Japanese Perspective for Compatibility Tests

Japan
GRSP Informal Group on Frontal Impact
April 18, 2011
Outline

• Car-to-car crash
  – Front rail height matching
  – Effectiveness of SUV SEAS
• Test method
  – FWRB + Option 2
  – FWDB Tests for SEAS Evaluation
• Harmonization
• Conclusions
Front Rail Height Matching
Front Rail Height

Test 1: Original height (Front rail passed)

Test 2: Height matching

Large car

Minicar

454 mm

324 mm

358 mm

354 mm
Deformation - Minicar

Test 1: Original height
Front rails passed

Test 2: Front rail height matching
Front rails made contact

Front rail (right) Engine top Engine bottom Transmission bottom Instrument panel Driver toe board Front passenger toe board

Test 1 (Front rail passed) Test 2 (Height match)

Deformation (mm)
Injury Criteria (Minicar)

Driver

Front passenger

Ratio of injury criteria to IARVs

Test 1 (Front rail passed)
Test 2 (Height match)
Effectiveness of SUV SEAS
Test conditions

Yaris (test mass 1091kg)
Surf (frame-type, test mass 2076 kg)

<table>
<thead>
<tr>
<th>Test 1</th>
<th>Yaris</th>
<th>Surf (w/SEAS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 2</td>
<td></td>
<td>Modified Surf (w/o SEAS)</td>
</tr>
</tbody>
</table>
Front Structures

Yaris

Surf

Surf w/ SEAS

Modified Surf (w/o SEAS)

SEAS

Bumper cover

377mm

SEAS
Structural Interaction
Deformation - Yaris -

- vs. Surf w/ SEAS
- vs. Modified Surf (w/o SEAS)

Bar chart comparing deformation in millimeters for:
- Front rail (R)
- Toe board (driver)
- A-pillar belt line (R)

- vs. Surf w/ SEAS
- vs. Surf w/o SEAS
## Injury Criteria

<table>
<thead>
<tr>
<th></th>
<th>vs. Surf w/ SEAS</th>
<th>vs. Surf w/o SEAS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Driver</td>
<td>Passenger</td>
</tr>
<tr>
<td>HIC 36ms</td>
<td>713</td>
<td>421</td>
</tr>
<tr>
<td>Neck-MY (Nm)</td>
<td>50</td>
<td>23</td>
</tr>
<tr>
<td>Chest 3ms (G)</td>
<td>53.4</td>
<td>32.8</td>
</tr>
<tr>
<td>Chest Def. (mm)</td>
<td>29</td>
<td>28.4</td>
</tr>
<tr>
<td>Femur-R (kN)</td>
<td>6.47</td>
<td>2.85</td>
</tr>
<tr>
<td>Femur-L (kN)</td>
<td>2.29</td>
<td>1.32</td>
</tr>
<tr>
<td>Knee-Disp.-R (mm)</td>
<td>20.7</td>
<td>13</td>
</tr>
<tr>
<td>Knee-Disp.-L (mm)</td>
<td>13.2</td>
<td>1.6</td>
</tr>
<tr>
<td>TI-Upr.-R</td>
<td>2.47</td>
<td>0.97</td>
</tr>
<tr>
<td>TI-Upr.-L</td>
<td>0.59</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Summary of Crash Tests

• Front rail matching is a first step for compatibility.
• SEAS of SUV reduced the intrusion to compartment of small car.
Test Method
TWG Voluntary Agreement

OPTION 1

The light truck's primary frontal energy absorbing structure (PEAS) shall overlap at least 50 percent of the Part 581 zone (Option 1a) AND at least 50 percent of the light truck's PEAS shall overlap the Part 581 zone (Option 1b)

OPTION 2

If a light truck does not meet the criteria of Option 1, there must be a secondary energy absorbing structure (SEAS), connected to the primary structure, whose lower edge shall be no higher than the bottom of the Part 581 bumper zone.
Effectives of TWG Voluntary Agreement

From IIHS accident analysis, the effectiveness of the TWG agreement has been demonstrated

- Driver fatality risks in cars were compared for the collisions of light trucks that met TWG agreement with that of light trucks not meeting the agreement
- The estimated benefits were a **19 percent reduction in fatality risk** to belted car drivers in front-to-front crashes with light trucks and a **19 percent reduction in fatality risk** to car drivers in front-to-driver-side crashes with light trucks.

FWRB Test + Option 2
Total Barrier Force in Full-Width Rigid Barrier (FWRB) Tests

![Graph showing total barrier force vs vehicle displacement]
F4/(F3+F4) in FWRB

Option 1a

\[ y = 0.00613x - 0.076 \]
\[ R^2 = 0.790 \]

Option 1b

\[ y = 0.00526x + 0.010 \]
\[ R^2 = 0.725 \]

Note: PEAS ground height was corrected according to impact location (z) 19
Front Rail Height Metrics of FWRB

Original Japanese measure

- \( F_3 + F_4 > 80 \text{ kN} \)
- \( 0.2 < \frac{F_3}{F_3 + F_4} < 0.8 \)

FIMCAR modification

- \( F_3 + F_4 \geq [100-LR] \text{ kN} \)
- \( F_4 \geq 35 \text{ kN} \)
- \( F_3 \geq 35 \text{ kN} \)
- \( LR=\text{Min} [(F_2+F_1-25 \text{ kN}); 35 \text{ kN}] \)
Test conditions and criteria for SEAS in US self regulation (Option 2)

Test condition (Static)

Criteria

Same test condition and criteria as truck RURP test (ECE R93)

Surf has met the Option 2 requirement with enough margin
Test Method

Stage 1: FWRB test

- F3 + F4 ≥ [100-LR] kN
- F4 ≥ 35 kN
- F3 ≥ 35 kN
- LR = Min [(F2+F1-25 kN); 35 kN]

@ LCW force 200 kN

Stage 2: Option 2 test

- F > 100 kN @400 mm

Pass/No

Pass/No

Fail

No

Yes

Yes
Other Merits of SEAS

• Robust performance to prevent the override/underrun is increased if the SEAS has enough performance. (In the accident data, there was a case that override/underrun occurred as though the same sized cars are crashed.)
FWDB Tests for SEAS Evaluation
SEAS Detection (FWDB)

- Full-width deformable barrier tests were conducted using Toyota SURF with and without SEAS
- The SEAS was in alignment with row 2 in a load cell barrier
Row-2 Force vs. Vehicle Displacement

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<table>
<thead>
<tr>
<th>Force of row-2 (kN)</th>
<th>Force of row-2 (kN)</th>
</tr>
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<tbody>
<tr>
<td>89 kN</td>
<td>73 kN</td>
</tr>
</tbody>
</table>

Vehicle displacement (m)

FIMCAR criterion
Max. until 40 ms (>100 kN)

<table>
<thead>
<tr>
<th>w/ SEAS</th>
<th>F2: 65 kN (Fail)</th>
</tr>
</thead>
<tbody>
<tr>
<td>w/o SEAS</td>
<td>F2: 18 kN (Fail)</td>
</tr>
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</table>

Honeycomb is so deep that the SEAS cannot transfer a reaction force to the barrier.
Summary of FWDB Tests for SEAS

• In the SUV FWDB test, the barrier force of the SEAS was too small to be detected, though this SEAS (meets the Option 2) was demonstrated effective in car-to-car crash.
Harmonization
Harmonize of Full Frontal Test

• A second step to improve frontal impact regulation shall be envisaged preferably by means of a GTR in TOR.
• US, Australia and Japan already introduced the FWRB as full frontal impact test, so probably harmonization is easier for the FWRB when the GTR is considered for the target.
Conclusions
## FWRB and FWDB

<table>
<thead>
<tr>
<th></th>
<th>Importance</th>
<th>FWRB</th>
<th>FWDB</th>
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<tbody>
<tr>
<td>PEAS height evaluation</td>
<td>High</td>
<td>Very Good</td>
<td>Good</td>
</tr>
<tr>
<td>SEAS detection</td>
<td>High</td>
<td>Impossible</td>
<td>Poor</td>
</tr>
<tr>
<td>Harmonization</td>
<td>Medium</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Cost</td>
<td>Medium</td>
<td>Good</td>
<td>Poor</td>
</tr>
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</table>

- Both FWRB and FWDB tests can evaluate the PEAS height.
- FWDB cannot evaluate the SEAS effectively.
- Harmonization with the US is easier for the FWRB when the GTR is considered for the target.
- It costs $5,000 (honeycomb) for every test in FWDB.
Conclusions

• By the combination of FWRB and Option 2 (SEAS) test, the structural interaction of vehicles can be evaluated, effectively.
• When considering GTR for the target, the FWRB may be accepted easier for the harmonization with the US.
• FWRB test is more economical than FWDB test in terms of PEAS height evaluation.
• Japan recommends the FWRB with Option 2 test.