Panel 2: Engineering Realities
Structural Crashworthiness,
Occupant Injury and Advanced Vehicle Design

Honda’s Thinking About Size, Weight and Safety
Fatality Rates
Weight Reduction & Downsizing
Compatibility Issues
Unnecessary Testing Increases Weight

Honda R&D
Koichi Kamijii
Senior Chief Engineer
2011.2.25
Occupant Fatality Rate Are Declining

Passenger Vehicle Occupant Fatality Rate per 100,000 Registered Vehicles, by Type of Vehicle and Year, 1999–2008

(Traffic Safety Facts: DOT HS 811 368)
Crashworthiness Improvements and Fatality Rates

NCAP/IIHS Rating and Fatality Rate

Frontal Crash of 4-door Sedan
Driver Death/ Number of Fleet Vehicles in 2001 and 2008

NCAP/IIHS Rating and Fatality Rate

2007

Assessment Result

NCAP  IIHS

Fatality Rate [Fatalities/10K Vehicles]

Fatality Rate

0

0.1

0.2

0.3

0.4

0.5

0.6

Reduced less than 1/2

Better Crashworthiness leads to lower fatality rates
Enhanced Safety Performance

New safety requirements will emphasize this trend, and crash avoidance technologies (e.g. crash mitigation brake) are getting popular.
Honda Accord BIW Weight History

- **SINCAP**
- **IIHS ODB**
- **NCAP 5 stars**
- **IIHS SICE**

NEW Safety Requirements

- **New 301**
- **New 214**
- **New 216**
- **New NCAP**
- **IIHS Roof**

**BIW Weight (kg)**

- 94M
- 98M
- 03M
- 08M
- Next

**High Strength Steel %**

- 0%
- 20%
- 40%
- 60%
- 80%

**BIW Wt.**

**HSS %**
Honda Accord BIW Weight

Performance Improvement

- 339 Kg
- 40% HSS (480) kg

Weight Reduction

- 365 Kg
- 50% HSS (590) kg

- HSS application
- Optimised Body construction

- IIHS-SICE structure improvement
- Rear offset crash 80km/h
- Body Rigidity and NV improvement
- EPA Class MID ⇒ LARGE

*1: Honda test result
*2: Excluding hang-on parts
Target of Weight Reduction

in case of mid-size vehicle

Curb. weight

Near term
✓ Optimize structure
✓ Revise joint method
✓ HSS Use Rate
~ based on current structure

Mid Term
✓ Expansion of light material application
✓ Multi-function structure

Require the countermeasure for performance, cost, etc.
Technology Direction of BIW

Aluminum Body

Target of Mass reduction from Steel

Steel Body

Future Material

Ultimate light-weight Body

'H90 NSX

'00 INSIGHT

-40%

-30%

'03 Accord

-20%

'08 Accord

-10%

Next Accord

HSS Expanding

Down Sizing can reduced fuel consumption

Customer Role:
• Consider smaller vehicles

Regulatory Role:
• Do not discourage smaller vehicles

OEM Role:
• Make attractive small vehicles:
  – Advanced Safety
  – Fun-to-drive
  – Functional
  – More fuel efficient
  → Downsizing can reduce CO2 by ~20%
## Consumer Downsizing Examples

<table>
<thead>
<tr>
<th>Downsize</th>
<th>Example</th>
<th>FE</th>
<th>GHG</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car to Car</td>
<td>Accord L4</td>
<td>32.6</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civic</td>
<td>39.3</td>
<td>226</td>
<td>-17%</td>
</tr>
<tr>
<td>Truck to Truck</td>
<td>Pilot 4WD</td>
<td>23.6</td>
<td>377</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CR-V 4WD</td>
<td>30.5</td>
<td>291</td>
<td>-23%</td>
</tr>
<tr>
<td>Truck to Car</td>
<td>Pilot 2WD</td>
<td>23.6</td>
<td>377</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accord V6</td>
<td>29.4</td>
<td>302</td>
<td>-20%</td>
</tr>
<tr>
<td>Truck to Car</td>
<td>CR-V 2WD</td>
<td>31.2</td>
<td>285</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Civic</td>
<td>39.3</td>
<td>226</td>
<td>-21%</td>
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Downsizing is a major consumer response to high fuel prices... This also results in reduced vehicle mass and potential compatibility concerns.
Vehicle Compatibility Challenges

Mass reduction is clearly a benefit for 42% of all fatal crashes because absolute energy is reduced.

Vehicle compatibility (e.g. Car to SUV) represents a key opportunity to reduce fatalities

* Distribution of Car Occupant Deaths 1999-2002 models during 2000-01
Fatality Trend for Compatibility is Improving
Fatality Rate by Segment & Model

Technologies exist to make small cars safe!
Compatibility Discussion Overview

- **We learned compatibility issues from real world accidents and crash test studies**

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Current Industry/ NHTSA MOU for Compatibility

Phase 1 Recommendation of EVC TWG
- Adopted in December 2003 as voluntary industry commitment - all vehicles sold on or after September 1, 2009.
- Criteria for geometrical compatibility

Phase 2 Recommendation of EVC TWG
- Adopted in November 2005 as voluntary industry commitment
- Performance criteria for effective secondary structures

"Effectiveness is measured by reduced intrusion in the car when a Secondary EA structure (SEAS) is added to the LTV."

At least, 50% of primary structure must be in FMVSS581 Zone and 50% of the zone be covered by the primary structure

At least, 50% of primary structure must be in FMVSS581 Zone and 50% of the zone be covered by the primary structure

Secondary Structure Added

Page 5
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<td></td>
<td>ACE</td>
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ACE™ (Advanced Compatibility Engineering) Body Structure

- Achieving Highly Efficient Energy Absorption
- Load Dispersion
- Preventing Misalignment with other Vehicle Bodies

**Former Body Structure**

**Improved Body Structure**

**Former Body vs. ACE™ Body**

- Force (kN)
- Displacement (mm)

Single load path

Multi-load path

Improved
Former
Load Distribution of Body Structure in Frontal Collision (FWDB test)

Conventional Structure

Advanced Structure (Honda’s ACE™)

Improved structure showed more homogeneous in barrier force distribution. Peak force can be reduced to improve partner protection.
Investigate quantitative evidence technically, not a hypothesis.
## Crash Performance & Real World Insurance Losses

<table>
<thead>
<tr>
<th></th>
<th>Fit</th>
<th>Accord</th>
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</thead>
<tbody>
<tr>
<td>POST TEST CABIN</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<tr>
<td>POST TEST A-PILLAR</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
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<tr>
<td>STRUCTURE</td>
<td>M</td>
<td>G</td>
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<tr>
<td>Personal injury protection</td>
<td>90</td>
<td>102</td>
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<tr>
<td>Medical payment</td>
<td>93</td>
<td>92</td>
</tr>
<tr>
<td>Body injury liability</td>
<td>84</td>
<td>84</td>
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</tbody>
</table>

### Crash Test Results

<table>
<thead>
<tr>
<th>Category</th>
<th>Fit</th>
<th>Accord</th>
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<tbody>
<tr>
<td>Head/Neck</td>
<td>A</td>
<td>G</td>
</tr>
<tr>
<td>Chest</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>Leg/Foot L</td>
<td>P</td>
<td>G</td>
</tr>
<tr>
<td>Leg/Foot R</td>
<td>P</td>
<td>G</td>
</tr>
<tr>
<td>Restraint</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>*Test weight</td>
<td>1330kg</td>
<td>1630kg</td>
</tr>
<tr>
<td>*Mass ratio</td>
<td>1:1.23</td>
<td></td>
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</tbody>
</table>

*Fit performed well in the real world too.*
# Insurance Losses of Small Cars

## 2007-09 models

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>ALL COVERAGE</th>
<th>Collision</th>
<th>Property damage liability</th>
<th>Comprehensive</th>
<th>Personal injury protection</th>
<th>Medical payment</th>
<th>Bodily injury liability</th>
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<tbody>
<tr>
<td>Chevrolet Aveo</td>
<td>132</td>
<td>126</td>
<td>114</td>
<td>108</td>
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<td>201</td>
<td>146</td>
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<tr>
<td>Hyundai Accent</td>
<td>129</td>
<td>124</td>
<td>124</td>
<td>74</td>
<td>172</td>
<td>170</td>
<td>151</td>
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<tr>
<td>Kia Rio</td>
<td>134</td>
<td>120</td>
<td>131</td>
<td>80</td>
<td>177</td>
<td>215</td>
<td>159</td>
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<tr>
<td>Toyota Yaris</td>
<td>124</td>
<td>130</td>
<td>107</td>
<td>96</td>
<td>183</td>
<td>177</td>
<td>121</td>
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<tr>
<td>Toyota Yaris hatchback</td>
<td>—</td>
<td>51</td>
<td>—</td>
<td>75</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Chevrolet Aveo</td>
<td>—</td>
<td>86</td>
<td>70</td>
<td>96</td>
<td>—</td>
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<td>—</td>
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<tr>
<td>Honda Fit</td>
<td>84</td>
<td>81</td>
<td>67</td>
<td>108</td>
<td>90</td>
<td>93</td>
<td>84</td>
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<tr>
<td>Kia Rio</td>
<td>117</td>
<td>114</td>
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<td>73</td>
<td>149</td>
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<td>Need Additional Research &amp; Industry MOU?</td>
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Does Weight reduction also reduce vehicle safety?

Conceptual diagram of collision energy absorbing

Better interaction and better balance of stiffness

Energy absorbing

Absorbed by Large car

Absorbed by Small car

Cabin Intrusion

Base line

Improved Compatibility

Cabin Intrusion

maintain survival space
<table>
<thead>
<tr>
<th>Offset</th>
<th>FWDB</th>
<th>FWRB</th>
<th>PDB</th>
<th>ODB</th>
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<tbody>
<tr>
<td>56-60kmh</td>
<td>Good</td>
<td>Limited</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>56-64kmh</td>
<td>Good</td>
<td>Limited</td>
<td>Poor</td>
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Honda recommends FWDB & PDB to develop compatibility standards.

Compatibility Test Procedure Research is Needed

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<th>Interaction With Geometry</th>
<th>Stiffness Matching With Geometry</th>
<th>Compartment stiffness (Strength)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FWDB</td>
<td>Good</td>
<td>Acceptable</td>
</tr>
<tr>
<td>FWRB</td>
<td>Limited</td>
<td>Acceptable</td>
</tr>
<tr>
<td>PDB 56-60kmh</td>
<td>Poor</td>
<td>Acceptable No bottoming</td>
</tr>
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<td>ODB 56-64kmh</td>
<td>Poor</td>
<td>Poor Bottoming</td>
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Honda recommends FWDB & PDB to develop compatibility standards.
Unnecessary Regulations?

• Honda’s Hypothesis:
  – Seatbelt usage is growing and effective
    • Seatbelt reminder is effective
    • Seatbelt laws and enforcement are effective
  – Unbelted Occupant testing requires additional vehicle length → causes increase in weight
  – Real crashworthiness is not changed
  – Can we save +20 kg on small cars?
Seat Belt Use

Potential to increase from 85% to 88% through wider acceptance of seat belt law enforcement.
Effectiveness of Seat Belt Reminder

Conclusions: “Belt reminders in Honda as well as Ford vehicles are increasing. Although the increase of seatbelt use rate is moderate (5.6 percentage points), on a national level it could have prevented at least 736 driver deaths in 2004.”

IIHS, 2006, Effectiveness and Driver Acceptance of the Honda Belt Reminder System
Unbelted Occupants Are Major Portion of Fatality Rates

15% of drivers (unbelted) make up 50% of fatalities!

2009 Traffic Safety Facts

2009 Traffic Safety Facts

Fatality Rate

Fatal Accidents

100% Seat Belt Usage Est.

Japan vs US Fatalities by Restraint Use

FMVSS 208’s Unbelted Occupant requirement seems to be ineffective
US and Jpn Fit Test Performance Comparison

**Highest NCAP Test (6 Stars)**

**JPN Honda Fit**

**US Honda Fit**

**Highest NCAP Test (5 Stars)**

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>Japan</th>
<th>Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>4105</td>
<td>3900</td>
<td>205</td>
</tr>
<tr>
<td>Fr Overhang</td>
<td>910</td>
<td>765</td>
<td>145</td>
</tr>
<tr>
<td>Weight</td>
<td>1168</td>
<td>1080</td>
<td>88</td>
</tr>
</tbody>
</table>

US Fit is 88lbs heavier partially due to longer front overhang compared to Jpn Fit. Safety performance is nearly equal. 100 mm of 148mm increase in length is due to unbelted occupant test. +20kg can be reduced.
Conclusion

- 42% of fatalities are Single Vehicle Crashes – these will all benefit from light weighting due to decreased energy.

- The application of intelligent design can improve safety even when controlling for weight and size.

- Improved compatibility (beyond current MOU) has the potential to further improve safety even as customers downsize and OEMs down weight. (stiffness)

- Unbelted occupant testing seems to be ineffective in reducing fatalities, while adding length and weight to small cars. Rethinking this issue could save +20kg for small cars.
Thank You for your attention