Assessment of Full Width Deformable Barrier test and CAE simulations for vehicle compatibility

- Development of software to evaluate, animate, interrogate and compare both test and CAE data -

ABSTRACT
Vehicle compatibility is on the Euro-NCAP road map and has been the subject for research by both in Europe (VC-COMPAT) and the USA (NHTSA). This presentation details the development of an automated method to assess and compare test and CAE data with respect to the proposed Full Width Deformable Barrier test defined by European Enhanced Vehicle Safety Committee Working Group 15 and also the Full Width Rigid Barrier (with high resolution load cell wall) by NHTSA. The output of the project was a fully interactive HyperWorks plug-in which allows the user to animate, interrogate and compare both test and CAE data.
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Introduction to Vehicle Compatibility

- The first vehicle compatibility agreement has been voluntarily committed to for the North American Market by the Alliance of Automobile Manufacturers in 2003 for implementation in 2009.

- The European Union funded a study into compatibility which completed in 2006. “Improvement of Vehicle Crash Compatibility through the Development of Crash Test Procedures (VC-COMPAT)”

- The protection of occupants in the colliding vehicles (partner protection) is on the Euro-NCAP road map (2014)
Linkage between Occupant and Partner Protection

<table>
<thead>
<tr>
<th>Occupant</th>
<th>Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>US NCAP</td>
<td>+ LCW NHTSA</td>
</tr>
<tr>
<td>IIHS</td>
<td>+ LCW FWCB</td>
</tr>
<tr>
<td>JN NCAP</td>
<td>+ LCW 64 ODB EEVC WG 15</td>
</tr>
<tr>
<td>Euro NCAP</td>
<td>+ LCW 80 ODB 60 PDB</td>
</tr>
</tbody>
</table>

- Rigid Wall
- Standard Barrier
- Load cells
- New Barrier

- 56 Km/h
- 64 Km/h
- 80 Km/h
- 60 Km/h

- Standard Barrier
- New Barrier

EEVC WG 15
NHTSA
## Partner Protection Test and Metric Data Set

### Test configuration

<table>
<thead>
<tr>
<th>FWCB</th>
<th>NHTSA</th>
<th>+ LCW</th>
<th>+ new barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>56 Kmh</td>
<td>56 Kmh</td>
<td>+ LCW</td>
<td>+ new barrier</td>
</tr>
</tbody>
</table>

#### Metrics

**NHTSA**

- Barrier force: \( F_{\text{max}} \) (Peak Total Load Cell Wall Force)
- HOF (Height of Force)
- AHOF (Height of Force @ 400 mm displacement)
- KWOF (Crush work stiffness @ 400 mm displacement)
- \( F_3 \) (2 peak forces in row 3)
- \( F_4 \) (2 peak forces in row 4)
- \( F_{3,40} \) (2 peak forces in row 3, < 40ms)
- \( F_{4,40} \) (2 peak forces in row 4, < 40ms)
- Barrier displacement

**TRL V3.0 Mar 2007**

- Barrier force: \( F_{\text{max}} \) (Peak Total Load Cell Wall Force)
- VSI (Area 1) (Vertical structural interaction)
- VSI (Area 2) (Vertical structural interaction)
- HSI (Area 1) (Horizontal structural interaction)
- HSI (Area 1 + outer support) (Horizontal structural interaction)
- HSI (Area 2) (Horizontal structural interaction)
- Barrier displacement

**TRL V2.0 Feb 2006**

- Barrier force: \( F_{\text{max}} \) (Peak Total Load Wall Force)
- RH (Relative homogeneity criterion)
- RH (Vertical (Row) relative homogeneity criterion)
- RH (Horizontal (Column) relative homogeneity criterion)
- RH (Total relative homogeneity criterion)
- Barrier displacement

**TRL V1.6 Feb 2006**

- Barrier force: \( F_{\text{max}} \) (Peak Total Load Cell Wall Force)
- PPAD (Partner protection assessment of deformation)
- AD (Average depth of deformation)
- AD (Average depth of deformation)
- AHOD (Average height of deformation)
- W (Width of deformation)
- \( Z_{\text{max}} \) (Height of maximum depth of deformation)
- Volume (Volume of deformation)
- Energy (Energy of deformation)

### Order of Importance

- No Metrics
- Software Exists
- Obsolete
- Software Exists
Evaluation Metrics for Partner Protection

• There are two different types of metrics that could be used for partner protection:
  – Barrier force
  – Barrier deformation

• As well as assessing partner protection, occupant protection evaluation is also proposed:
  – BiW deformation
  – Occupant injury

• At present there is no standard software for assessing barrier forces for partner protection.

• This was the motivation for developing the “Hyundai Barrier Evaluation Tool”.
The automated tool has the following requirements:

- Integration within Hyundai CAE/test environment.

- Read data from different sources
  - Test (ISO/DIADEEM) & CAE (DYNA)

- Compare data

- 2D curve plotting
  - Load cell wall segments vs. time

- 3D curve plotting
  - Animated 3D bar chart

- Report
Input Data

- CAE/Test Data from both vehicle and barrier are required:
  - Vehicle
    - Vehicle acceleration.
    - Identified by node number, ISO tag “BPIL” or NHTSA tag “BPLR”
  - Barrier
    - LCW forces.
    - Identified by channel code or Rigidwall segment number.
User Interface

- The GUI is launched from a pull down in HyperGraph/HyperView

Automatic identification of data channels and parameters based on data format type

Restart/reload from configuration file
• Following the processing of the data, the software generates a table with the necessary metrics.

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHOF(_{40})</td>
<td>406-508mm</td>
</tr>
<tr>
<td>F(_{\text{total\ Peak}})</td>
<td>&gt;350 kN</td>
</tr>
<tr>
<td>F(_{3}) Peak</td>
<td>&gt;100kN</td>
</tr>
<tr>
<td>F(_{3}(40))</td>
<td>&gt;100kN</td>
</tr>
<tr>
<td>F(_{4}) Peak</td>
<td>&gt;100kN</td>
</tr>
<tr>
<td>F(_{4}(40))</td>
<td>&gt;100kN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Metric Name</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Velocity</td>
<td>15.278 - 15.834 m/s</td>
</tr>
<tr>
<td>AHOF(_{400})</td>
<td>406-508mm</td>
</tr>
<tr>
<td>F(_{3}(400))</td>
<td>&gt;100kN</td>
</tr>
<tr>
<td>F(_{4}(400))</td>
<td>&gt;100kN</td>
</tr>
<tr>
<td>Kw(_{400})</td>
<td>1300-1700N/mm</td>
</tr>
</tbody>
</table>

• The corresponding 2-D charts to enable their interpretation are also created:
  – Filtered and unfiltered load cell wall data
  – AVS Diagram
  – Total load cell wall forces
  – Row 3 and row 4 forces
  – Height of forces
  – Crush work Stiffness & energy
Following the processing of the data, the software generates a table with the necessary metrics.

The corresponding 2-D charts to enable their interpretation are also created:
- Filtered and unfiltered load cell wall data
- TRL Target row loads
- TRL Target cell loads
- Peak load cell forces (rows 2 to 5)
- Negative deviations (rows 2 to 5)
Animation of Forces and Vehicle Simulation

- The forces can be animated allowing the user to visualize the load distribution.
- The load cell wall forces can be animated and manipulated in 3 dimensions just like a 3-D CAE model.
Hyundai Barrier Evaluation Software, Key Points

• As the software has been created as a HyperWorks plug-in it will work on multiple platforms.

• The software has been tested under the following conditions:
  – HyperWorks versions 9 & 10
  – Windows XP (32 & 64 bit)
  – LINUX (Redhat)

• The use of a configuration file allows the user to reload all necessary data:
  – location of input files
  – location of output files
  – location of results
  – Evaluation parameters

• All current metrics for FWRD and FWDB are automatically evaluated and exported in a standardized format (.htm file).
Conclusions

- A new software tool for the evaluation of FWRB and FWDB data was successfully developed (Hyundai Barrier Evaluation Tool).

- Both test and simulation data sets can be read in and compared using a single software tool.

- Through the ability to animate the results in 3 dimensions and review the differences between data sets, the user is able to rapidly identify and understand the root causes for the resultant metric values or changes in their values when comparing data sets.

- The Hyundai Barrier Evaluation Tool can help address three major aspects of vehicle front ends for vehicle compatibility:
  - Geometry;
  - Stiffness;
  - Energy absorbance.
References


3. NHTSA, A Report on Voluntary Industry Effort to Further Enhance Front to Front Vehicle Crash Compatibility (DRAFT), 11-12-08.


5. KIA joins in voluntary commitment to enhance vehicle safety, 4 December 2003, retrieved from www.kiamedia.com


