Overview on physical demonstrators

Jens Meschke / Volkswagen AG
Overall objectives of physical demonstrators

- European carmakers (CRF, Daimler, Opel, TME, Volvo, VW) and suppliers (Batz, Benteler, Novelis, tkse) have joined forces to commonly develop innovations in vehicle lightweighting (mass reduction of ~25%) focusing on costs (3 €/kg @100,000 u.p.a.) and global warming potential (LCA impact -6%).

- In work package WP5 the ALLIANCE consortium was working on eight different demonstrators of real vehicle models. The demonstrators “Integrated rails, wheel house and strut tower” by Opel and the “Rear bumper reinforcement” by TME are virtually demonstrated only.

This presentation encompasses design, optimization and prototyping of the following physical demonstrator parts:
Front door hybrid structure for an automatically driven electric vehicle / VW

- Reference door steel concept
- Lightweighting by multi-material approach
- Quantity 100,000 p.a.
- Comparison life cycle 200,000 km vs. 600,000 km
- Door prototype as demonstrator only (no testing)
Front door hybrid structure for an automatically driven electric vehicle / VW

<table>
<thead>
<tr>
<th>Nr.</th>
<th>Part</th>
<th>Conventional steel design</th>
<th>Lightweight design</th>
<th>CO₂-emissions [kgCO₂-eq.]*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Material</td>
<td>t [mm]</td>
<td>m [kg]</td>
</tr>
<tr>
<td>1</td>
<td>Glazing</td>
<td>Polycarbonate</td>
<td>3,0</td>
<td>3,5</td>
</tr>
<tr>
<td>2</td>
<td>Outer panel</td>
<td>CR180BH</td>
<td>0,7</td>
<td>6,5</td>
</tr>
<tr>
<td>3</td>
<td>Closing plate B-pillar</td>
<td>CR300LA</td>
<td>2,0</td>
<td>5,8</td>
</tr>
<tr>
<td>4</td>
<td>Reinforcement B-pillar</td>
<td>CR1350Y1700T-MS</td>
<td>1,8</td>
<td>7,9</td>
</tr>
<tr>
<td>5</td>
<td>Side protection bar</td>
<td>CR700Y980T-DP</td>
<td>1,35</td>
<td>1,3</td>
</tr>
<tr>
<td>6</td>
<td>Crash bar</td>
<td>CR210LA</td>
<td>1,2</td>
<td>0,7</td>
</tr>
<tr>
<td>7</td>
<td>Waste rail profile</td>
<td>CR240LA</td>
<td>1,5</td>
<td>2,0</td>
</tr>
<tr>
<td>8</td>
<td>Reinforcement lock</td>
<td>CR210LA</td>
<td>1,0</td>
<td>0,7</td>
</tr>
<tr>
<td>9</td>
<td>Inner panel</td>
<td>CR4</td>
<td>0,8</td>
<td>10,7</td>
</tr>
</tbody>
</table>

*CO₂-emissions in comparison to conventional steel design

<table>
<thead>
<tr>
<th>Nr. Part</th>
<th>Conventional steel design</th>
<th>Lightweight design</th>
<th>CO₂-emissions [kgCO₂-eq.]*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abs.</td>
<td>39,1</td>
<td>Abs. 28,1</td>
<td>-41,7</td>
</tr>
<tr>
<td>Abs.</td>
<td>28,1</td>
<td>-130,8</td>
<td>-28%</td>
</tr>
</tbody>
</table>

Weight saving achieved: - 27 %
Achieved reduction in GWP: - 42 kg CO₂ equ.
Additional costs in €/kg-saved: + 1,56 € / kg saved (determined by BaxCo)
Comparison of reference and ALLIANCE final design

**Initial concept**
- One piece inner panel
- 3 piece ringframe for material yield
- Hinge & lock reinforcements c/o steel design

**Developed concept**
- One piece inner panel
- 1 piece ringframe for assembly & geometry
- Hinge & lock reinforcements extended for frame stiffness
- Lower reinforcement for increased stiffness
# Main features of the final design

- **BoM**, foreseen/applied manufacturing technologies, weight saving achieved, achieved reduction in GWP, additional costs in €/kg-saved + picture(s)

## Manufacturing

### Forming
- Panels, reinforcements, sidemember
  - Cold deep/stretch drawing
  - Hot forming considered but not applied

### Joining
- Rivet & adhesives
- Reinforcements to panel
- Laser welding
- Ringframe to window frame
- Bolting
- Side member

## Material highlights

- **Inner panel**: 6016 High formability “Advanz™ 6HF – e200” t 1.2 mm
- **Outer panel**: 6016 Strength & hemming perf “Advanz™ 6F – e170” t 1.0 mm
- **Reinforcements**: 6451 High strength “Advanz™ 6F – s600SPX” t 1.2 – 3.0
- **Sidemember**: UHSS DP1000 t 1.5

## Achievements for design equivalent to steel

- **Weight saving**: 35 % or 6kg / frt door
- **Reduction in GWP**: - 57.0 kg CO2 equ (scaling XC90 design)
- **Additional costs in €/kg-saved**: + 4.5 € / kg saved (est from calculations BaxCo)

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This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723839
Rear floor pan / Toyota Motor Europe

- Lightweight through use of alternate materials and joining technology.

<table>
<thead>
<tr>
<th>Reference (Steel rear floor pan)</th>
<th>Concept (Plastic PP + 40% long glass fibre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drawn galvannealed steel sheet joint by spot weld</td>
<td>Injected LGF-PP bonded to E-coated steel sheet</td>
</tr>
</tbody>
</table>

- Shape optimization using BATZ technology: IMC (Injection Molding Compound) + WIT (Water Injection Technology)
- Initial geometry developed using topology simulation
- Full vehicle & cut body demonstrators produced to validate production feasibility and performance

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723839
Weight saving achieved: -25%
Achieved reduction in GWP: -20.2% kgCO₂ eq.
Additional cost in €/kg-saved: +4.6 € / kg saved (determined by BaxCo)
**Hood / Centro Ricerche Fiat**

- Reference Fiat 500 steel concept
- Lightweighting approach by light alloy introduction and reinforcement integration exploiting multi-thickness patchwork solution
- Quantity 100’000 vehicles per year
- Physical demonstrator is manufactured

**Diagram:**
- Material input: Raw blank, Reinforcement blank
- Cut station
- Stamping station
- Positioning and welding on plow
- Structural frame
- Cut and finishing

**Manufacturing line:**

**Spotweld:**
- Optimized position
- Manufacturing line
- Patch after structural panel stamping operations

**Micrography:**
- Spotweld between 0.6-2.0 mm Al sheets section micrography

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*European Union’s Horizon 2020 grant agreement No 723839*
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Front bumper beam (aluminium) / CRF / BENTELER

- Reference Jeep Renegade aluminum 6000 class design
- Lightweighting approach by light alloy introduction of class AA-7003
- Proved feasibility of low thickness extrusion of aluminum alloy 7003 at 1.8 mm wall thickness (Novelty!)
- Weight reduction design with local reinforcement optimization

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**Section A - A**

**Thickness measurement**

1.81 mm

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Crashbox to Beam
Reinforcement to Beam
Crashbox to Reinforcement

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Image: Research and innovation programme under grant agreement No 723839
Front bumper beam (aluminium) / CRF / BENTELER

Part Brakedown

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>Lightweight design</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Thickness</td>
<td>Material</td>
</tr>
<tr>
<td>Flange plates</td>
<td>2</td>
<td>2.5 &amp; 5.0</td>
</tr>
<tr>
<td>Crash boxes</td>
<td>2</td>
<td>2.3 to 2.7</td>
</tr>
<tr>
<td>Beam</td>
<td>1</td>
<td>2.2 to 2.7</td>
</tr>
<tr>
<td>Reinforcements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assembly operations - welding sequence

21-33% Weight

-28%

-22 % @ 150000km
determined by

3€/Kg Saved
(compared to benchmark vehicle)
determined by

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723839.
Rear bumper beam (aluminium) for US / BENTELER

- Reference: 7000 series aluminium beam; steel crash boxes Toyota C-HR
- Lightweighting approach by
  - Ultra-high strength AW7046 aluminium material
  - Material allocation where needed
  - Open Beam with more forming
- Quantity 25,000 p.a.
- Mainly designed for high speed rear crash

- TME / BENTELER Proposal: 7000 series aluminium component

- Advanced High-Strength Steel
  - Ultra-high strength AW7046 3 - 4 mm
  - Tailored Extruded Blank in y-direction
- Ductile AW7003 2.1 mm
- Physical demonstrator
- Funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723839
**Rear bumper beam (aluminium) for US / BENTELER**

<table>
<thead>
<tr>
<th></th>
<th>Reference US</th>
<th>Lightweight design</th>
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<tr>
<td></td>
<td>n</td>
<td>Thickness</td>
</tr>
<tr>
<td>Flange plates</td>
<td>2</td>
<td>2.0 &amp; 2.6</td>
</tr>
<tr>
<td>Crash boxes</td>
<td>2</td>
<td>1.2 &amp; 2.0</td>
</tr>
<tr>
<td>Beam</td>
<td>1</td>
<td>2.5 to 3.5</td>
</tr>
<tr>
<td>Towing Nut</td>
<td>1</td>
<td>2.0 to 2.6</td>
</tr>
<tr>
<td>Total weight</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

-21-33% Weight

-45% GWP (Global Warming Potential)

-44% @ 150000km

-5 €/kg saved

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Front bumper beam (steel) / Daimler

1. Absorber, upper left
2. Absorber, lower left
3. Absorber, upper right
4. Absorber, lower right
5. Bumper Beam
6. Closing plate
7. Console, left
8. Console, right
9. Reinforcement, left
10. Reinforcement, right

Front bumper beam: Comparison of physical, virtual demonstrator and reference

<table>
<thead>
<tr>
<th>Variant</th>
<th>Beam</th>
<th>Weight [kg]</th>
<th>Plate</th>
<th>Weight [kg]</th>
<th>Total Beam &amp; Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Demonstrator / Variant 2.2KU</td>
<td>DP-K850Y1180T-DH 1.50 mm</td>
<td>3.51</td>
<td>DP-K850Y1180T-DH 1.00 mm</td>
<td>1.63</td>
<td>5.79</td>
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<tr>
<td>Virtual Demonstrator / Variant 2.3KU</td>
<td>DP-K850Y1180T-DH 1.30 mm</td>
<td>3.04</td>
<td>DP-K850Y1180T-DH 1.20 mm</td>
<td>1.78</td>
<td>4.82</td>
</tr>
<tr>
<td>Reference</td>
<td>PSC950Y1300T 1.35 mm</td>
<td>3.16</td>
<td>CR330Y590DP1G150/50-U / 1.75 mm</td>
<td>2.85</td>
<td>6.01</td>
</tr>
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Front bumper beam: Comparison of physical, virtual demonstrator and reference

<table>
<thead>
<tr>
<th>Variant</th>
<th>Weight Saving [kg]</th>
<th>GWP [kg]</th>
<th>Cost [€/kg saved]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rear bumper beam</td>
<td>-0.83 / -0.92</td>
<td>-0.03 / -0.04</td>
<td>-0.00 / -0.00</td>
</tr>
<tr>
<td>Rear floor panel</td>
<td>0.97</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Door concept 1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Outer concept 2</td>
<td>0.06</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Bumper beam</td>
<td>-0.18</td>
<td>-0.06</td>
<td>-0.00</td>
</tr>
<tr>
<td>Front</td>
<td>0.56</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>FCB</td>
<td>0.53</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Grille tower &amp; Int. Rail</td>
<td>-0.36 / -0.37</td>
<td>0.15</td>
<td>-0.15</td>
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<tr>
<td>Total</td>
<td>-3.00 / -3.14</td>
<td>0.65</td>
<td>-0.65</td>
</tr>
</tbody>
</table>

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