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

- Development of innovative vehicle concepts for the mobility of the future
- Demonstration of DLR key and breakthrough technologies
- Platform for strategic cooperation with industry and research
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*

* compared to vehicles of the same class
Challenges, trends and vehicle innovations (extract)

- **Urbanization**
  - Housing structures, Infrastructure

- **Connectivity**
  - Communication technology/ Smart
  - Internet of Things
  - Transit markets

- **New York**
  - Resources curtness / Peak Oil / energy requirement

- **Gender Shift**
  - Cradle-to-Cradle / material requirements

- **Globalization**
  - Mobile Commerce
  - Mixed Mobility / Multimobility

- **Knowledge Culture**
  - Industry 4.0
  - Digitalization

- **New York**
  - (Car) Sharing
  - Autonomous Driving
  - Big Data

- **Health**
  - Flexibility
  - Mobility as a service
  - Accessibility

- **Individualization**
  - Mobility demand

- **Silver Society**
  - Demographic change
  - Safety – Vehicle and road user

- **Neo ecology**
  - Climate change

- **Safety / Security**
  - E-mobility
  - Emission

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
- NGC UMV People- und Cargomover Long
- Navya Arma

- Increasing architecture diversity (derivatives) for different use cases (sharing, public transport, …).
Challenges, trends and vehicle innovations
Electro mobility and vehicle architecture

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

Variety of drive train and energy storage rises.

Daimler: electric concept

VW: MEB platform

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
Challenges, trends and vehicle innovations
Sustainability and vehicle mass

- Increasing total weight with a slightly trend downward

**Metallic innovations**
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

<table>
<thead>
<tr>
<th>Customer benefit</th>
<th>NGC SLRV: safe, economic, efficiency</th>
<th>NGC UMV*: mobility-as-a-service, adaptable, intermodal</th>
<th>NGC IUV: comfortable, range, flexible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomous driving</td>
<td>up to SAE-Level 3</td>
<td>up to SAE-Level 5</td>
<td>up to SAE-Level 4</td>
</tr>
<tr>
<td>Emission</td>
<td>local zero, H₂ FC</td>
<td>local zero, BEV</td>
<td>local zero, H₂ FC / PHEV</td>
</tr>
<tr>
<td>Energy percentage for traction</td>
<td>-</td>
<td>+20%*</td>
<td>+10%*#</td>
</tr>
<tr>
<td>Mass</td>
<td>450 kg / &lt; 90 kg BIW</td>
<td>-25% / 680 kg§</td>
<td>-30% / &lt; 250 kg BIW</td>
</tr>
<tr>
<td>Range</td>
<td>400 km</td>
<td>urban / modular battery</td>
<td>up to 1000 km</td>
</tr>
<tr>
<td>Safety</td>
<td>equivalent to M1</td>
<td>„Safe System Approach“ active &amp; passive</td>
<td>active &amp; passive</td>
</tr>
<tr>
<td>Life cycle costs</td>
<td>-25% comp. to SoA</td>
<td>Reduction by modular platform</td>
<td>-25% comp. to SoA</td>
</tr>
</tbody>
</table>

* 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

![Graph showing vehicle length vs body in white weight for different designs and materials.]

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

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

Sandwich floor with integrated seat

Roll-over bar

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

Aluminum foam sandwich construction
NGC vehicle structures
Safe Light Regional Vehicle (SLRV)

Absorption of crash energy through elongation of material

Stabilization of the cross section

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
NGC vehicle structures
Urban Modular Vehicle (UMV)

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

Modular architecture

Shear fields

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

Profiles
- Length variability
- Adaptability
- Function integration

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

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

Force peak $\approx 242$ kN
Intrusion $\approx 164$ mm

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

Profiles and unidirectional loaded components
- Optimization of the layer structure

Safety concept
- Intrusion-resistant passenger compartment for protection of occupants and integrated energy storage tanks (H\textsubscript{2} tanks)
- Energy consumption concentrated on sill area

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

Additional information, e.g. [19, 20]
NGC vehicle structures
Inter Urban Vehicle (IUV)

- Challenge: use of the right topology, materials and manufacturing processes
NGC vehicle structures
Inter Urban Vehicle (IUV)

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

![Sandwich plate diagram](image)

* 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
Source


Source

Source


