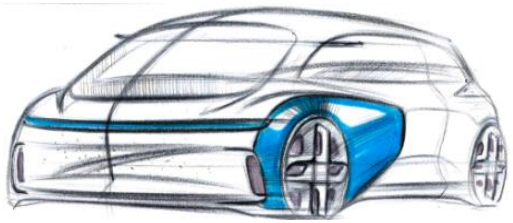
Health

(Car) Sharing

Flexibility

Communication technology/ Smart

Autonomous Driving



Mobility as a service

Internet of Things

New York

Big Data

Individualization

Accessibility

Transit markets

Mobility

Mobility demand

Resources curtness / Peak Oil / energy requirement

Demographic change

Sustainability (Efficiency, consistency, Sufficiency)

Gender Shift

Cradle-to-Cradle / material requirements

Silver Society

Safety – Vehicle and road user

Climate change

E-mobility

Emission

Neo ecology

Safety / Security

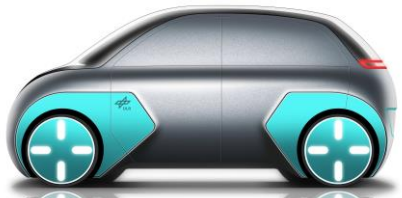
Data source: based on [1, 2, 3]

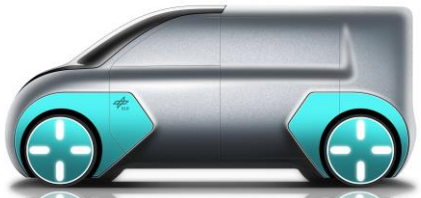
Challenges, trends and vehicle innovations

Autonomous driving and vehicle package

Autonomous with driver's workplace, higher speed

Rinspeed Oasis





NGC UMV Basic und Cargo Long

Autonomous, driverless, lower speed

Local Motors Olli

Navya Arma

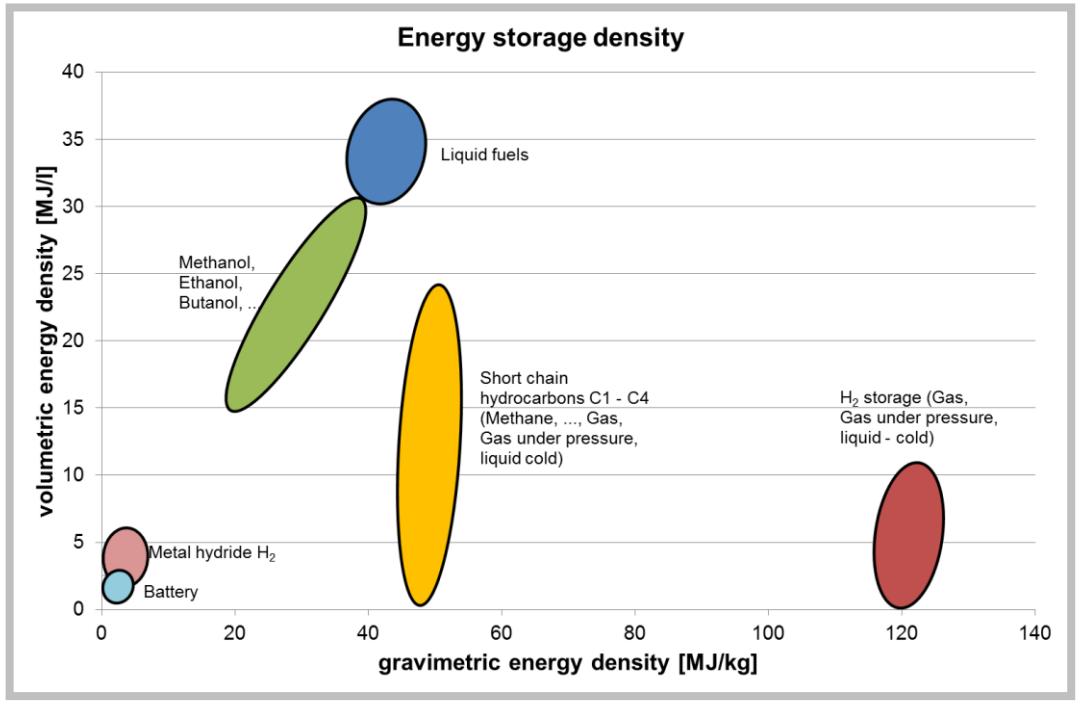
NGC UMV People- und Cargomover Long

➢ **Increasing architecture diversity (derivatives) for different use cases (sharing, pubic transport, …).**

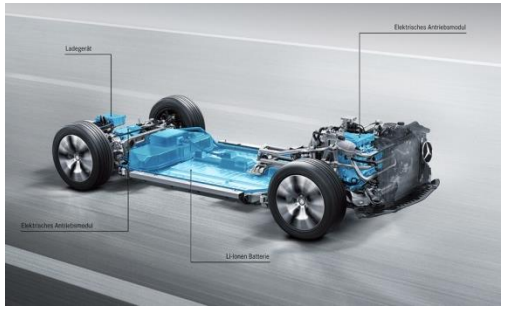
Picture source top: [4, 5, 6]

Challenges, trends and vehicle innovations
Electro mobility and vehicle architecture

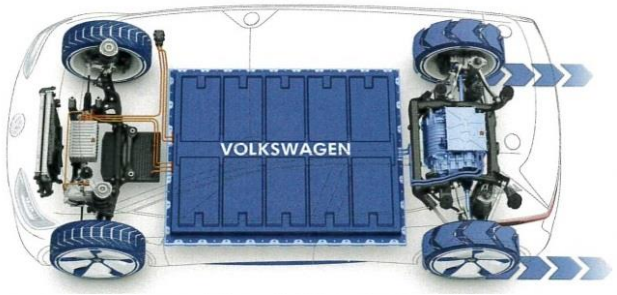
- Lower specific energy densities of alternative storage media and novel vehicle architectures / platforms



Daimler: electric concept



VW: MEB platform



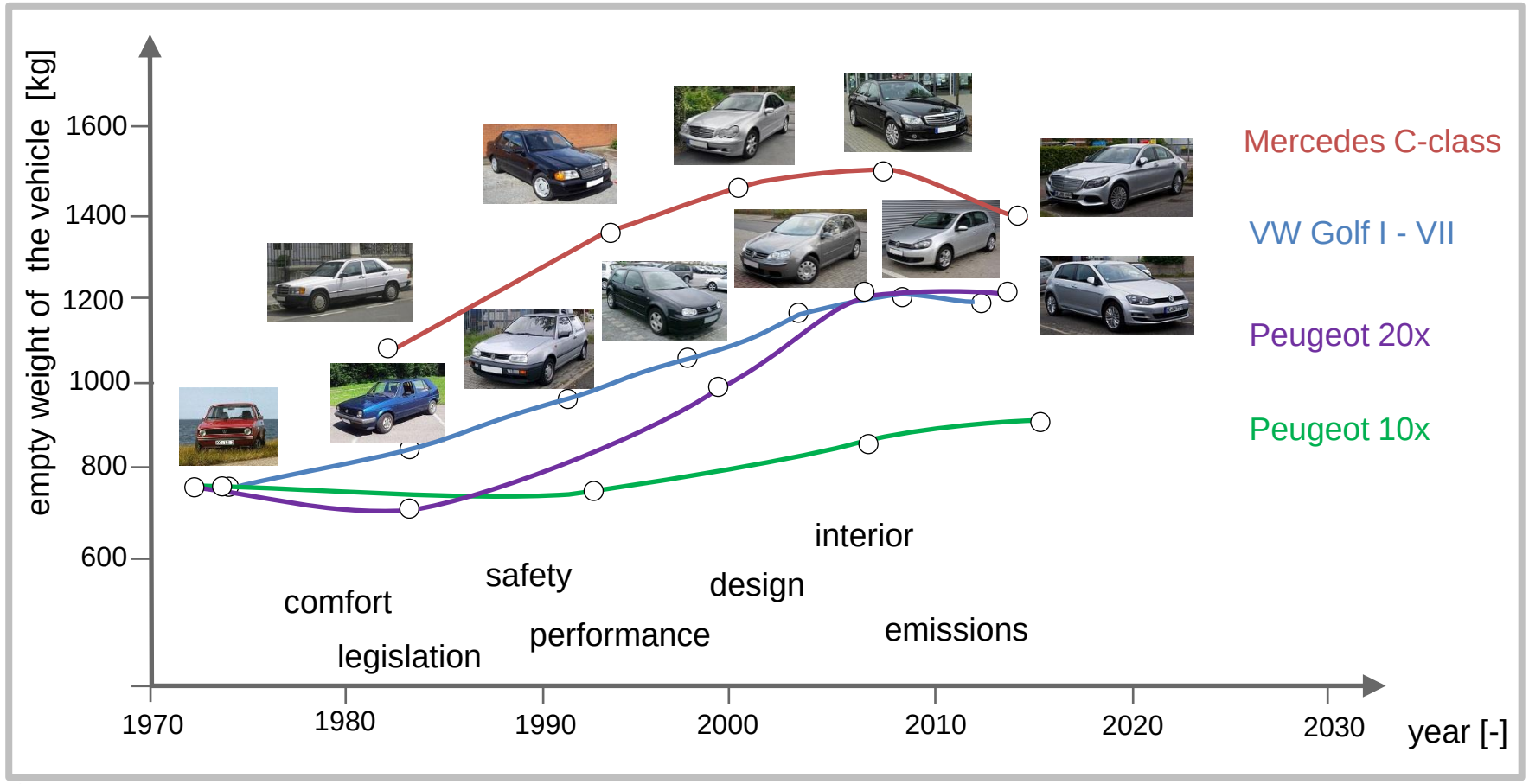
➢ **Variety of drive train and energy storage rises.**

Picture source left: own graph based on literature sources, right: [7, 8]

Challenges, trends and vehicle innovations

Sustainability and vehicle mass

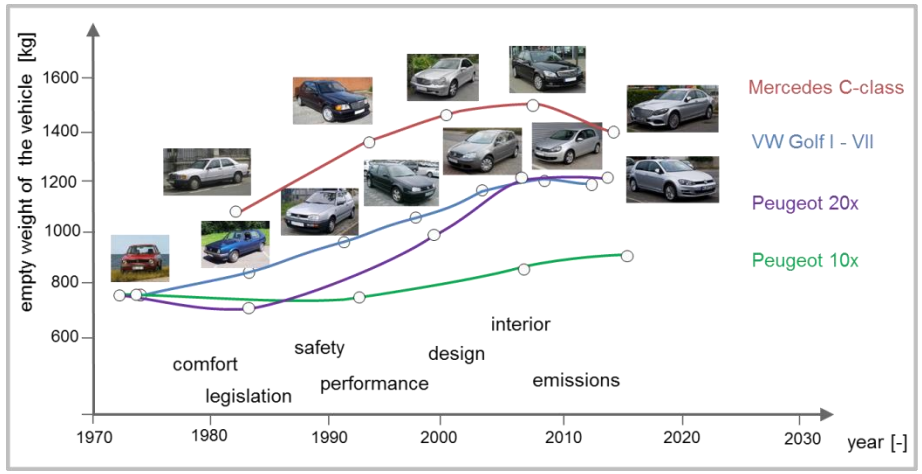
- Increasing total weight with a slightly trend downward

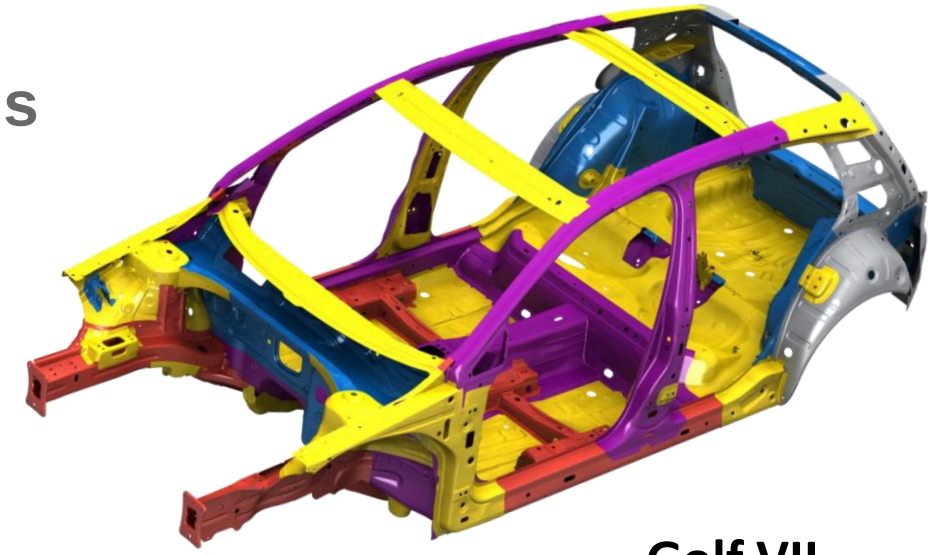


Picture source: Wikipedia, date source: manufacturer

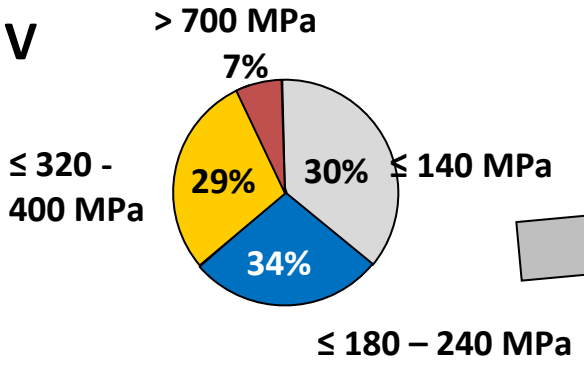
Challenges, trends and vehicle innovations
Sustainability and vehicle mass

- Increasing total weight with a slightly trend downward

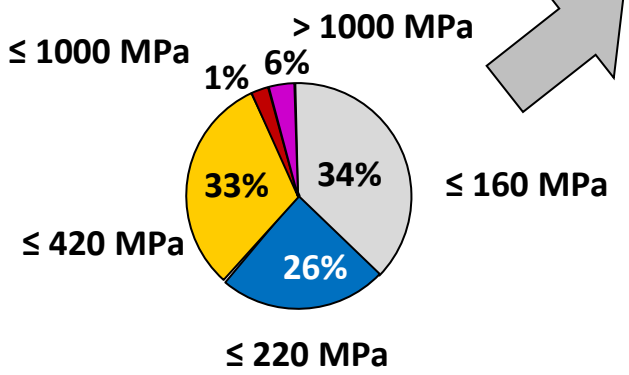




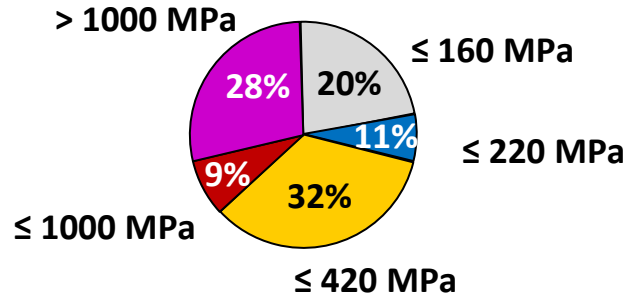
Golf V



Golf VI



Golf VII



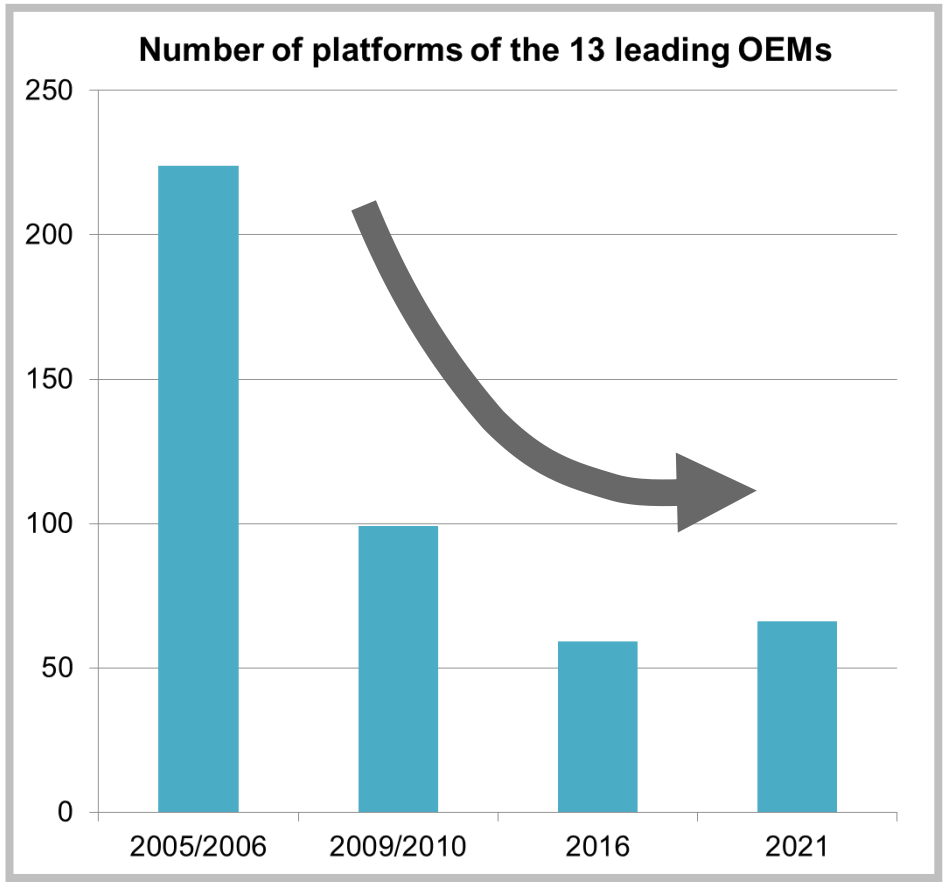
- Mild Steel
- High-Strength Steel
- Highest-Strength Steel
- Advanced-High-Strength Steel
- Ultra-High-Strength Steel, hot formed

➢ **Metallic innovations**

Picture source: Wikipedia, date source: manufacturer, [9, 10, 11]

Challenges, trends and vehicle innovations
Individualization vs. production

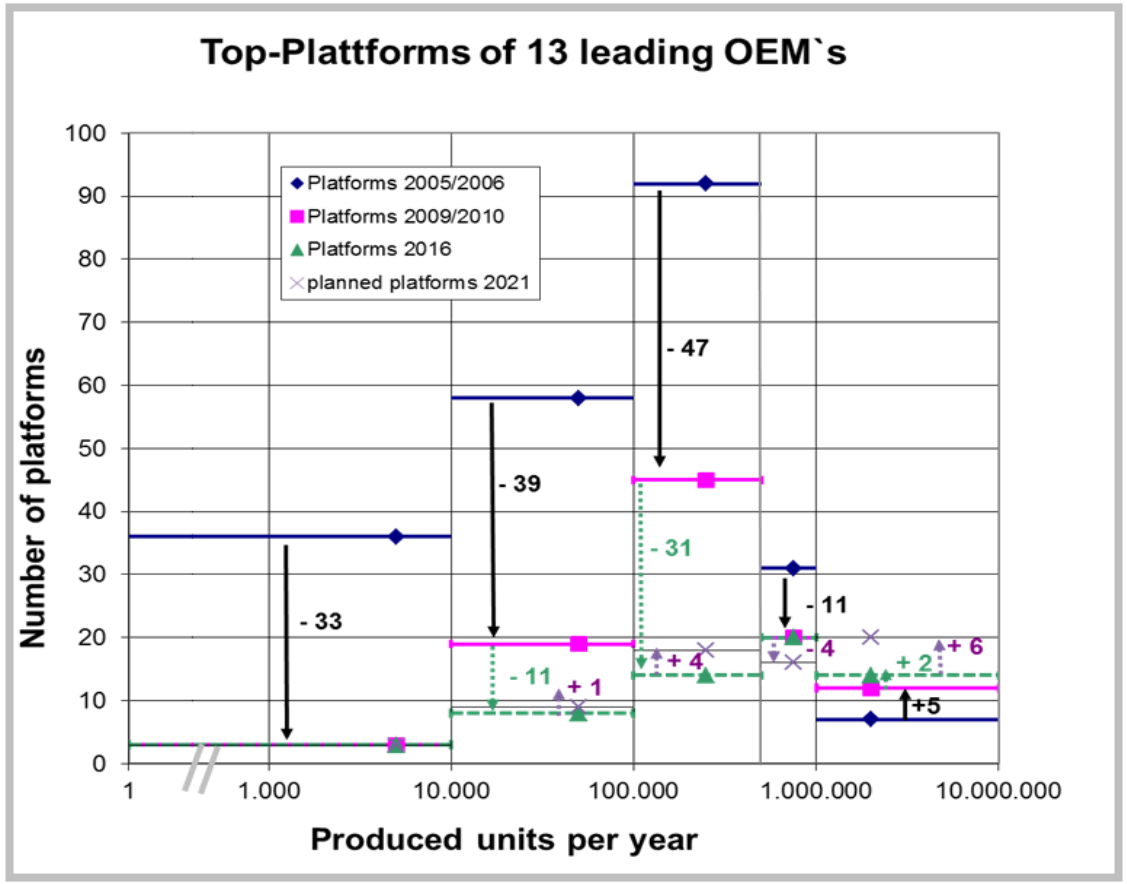
- Despite increasing model diversity: significant tendency to few and large platforms

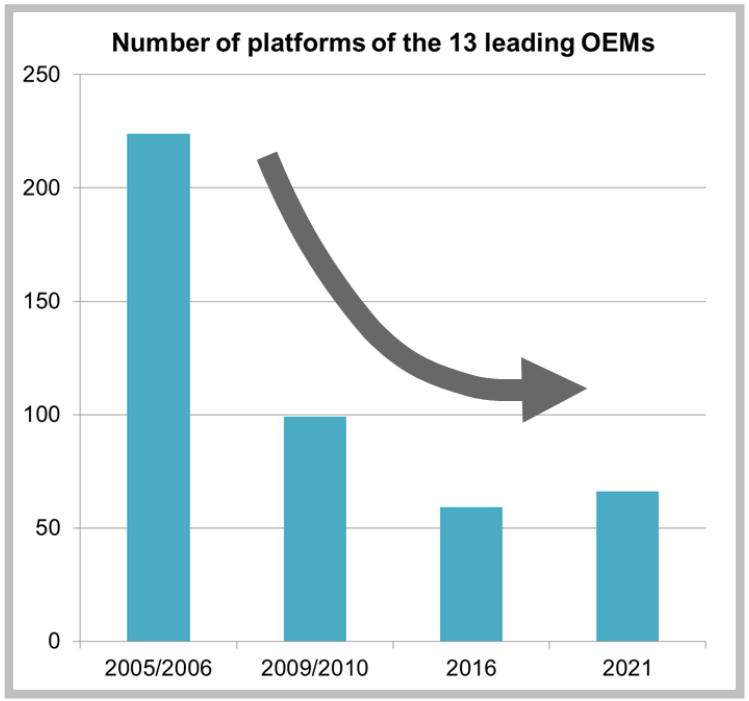


Source: own graph based on [12, 13, 14]

Challenges, trends and vehicle innovations
Individualization vs. production

- Despite increasing model diversity: significant tendency to few and large platforms till 2016





➢ **The importance of optimized platforms and modules increases.**

Source: own graph based on [12, 13, 14]

Objectives of the NGC vehicle concepts

Carriers of technology

NGC SLRV

NGC UMV

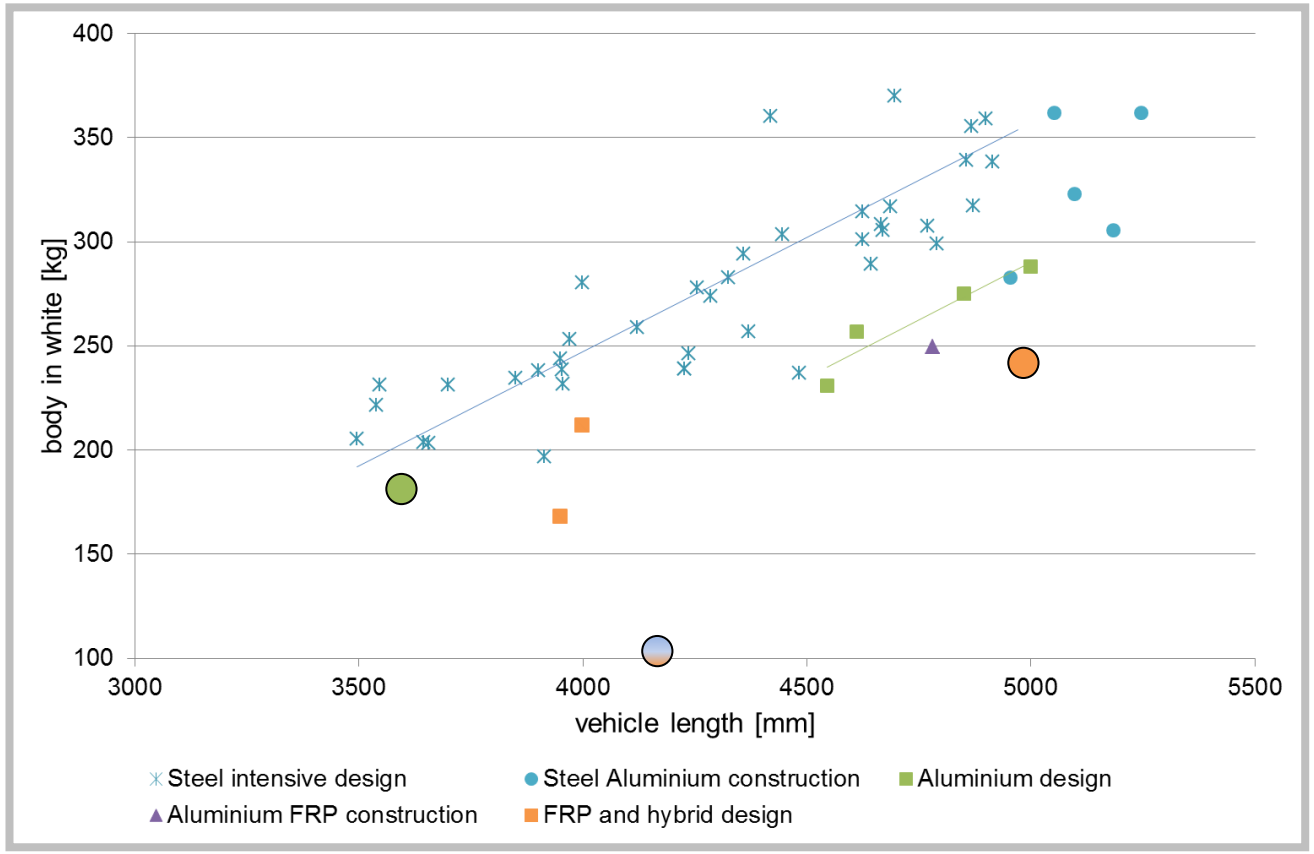
NGC IUV

Customer benefit	NGC SLRV: safe, economic, efficiency	NGC UMV$: mobility-as-a-service, adaptable, intermodal	NGC IUV: comfortable, range, flexible
Autonomous driving	up to SAE-Level 3	up to SAE-Level 5	up to SAE-Level 4
Emission	local zero, H_2 FC	local zero, BEV	local zero, H_2 FC / PHEV
Energy percentage for traction	-	+20%*	+10%*#
Mass	450 kg / < 90 kg BIW	-25% / 680 kg§	-30% / < 250 kg BIW
Range	400 km	urban / modular battery	up to 1000 km
Safety	equivalent to M1	„Safe System Approach“ active & passive	active & passive
Life cycle costs	-25% comp. to SoA	Reduction by modular platform	-25% comp. to SoA

* Real word, summer / winter, ref. BMW i3 2015; # ref. Tesla Model S; § total mass without battery, $ UMV Basic

Objectives of the NGC vehicle structures
Vehicle structure and body in white

- Current developments for material and production based innovations

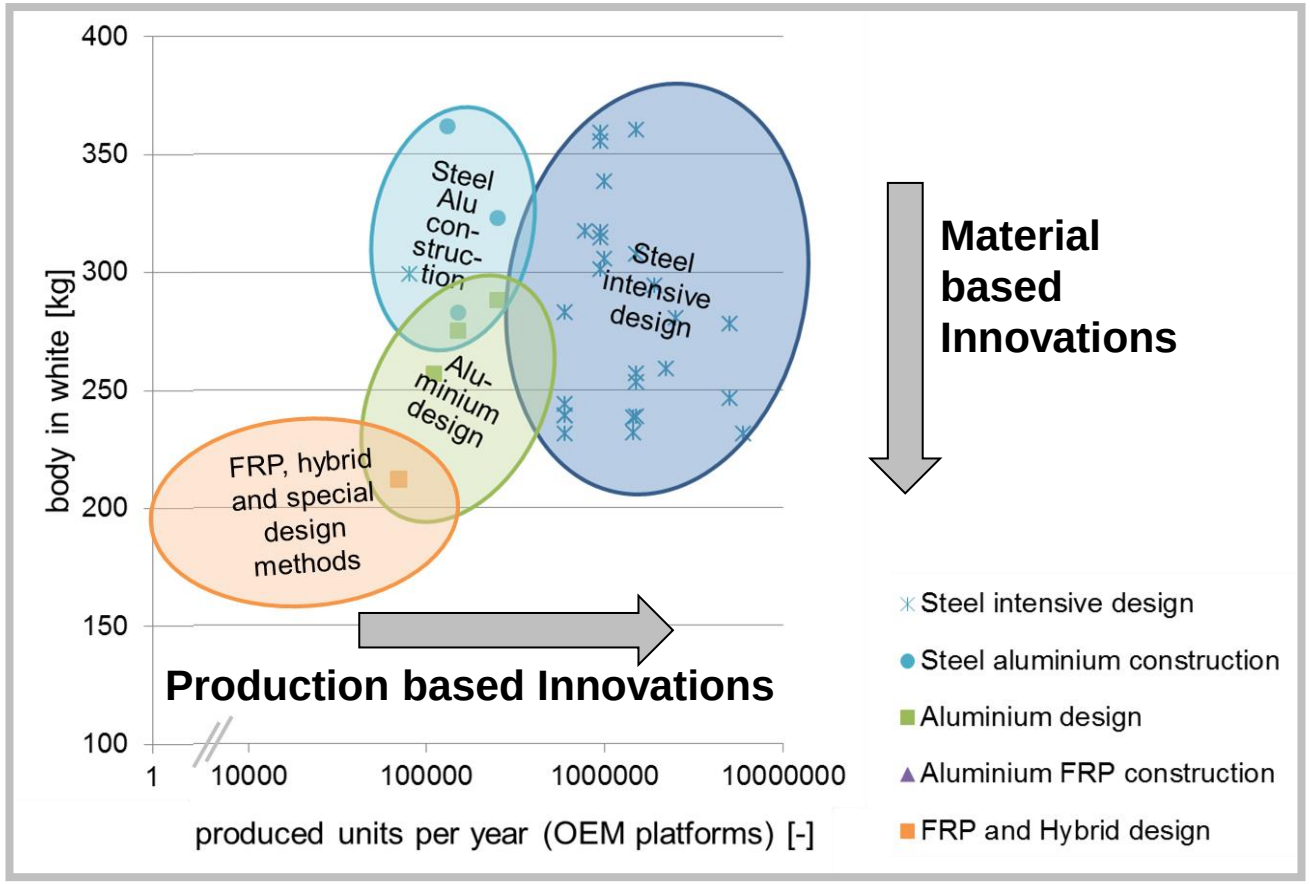


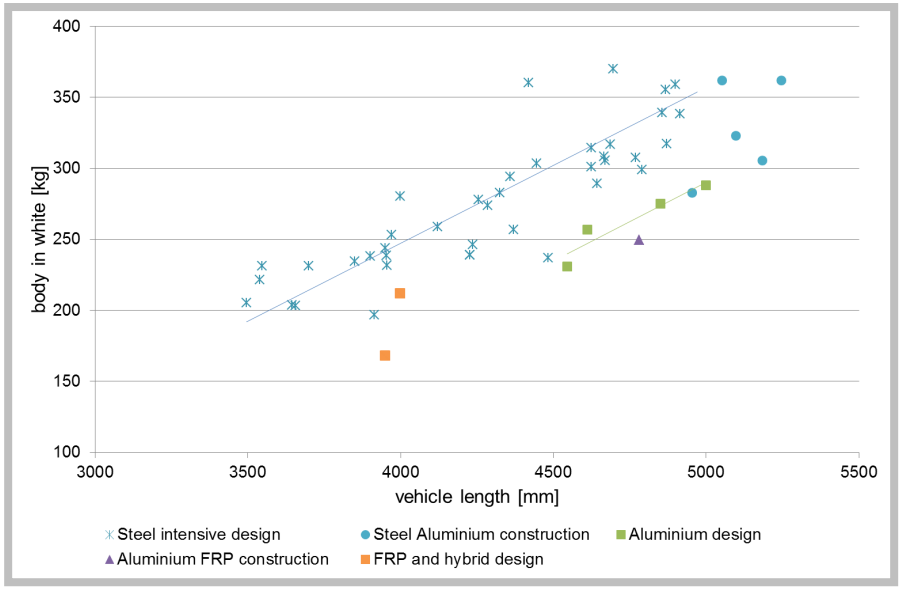
Aim NGC SLRV (L7e class)
Aim NGC UMV (Basic)
Aim NGC IUV

Source: own graph based on literature and manufacturer data 2002 - 2016

Objectives of the NGC vehicle structures
Vehicle structure and body in white

- Current developments for material and production based innovations



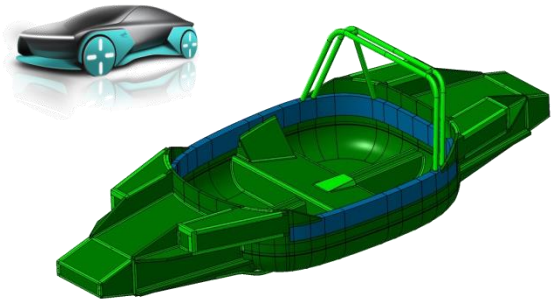


➢ **The combination with an intelligent lightweight design (change of topology) with the right system boundary is necessary.**

Source: own graph based on literature and manufacturer data 2005 - 2016 in combination with [12, 13, 14]

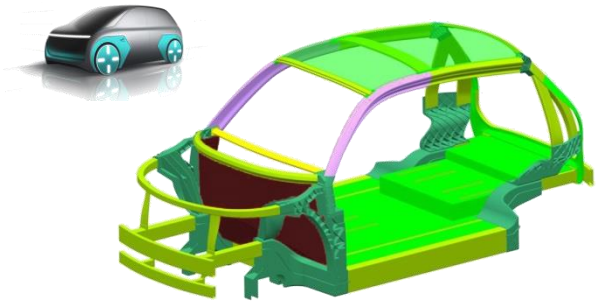
Objectives of the NGC vehicle structures

Save Light Regional Vehicle (SLRV)



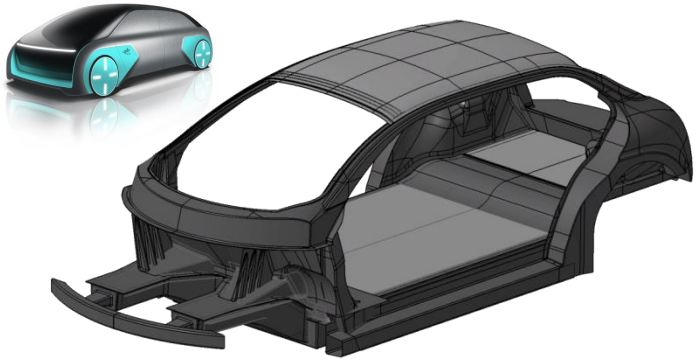
- Metal-foam-sandwich body in white
- Crash safety state of the art of today automotive vehicles (M1 class)
- Body in white mass lower than 90 kg

Urban Modular Vehicle (UMV)



- Modular multi-material-design body in white
- Adaptable safety structure with combination of active and passive safety
- Body in white mass lower than 180 kg

Interurban Vehicle (IUV)

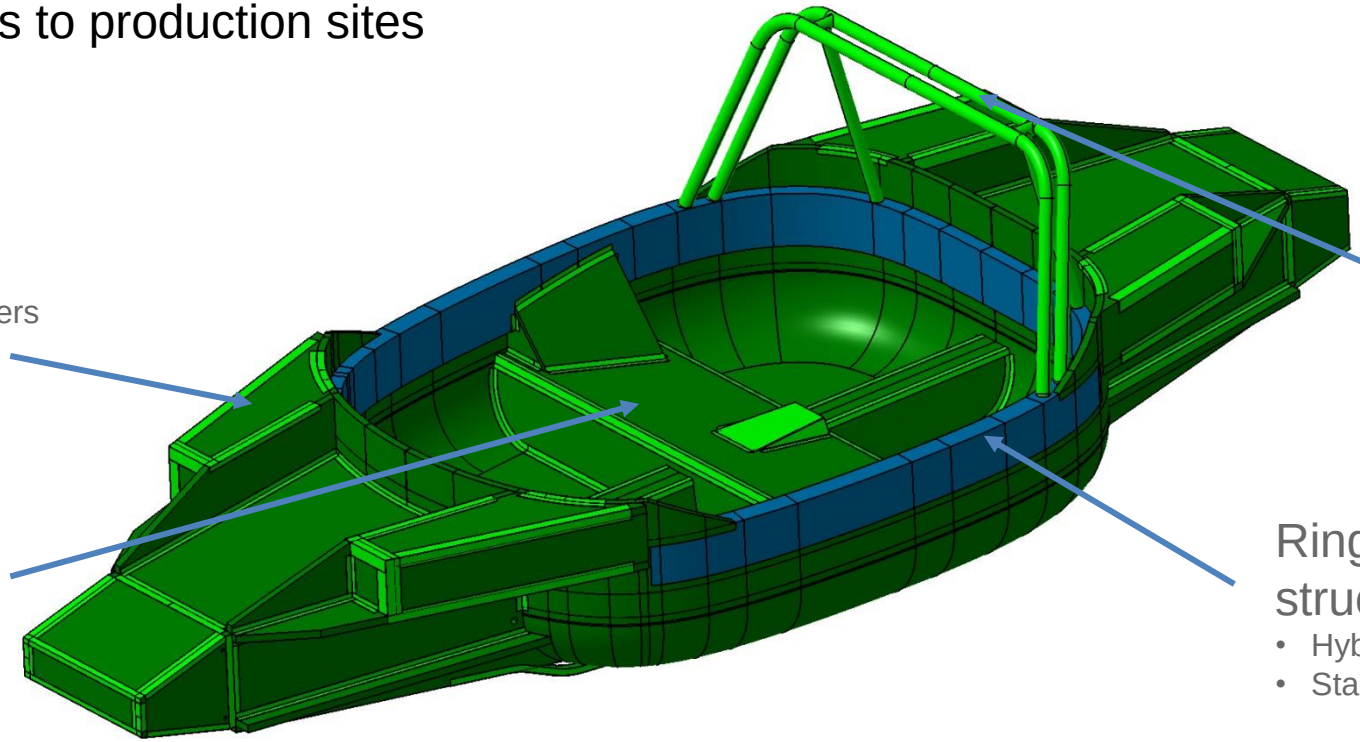


- Fiber reinforced intensive body in white
- Function integrated FRP (e.g. structure integrated sensors)
- Body in white mass lower than 250 kg

NGC vehicle structures
Safe Light Regional Vehicle (SLRV)

- Construction method comparable to prototype car construction
- High crash integrity by using sandwich structure and ring-frame-structure
- Low requirements to production sites

Materials
- Aluminum foam sandwich
- Aluminum profiles
- Cast aluminum
- Ring-frame-structure



Front end structure
- Sandwich plate design
- Aluminum profiles and corners

Roll-over bar

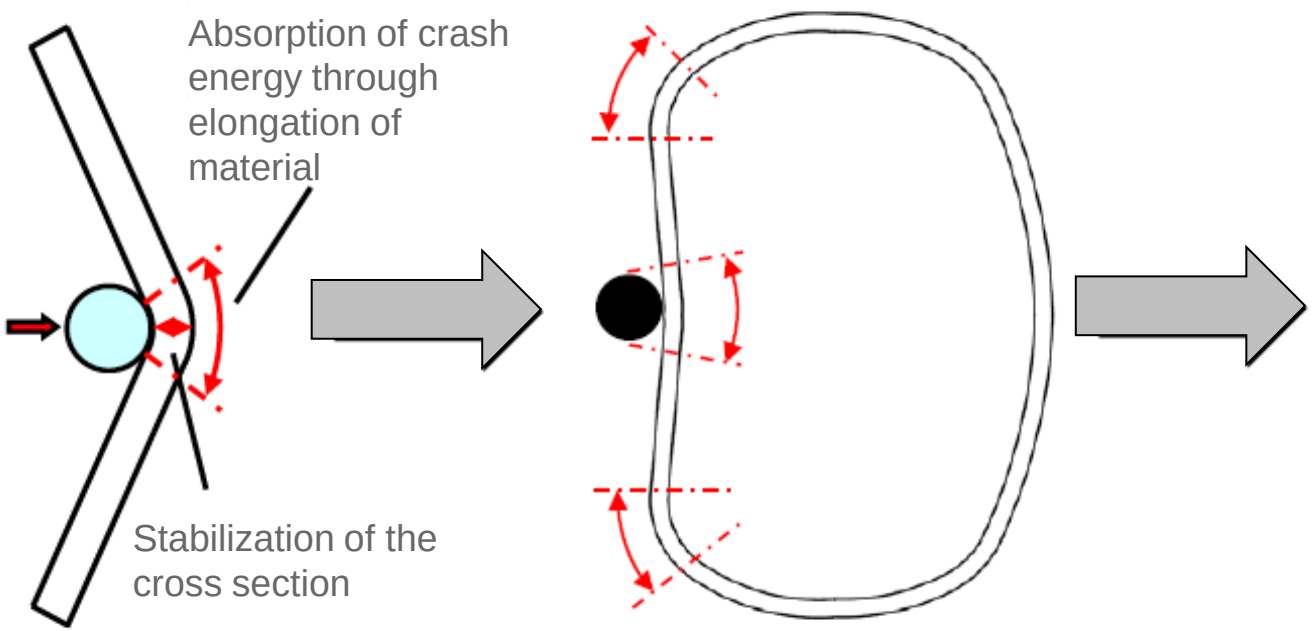
Sandwich floor with integrated seat

Ring-framework-structure
- Hybrid profile
- Stabilizing core

➢ Aluminum foam sandwich construction

Additional information, e.g. [15, 16]

NGC vehicle structures
Safe Light Regional Vehicle (SLRV)



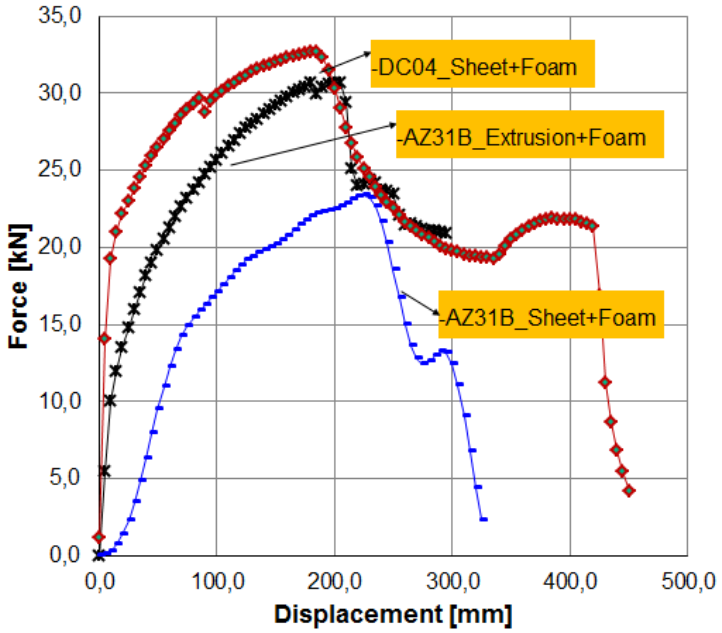
Ring shaped structure should lead to an even better distribution of plastic strain

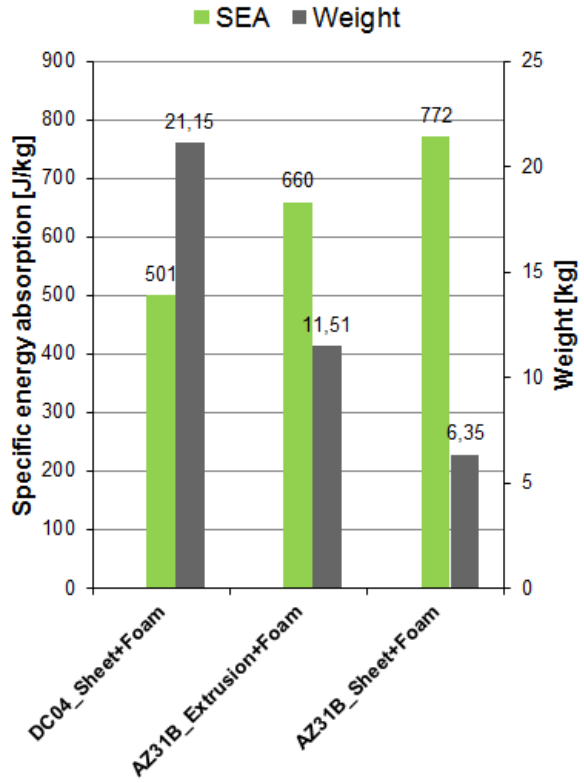
Application:
Ring-shaped frame of a lightweight vehicle concept (metal-monocoque structure)

Additional information, e.g. [15, 16]

NGC vehicle structures
Safe Light Regional Vehicle (SLRV)

- Solution for bending load cases, (bumper beams):
  - Stabilizing the profile with a foam core which to improve fracture behavior and enable higher specific energy absorption



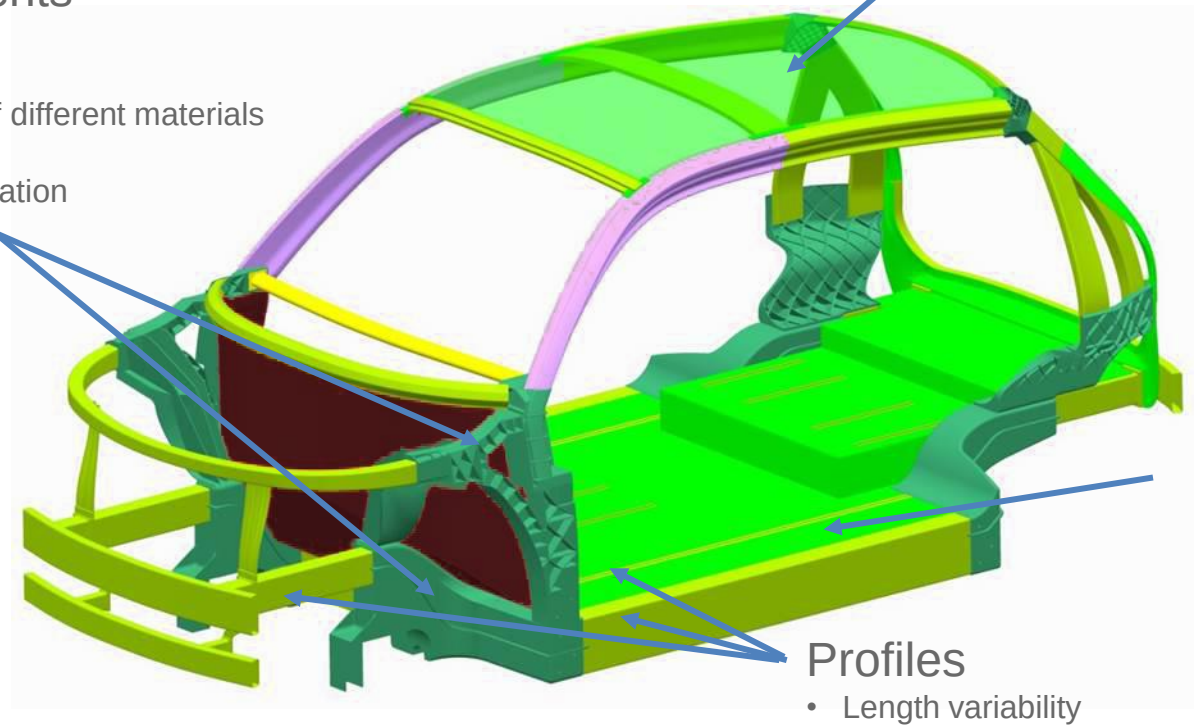


Additional information, e.g. [15, 16]

NGC vehicle structures
Urban Modular Vehicle (UMV)

Node elements
- Cast nodes
- Adaptive node
- Combination of different materials
- modularizing
- Function integration

Shear fields



Materials
- Aluminum sheet
- Aluminum extrusion profiles
- Cast aluminum
- Ultra High Strength Steels
- Fiber reinforced plastics
- Magnesium

Modular architecture

Sandwich plates
- Crash-/Passenger cell area
- Function integration
- loads and functions (for example: air channel)
- modularizing

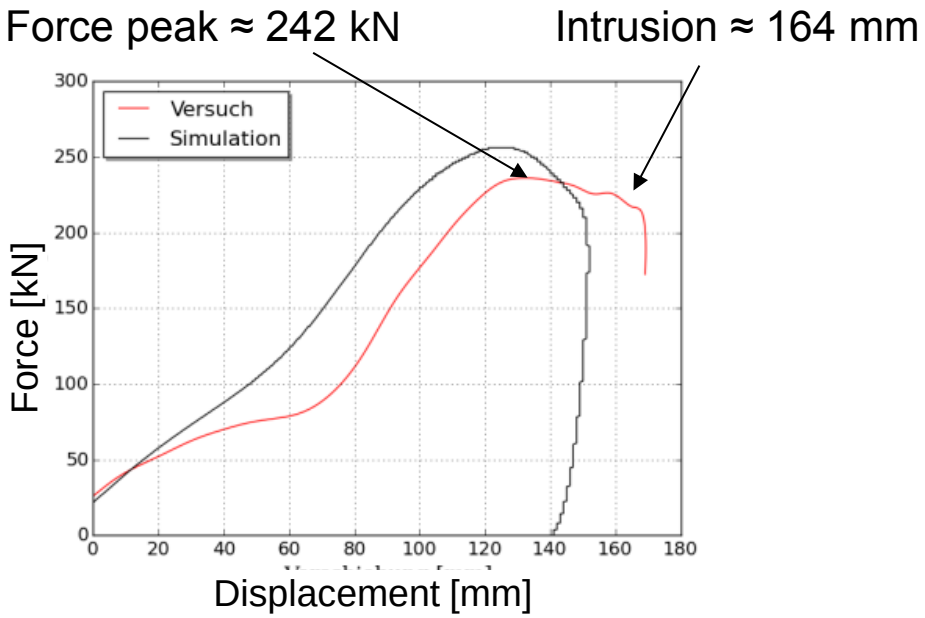
Profiles
- Length variability
- Adaptability
- Function integration

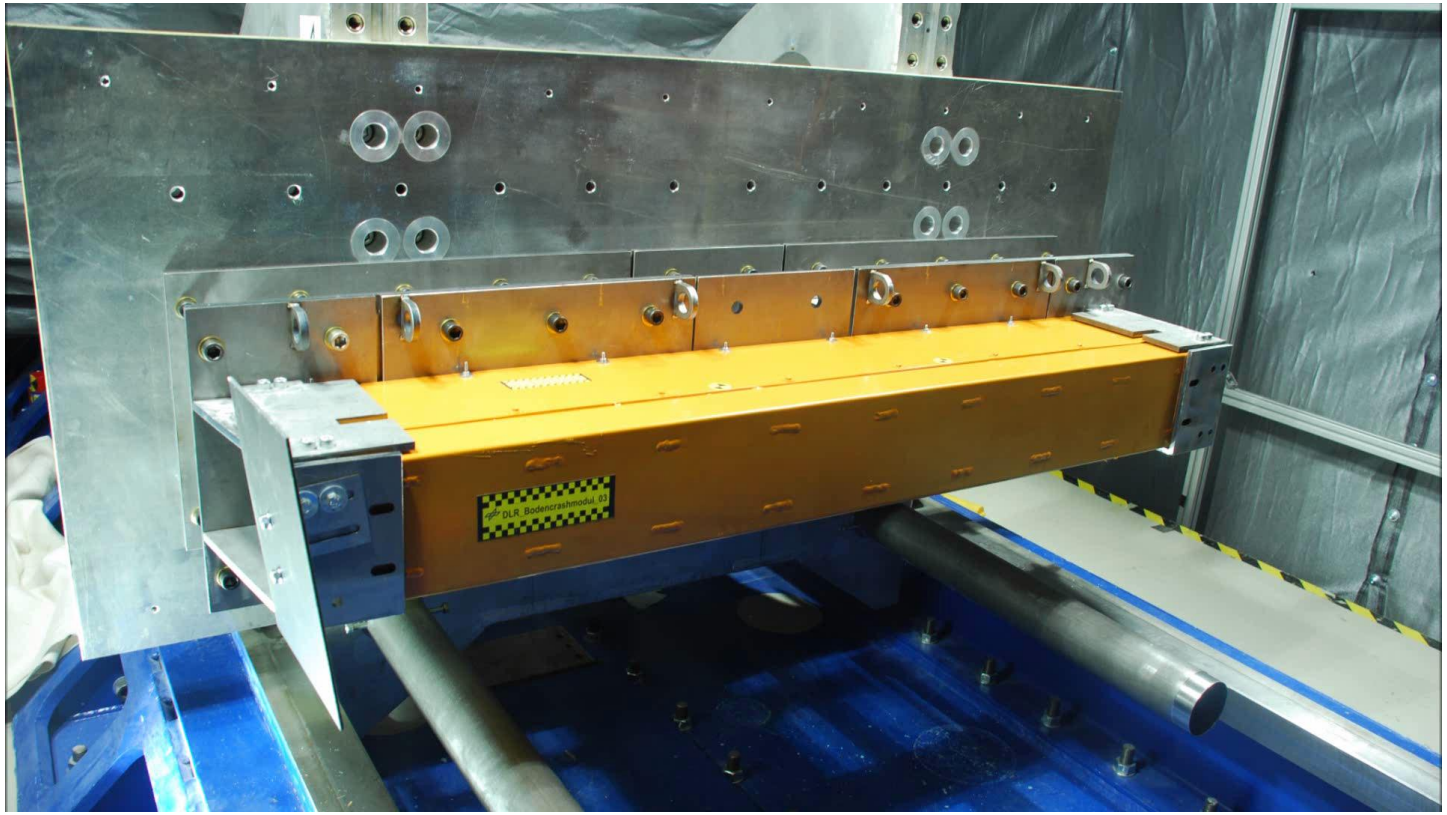
➢ Aluminum intensive frame structure with profiles and nodes with functionally integrated sandwich surfaces and flat components in FRP

Additional information, e.g. [17, 18]

NGC vehicle structures
Urban Modular Vehicle (UMV)

- Impact mass 750 kg
- Euro NCAP Poletest
- v = 29 km/h

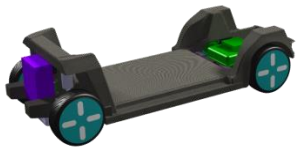


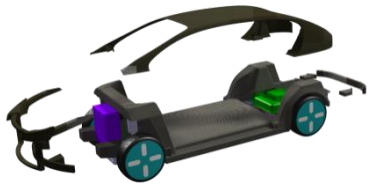


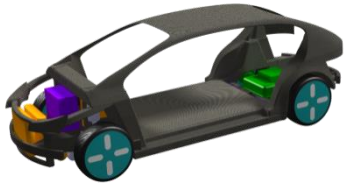
Additional information, e.g. [17, 18]

NGC vehicle structures
Inter Urban Vehicle (IUV)

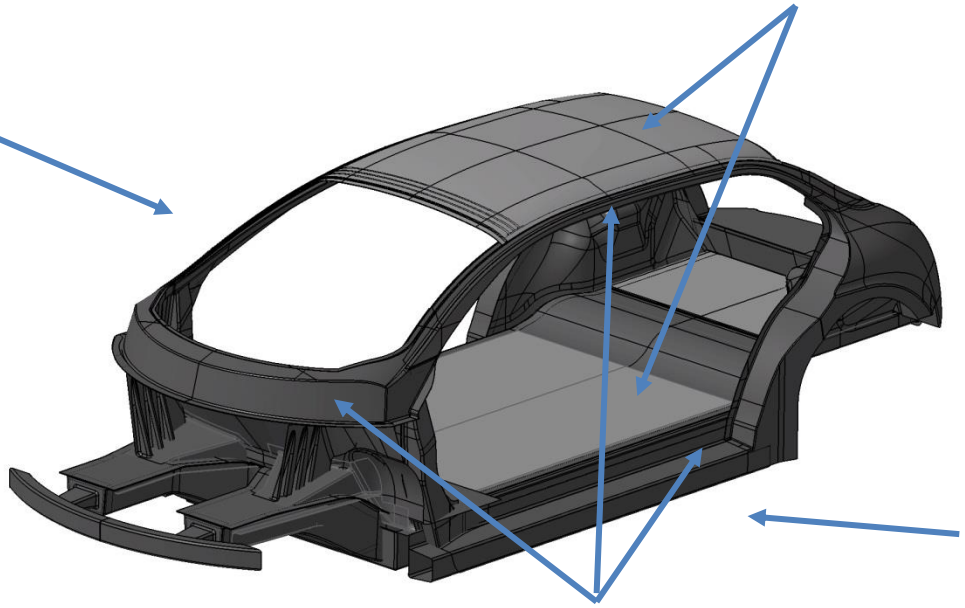
Construction concept
- Rolling Chassis concept
- FRP intensive
- High functional integration







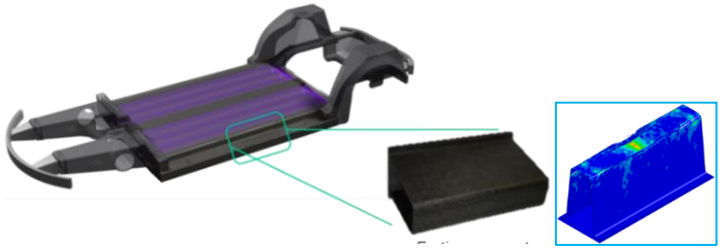
Shear fields and floor
- e.g. functional integrated sandwich design



Materials
- Aluminium sheet
- Aluminium extrusion profiles
- Cast aluminium
- Ultra High Strength Steels
- Fibre reinforced plastics (Profils and sheets)
- Fibre reinforced plastics (Sandwich)

Safety concept
- Intrusion-resistant passenger compartment for protection of occupants and integrated energy storage tanks (H_2 tanks)
- Energy consumption concentrated on sill area

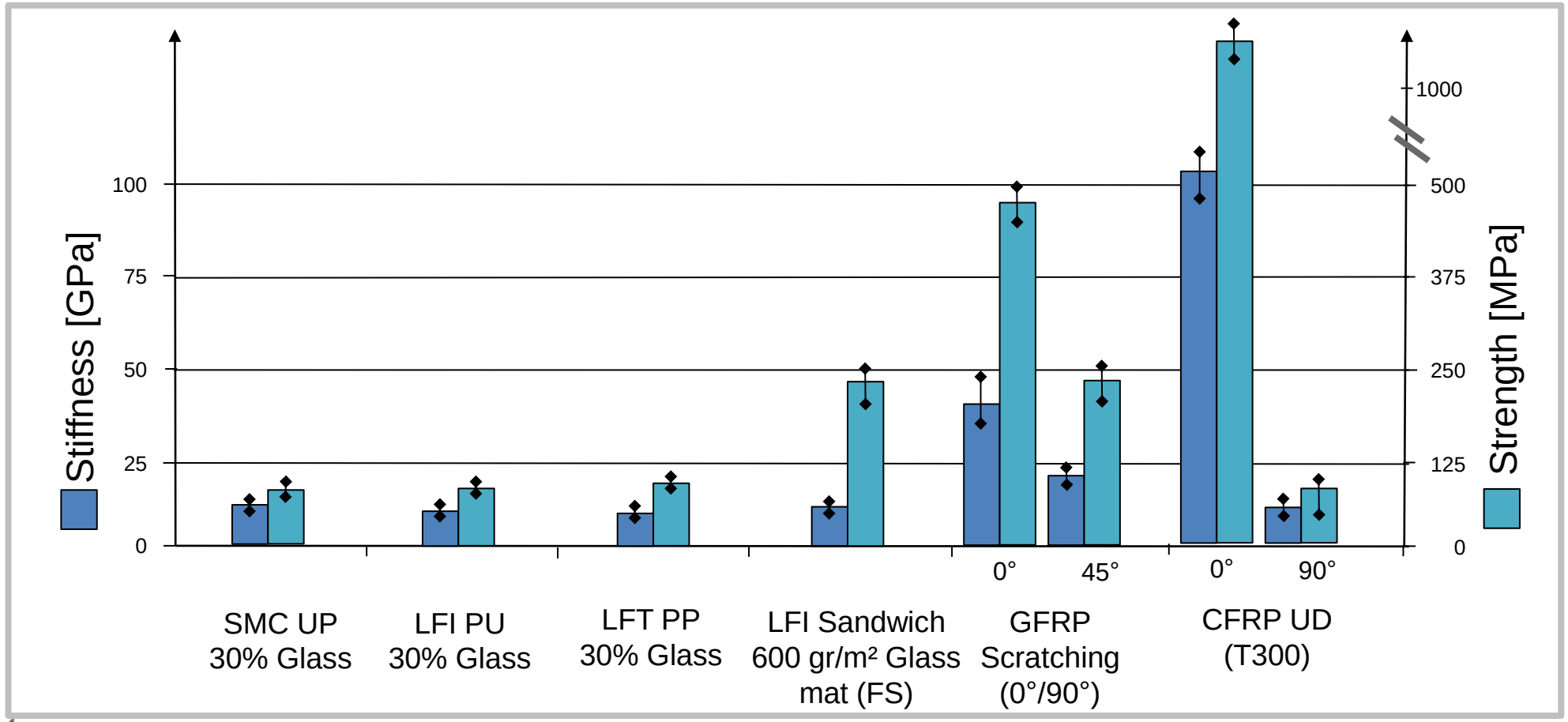
Profiles and unidirectional loaded components
- Optimization of the layer structure



Additional information, e.g. [19, 20]

NGC vehicle structures
Inter Urban Vehicle (IUV)

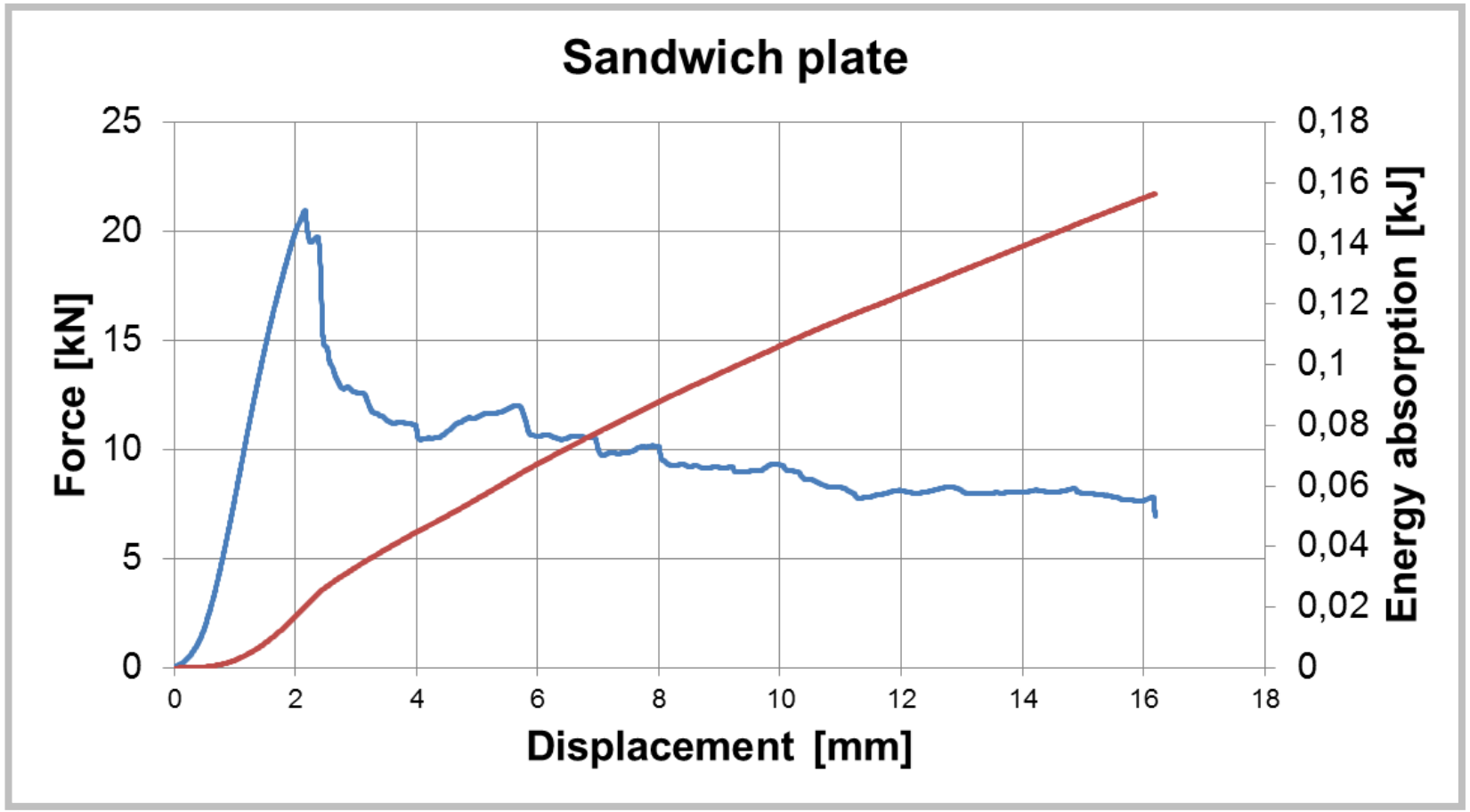
- Challenge: use of the right topology, materials and manufacturing processes



Compilation from own measurements

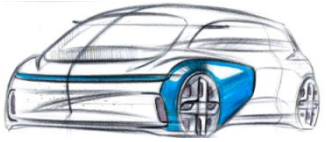
NGC vehicle structures
Inter Urban Vehicle (IUV)

- Example: crushing of „in plane loaded“ sandwich plates

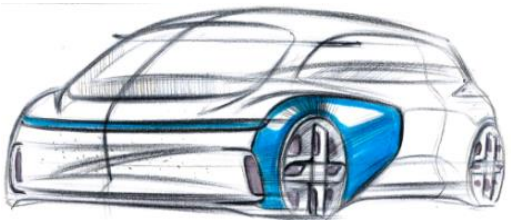


* Sandwich plate: L/B/H: 200mm x 210mm x 30mm; mass: 170 gr. / app. 4 kg/m²; faces: randomly oriented glass fiber with polyurethane matrix; core: paper based honeycombs

Summary and Outlook



- Future trends, such as automation, digitalization and electro mobility, will have a significant impact on vehicle architecture and structural design.
- Due to the increasing variety of variants (vehicle concepts, electro mobility, materials, …), the production must become more flexible and modular.
- In order to support specific requirements (emissions, energy consumption, range, driving dynamics, safety, costs, modularity, …) intelligent multi material design and lightweight construction (optimization of construction, materials, manufacturing processes, system boundaries) are necessary.
- DLR is addressing the different technological challenges with their Next Generation Car Project (NGC).



Thank you

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