Pedestrian Protection
Study on Technical Feasibility of EEVC WG 17

- Project Partners
- Definition of Technical Feasibility
- Methodology of Technical Feasibility Evaluation
- Process
- Results
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- Project Partners

ACEA

Vehicle models and EEVC impactor test results

MAE (MATRA)

Vehicle modification (FE) and expertise on technical feasibility

FE pedestrian impactor test simulation

TNO

Comparison of protection level offered by base and modified cars using MADYMO full body simulation
• Definition of Technical Feasibility

The Directive on Pedestrian Protection will be a subject of vehicle type approval for the relevant vehicles.

The legislative tests and their criteria have to be met with a confidence level to the limits (usually 80%)
• by all models and variants
• for all possible versions (worst case condition)
• without any exception

**Technical Feasibility** is given if design solutions can be provided for all relevant vehicle types that fulfil pedestrian protection legislation without exception and simultaneously meet all other legislative and functional requirements that must be met for an introduction to the market.
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• Methodology of Technical Feasibility Evaluation

Vehicle Classes

The four main passenger car classes were studied on the basis of FE simulation:

• Super Mini Car
• Executive Car
• Sport Utility Vehicle(SUV)
• Sport´s Car

Technical modifications were developed for these cars in order to comply with EEVC WG17 requirements to the maximum possible level considering vehicle functional requirements and target conflicts.
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• Methodology of Technical Feasibility Evaluation

Vehicle Functional Requirements – Examples:

• Vehicle ramp angle
• Field of vision
• Front light output area
• Engine cooling – air intake area
• Damageability by
  - Normal vehicle use like bonnet slam, car wash etc.
  - Low speed impacts (RCAR)
• Wind load and vibration regarding durability
• Fuel consumption and exhaust emission
• Other passive vehicle safety requirements
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- Methodology of Technical Feasibility Evaluation

Vehicle Modifications - Examples:

- Maintaining the typical vehicle class
- Re-arranging engine compartment package as far as possible while keeping the functionality
- Changing vehicle shape to provide deformation space or
- Introducing a deployable bonnet (example: sport’s car)
- Design all relevant body parts accordingly
- Modify structure, reduce stiffness and use alternative material when necessary
- Go to the limits of manufacturability
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• Process

  • Vehicle FE models and pedestrian impactor test results were provided by the vehicle manufacturers
  • Validation of FE vehicle models by impactor test simulation and real test results
  • Modification of the FE models for maximum possible compliance with EEVC WG17
  • Investigation of technical limitations resulting from conflicts:
    - between the different pedestrian test requirements,
    - vehicle functionality and manufacturability
    - other legal requirements
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- Theoretical Minimal Deformation Depth for Compliance (MATRA)

Sufficient deformation room and low stiffness over the full width of the car front including wings is the pre-requisite for compliance. Only with ideal energy absorption conditions the minimal deformation room shown above would be enough. This cannot be reached in all places → more deformation space is needed in reality.
Executive Car
Executive Car

Design approaches for legform and upper leg

MODIFIED MODEL

- The curvature of the bonnet and the stiffener is modified
- The curvature of the headlamp is modified
- Modification of the shield in order to not have the BLEH point on the shield

INITIAL MODEL

- Initial BLEH = 721.26 mm
- Modified BI = 237.57 mm
- Modified BLEH = 684 mm

200 J curve
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Executive Car - Results

<table>
<thead>
<tr>
<th>CRITICAL = &gt; EEVC + 50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRITICAL = EEVC + 50%</td>
</tr>
<tr>
<td>NOK = EEVC + 20%</td>
</tr>
<tr>
<td>NOK =&lt; EEVC</td>
</tr>
<tr>
<td>OK = EEVC -20%</td>
</tr>
</tbody>
</table>

Initial Map

Modified Car

- Adult Head Test
- Child Head Test
- Upper Leg Test
- Legform Test
## Executive Car – Results and main conflicts

<table>
<thead>
<tr>
<th></th>
<th>EEVC Criteria WG17 –20%</th>
<th>Technical feasibility</th>
<th>Certification / Specifications (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Head impact</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hinges’ and latches’ stiffness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wing area / Bonnet’s borders</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Upper leg impact</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>200J</td>
<td></td>
<td>Latch and striker to be redesigned</td>
<td>Durability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cooling system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Packaging</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>New car’s front end</td>
</tr>
<tr>
<td>400J</td>
<td>Front end stiffness</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lower leg impact</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Low speed impacts</td>
</tr>
</tbody>
</table>

(*) Vehicle’s and customer’s functions expertise

- • Remains a possible solvable problem
- •• Remains an unsolvable problem
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SUV car
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Sport utility Vehicle

Two options for an upper leg development:

A: Providing deformation room
B: Lowering energy by vehicle shape

Both approaches fail.
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Sport Utility Vehicle

**Initial Map**

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- **CRITICAL** = EEVC + 50%
- **NOK** = EEVC + 20%
- **NOK** =< EEVC
- **OK** = EEVC -20%

**Modified Car**

Modified to the maximum HIC reduction but unresolvable functional problems remain

(ref. Matrix of conflicts).

- Adult Head Test
- Child Head Test
- Upper Leg Test
- Legform Test

(legform test)
### Pedestrian Protection
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**Sport Utility Vehicle – Results and main conflicts**

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<tbody>
<tr>
<td><strong>Head impact</strong></td>
<td>Hinges’ stiffness</td>
<td>Packaging and</td>
<td>Air intake surface,</td>
</tr>
<tr>
<td></td>
<td>Wing area / Bonnet’s</td>
<td>architectural problems</td>
<td>reliability and fluttering</td>
</tr>
<tr>
<td></td>
<td>borders</td>
<td>remain</td>
<td>problem</td>
</tr>
<tr>
<td><strong>Upper leg impact</strong></td>
<td>No solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lower leg impact</strong></td>
<td></td>
<td></td>
<td>Damages on bumper skin</td>
</tr>
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Super Mini Car
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Super Mini Car - Results

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<th>Modified Car</th>
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Modified to the maximum HIC reduction but unresolvable functional problems remain (ref. Matrix of conflicts).
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<tr>
<td><strong>Head impact</strong></td>
<td>Hinges’ and latches’ stiffness</td>
<td></td>
<td>Reliability</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Upper leg impact</strong></td>
<td></td>
<td></td>
<td>Reliability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Latch accessibility</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Architectural problem</td>
</tr>
<tr>
<td><strong>Lower leg impact</strong></td>
<td></td>
<td></td>
<td>Damages on bumper skin</td>
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<td></td>
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Sport’s car
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Sport´s Car

Deployable Bonnet System

Characteristics of the pop up bonnet:
- Two front actuators (50mm, angle : 58deg/horizontal)
- Two rear actuators (100mm, angle : 67deg/horizontal)
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Sport´s Car

Bonnet in deployed position
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Sport´s Car

Initial Map

Modified Car

CRITICAL = > EEVC + 50%
CRITICAL = EEVC + 50%
NOK = EEVC + 20%
NOK =< EEVC
OK = EEVC - 20%

Adult Head Test
Child Head Test
Legform Test
Not studied
### Pedestrian Protection
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**Sport’s Car – Results and main conflicts**

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<th>EEVC Criteria</th>
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<tr>
<td><strong>Head impact</strong></td>
<td>WG17 -20%</td>
</tr>
<tr>
<td>* *</td>
<td>The inertia of the bonnet prevent from reaching the criteria</td>
</tr>
<tr>
<td></td>
<td>Impact detection, calibration</td>
</tr>
<tr>
<td></td>
<td>Crash behaviour to be validated</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Upper leg impact</strong></td>
<td>The energy level is below 200J, then the test is skipped</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lower leg impact</strong></td>
<td></td>
</tr>
<tr>
<td></td>
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