

**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

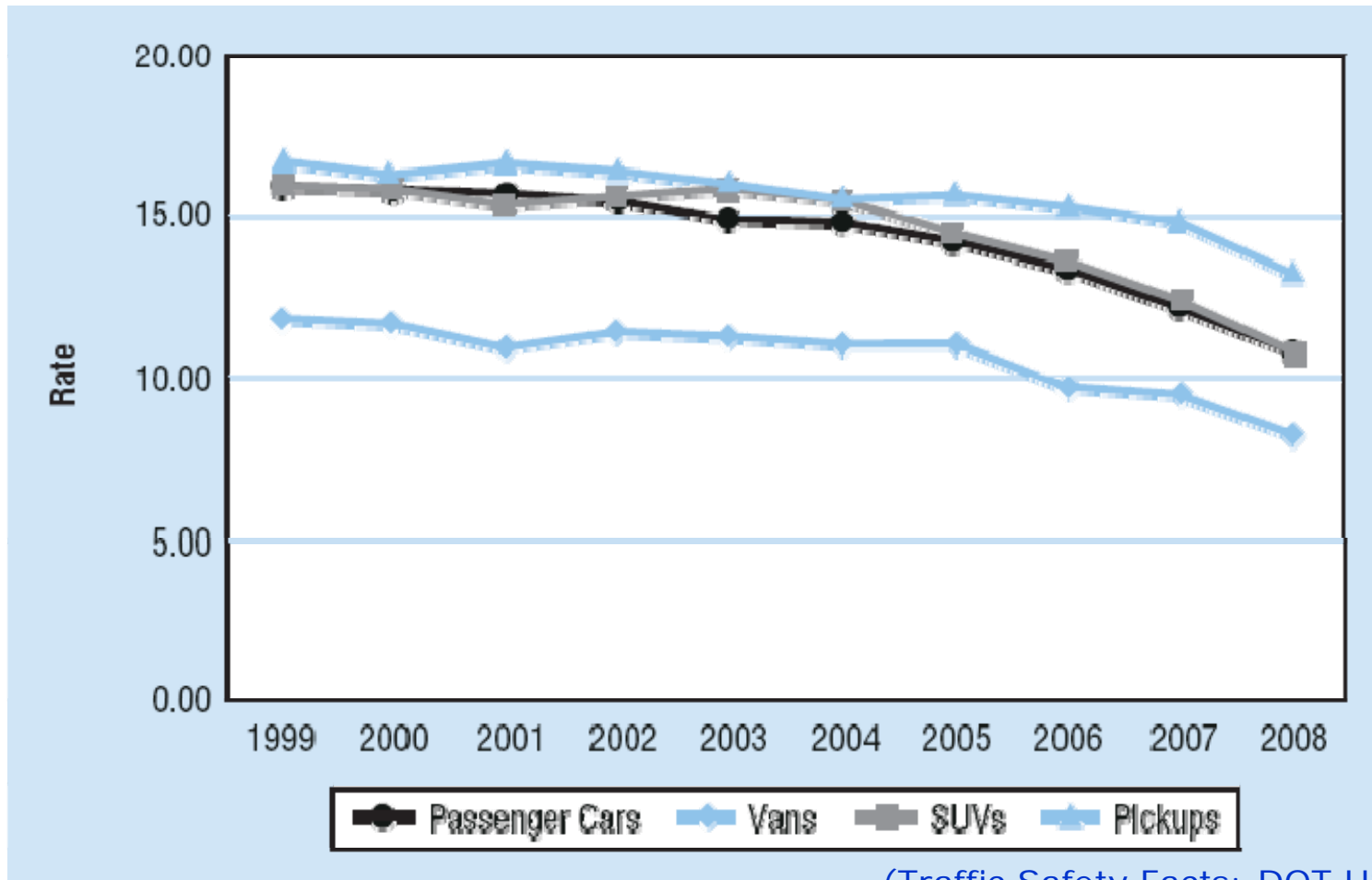
Compatibility Issues

Unnecessary Testing Increases Weight

**Honda R&D
Koichi Kamiji
Senior Chief Engineer
2011.2.25**

Occupant Fatality Rate Are Declining

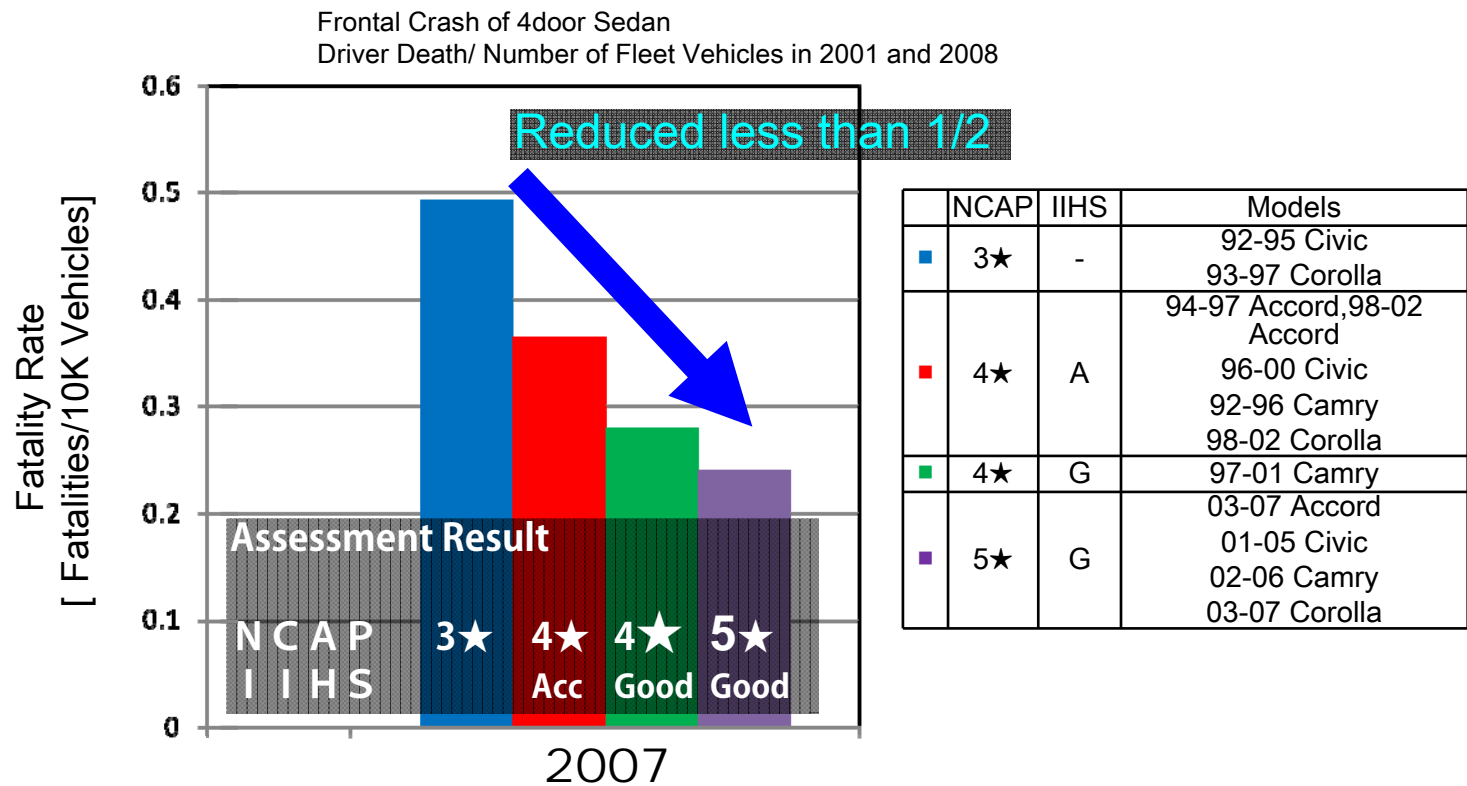
Passenger Vehicle Occupant Fatality Rate per 100,000 Registered Vehicles, by Type of Vehicle and Year, 1999–2008



(Traffic Safety Facts: DOT HS 811 368)

Crashworthiness Improvements and Fatality Rates

NCAP/IIHS Rating and Fatality Rate



Better Crashworthiness leads to lower fatality rates

Enhanced Safety Performance



2011 Honda Accord 4-Door

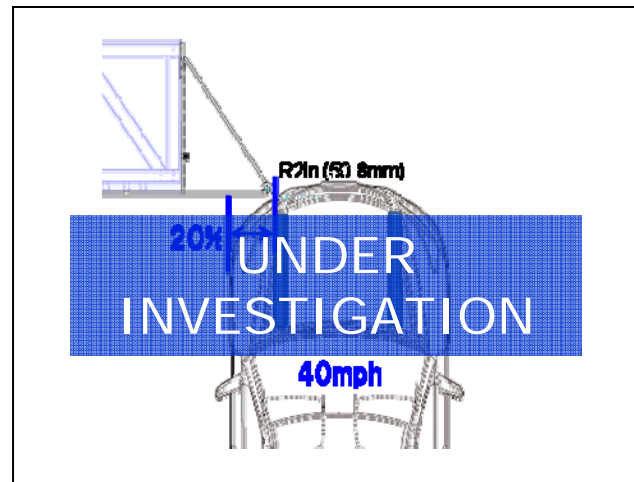
Overall Rating ★★★★★

Frontal Crash	★★★★★
Side Crash	★★★★★
Rollover	★★★★★

Vehicle Test Weight: 1,663

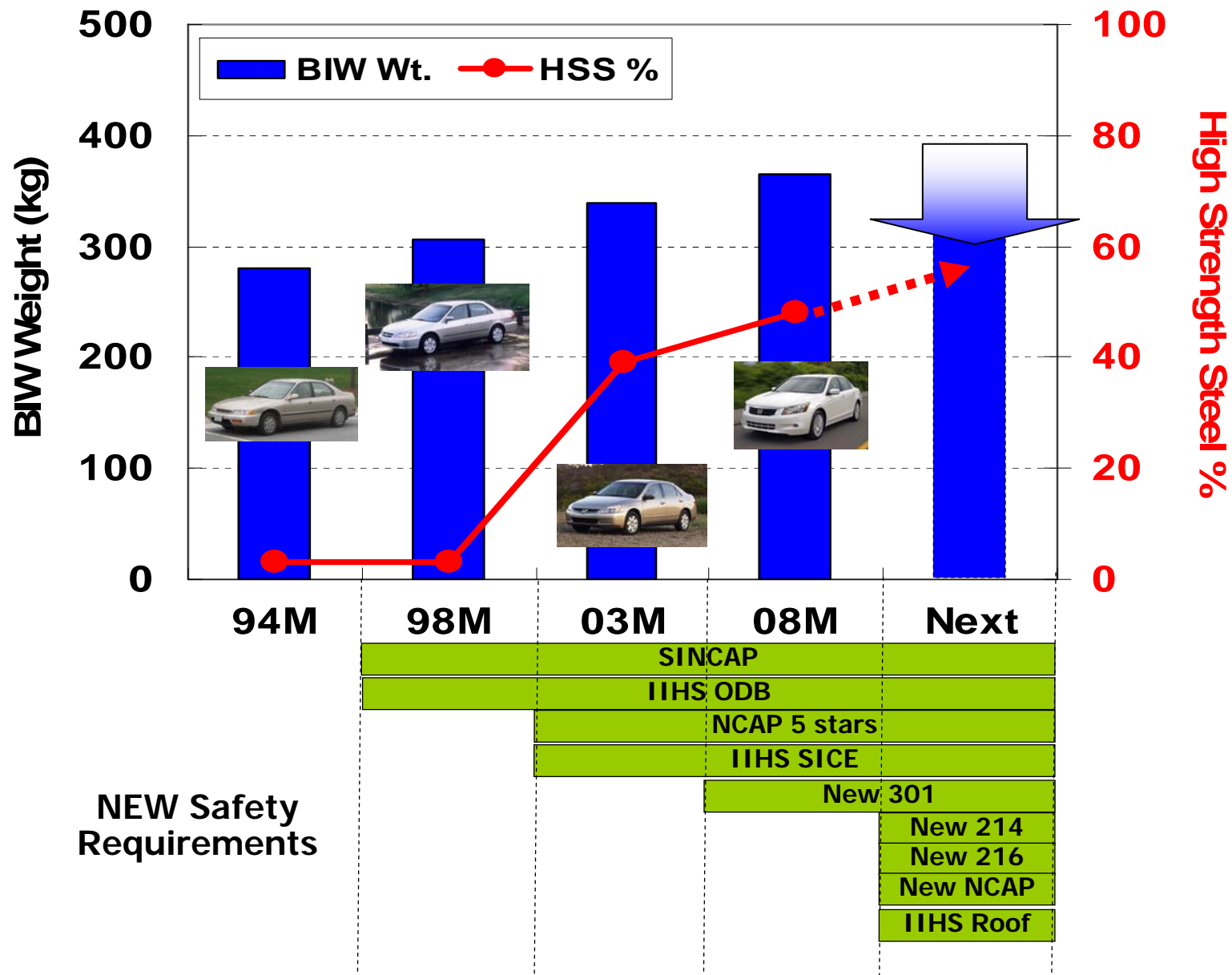
Available Advanced Technology Features

Electronic Stability Control: Standard View Video	Forward Collision Warning: N/A View Video	Lane Departure Warning: N/A View Video
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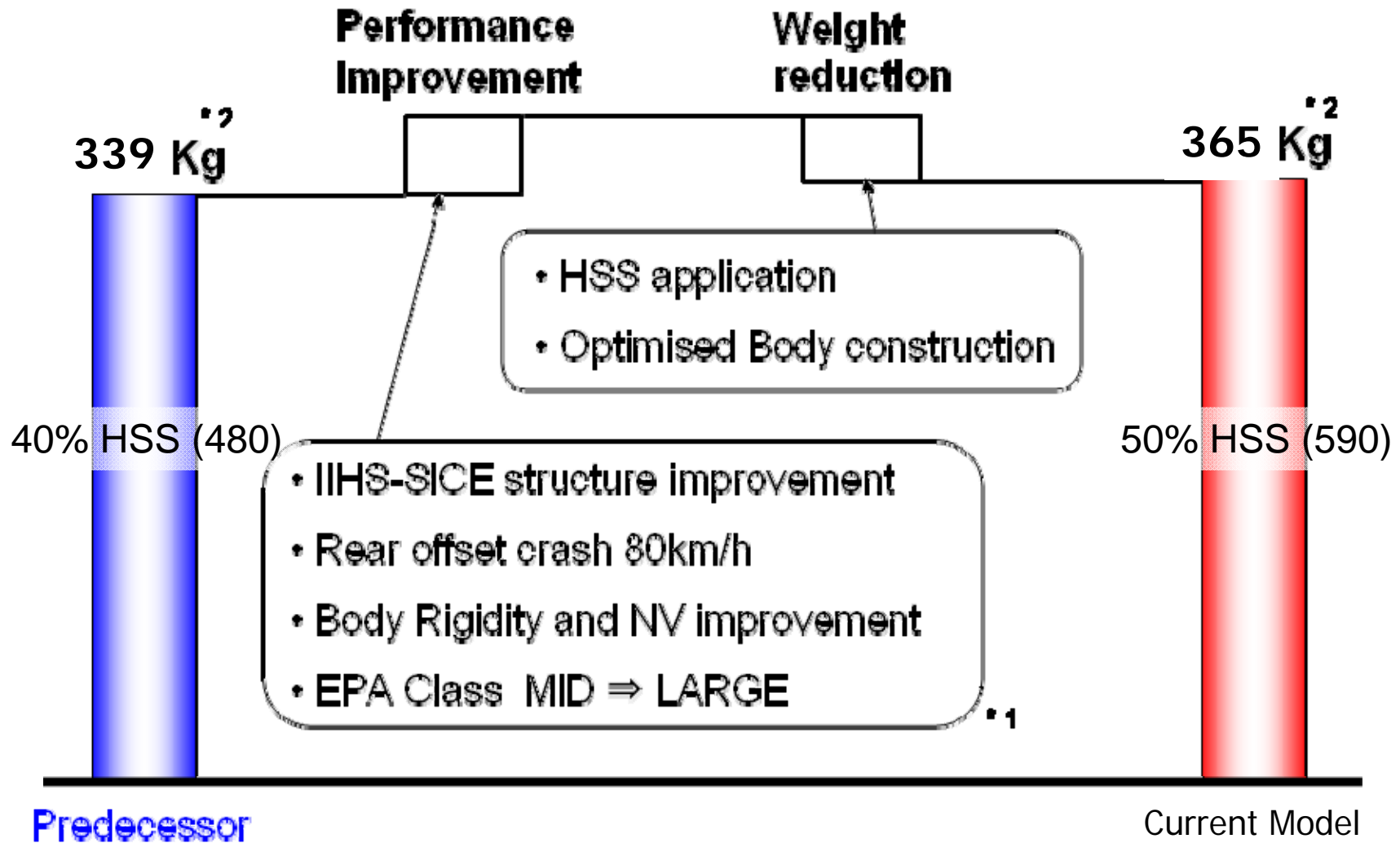


New safety requirements will emphasize this trend, and crash avoidance technologies (e.g. crash mitigation brake) are getting popular.

Honda Accord BIW Weight History



Honda Accord BIW Weight

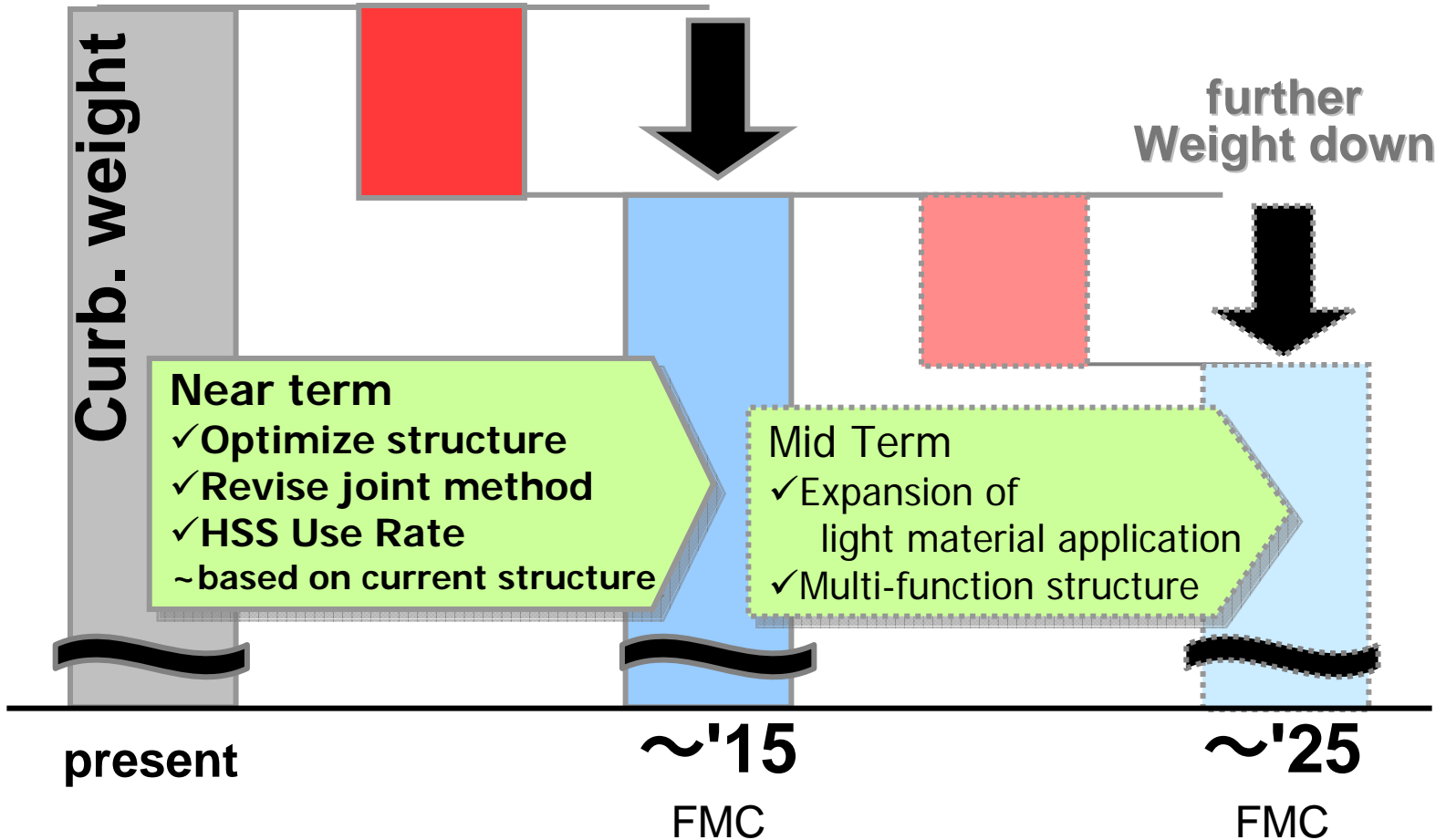


*1: Honda test result

*2: Excluding hang-on parts

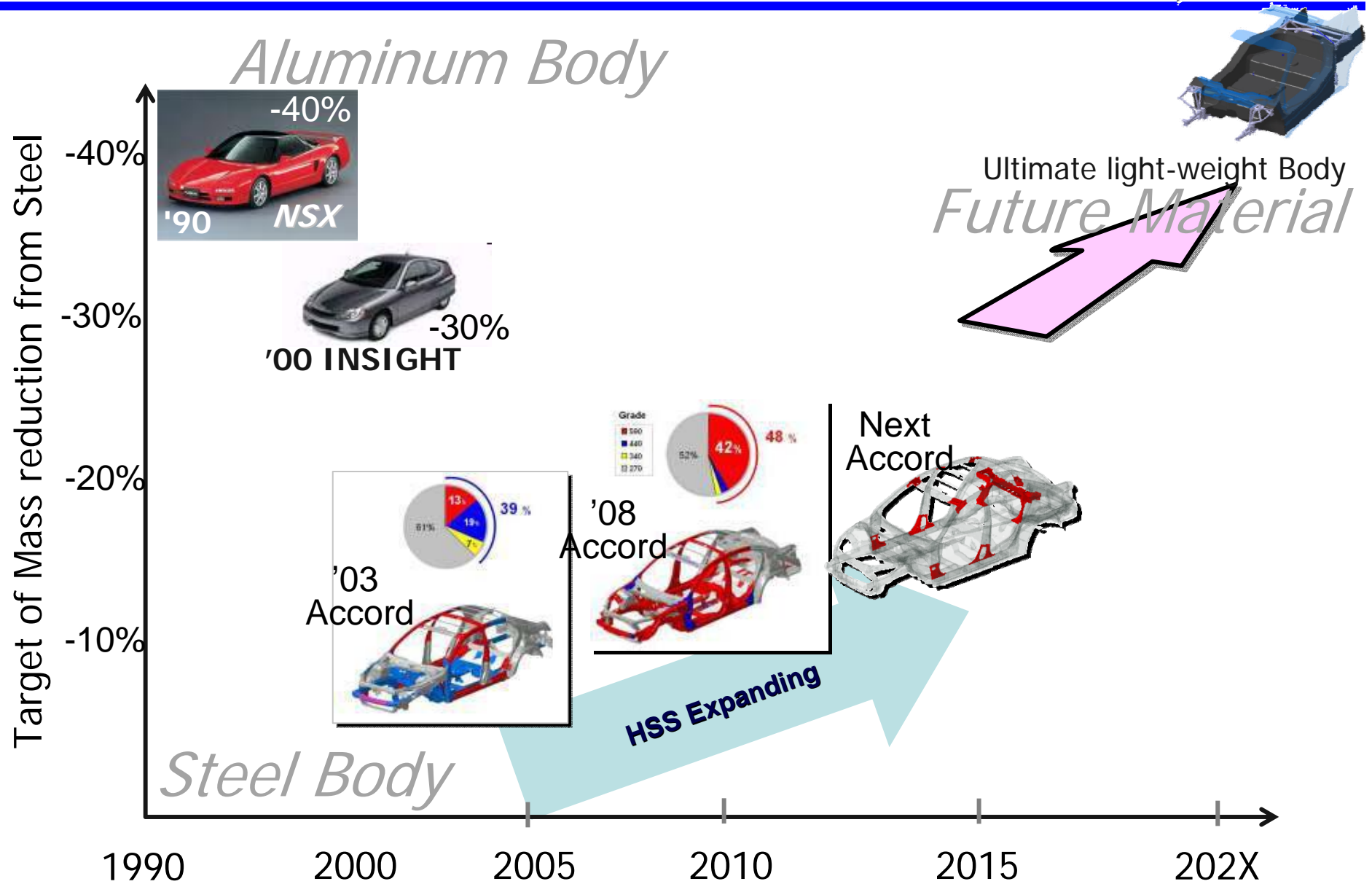
Target of Weight Reduction※

in case of mid-size vehicle



※Require the countermeasure for performance, cost, etc.

Technology Direction of BIW



Down Sizing can reduced fuel consumption

Customer Role:

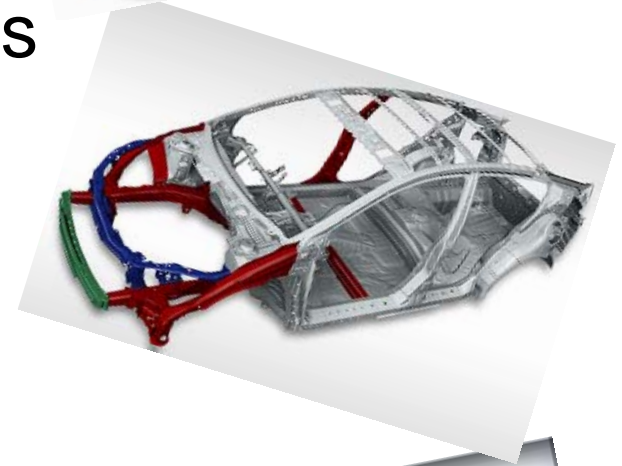
- Consider smaller vehicles

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%



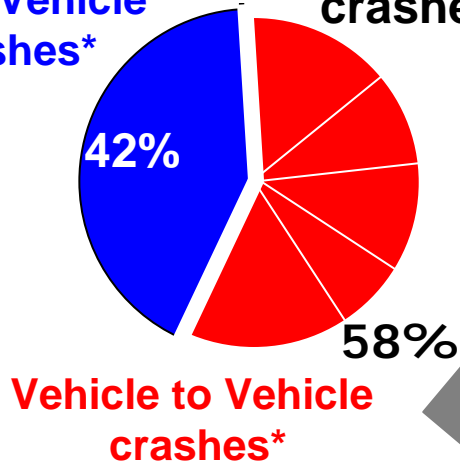
Consumer Downsizing Examples

Downsize	Example	FE	GHG	Savings
Car to Car	Accord L4	32.6	273	
	Civic	39.3	226	-17%
Truck to Truck	Pilot 4WD	23.6	377	
	CR-V 4WD	30.5	291	-23%
Truck to Car	Pilot 2WD	23.6	377	
	Accord V6	29.4	302	-20%
Truck to Car	CR-V 2WD	31.2	285	
	Civic	39.3	226	-21%

Downsizing is a major consumer response to high fuel prices... This also results in reduced vehicle mass and potential compatibility concerns

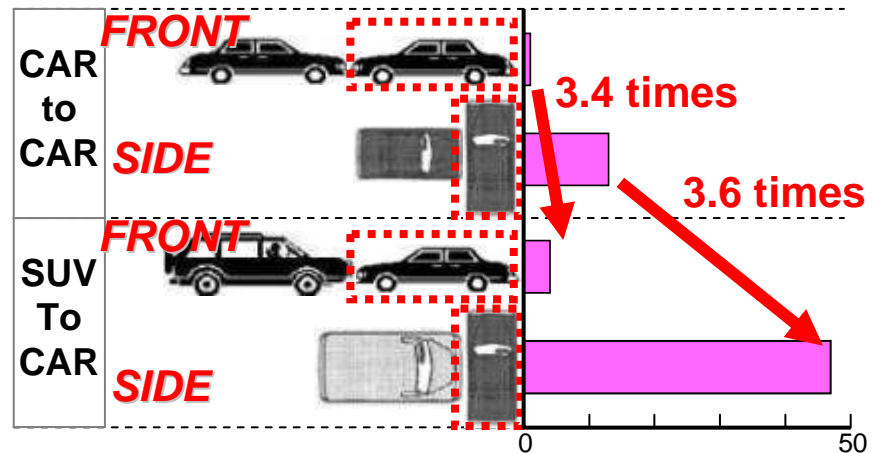
Vehicle Compatibility Challenges

Single Vehicle crashes*



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

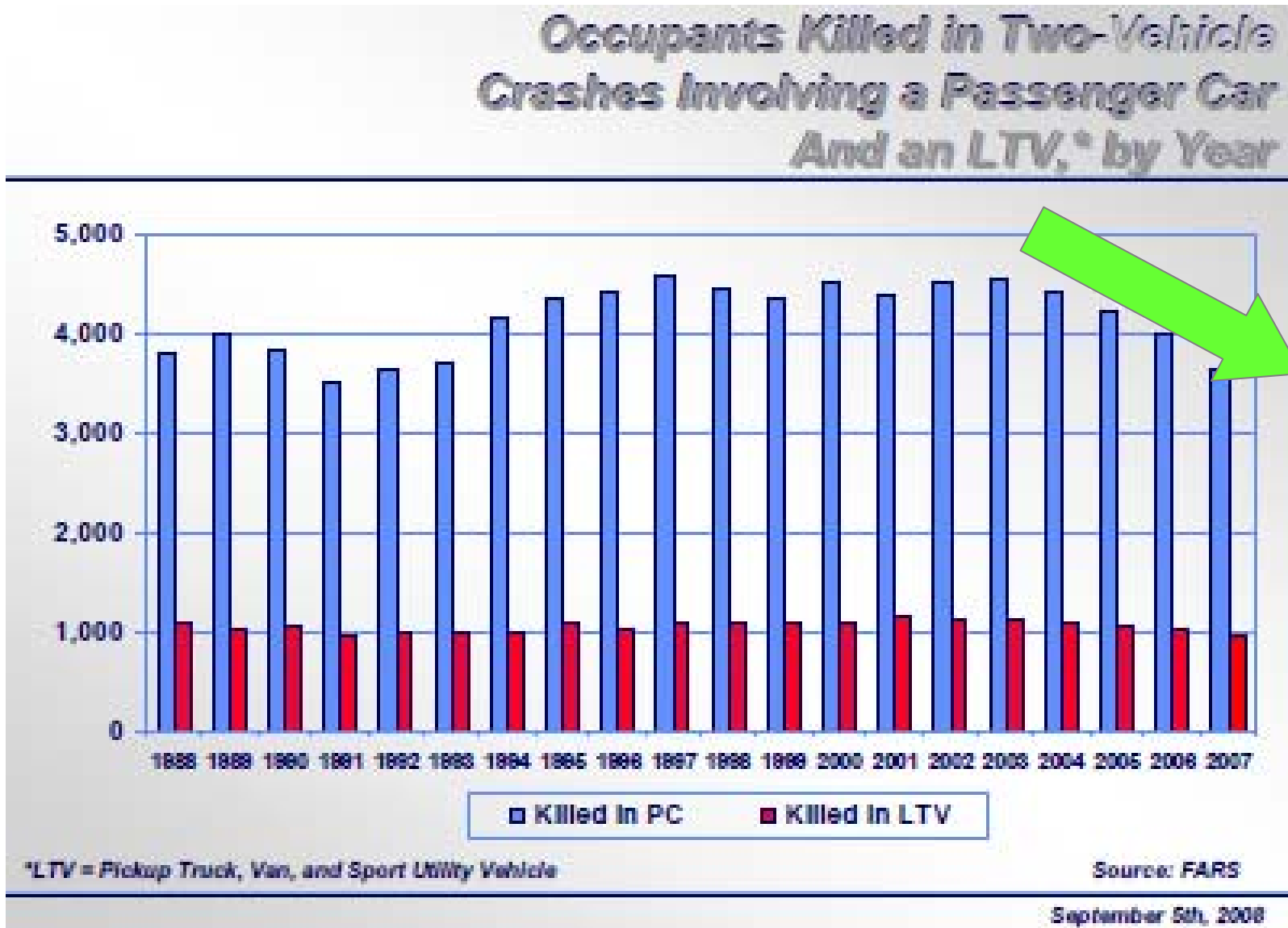
Passenger car driver fatality rate



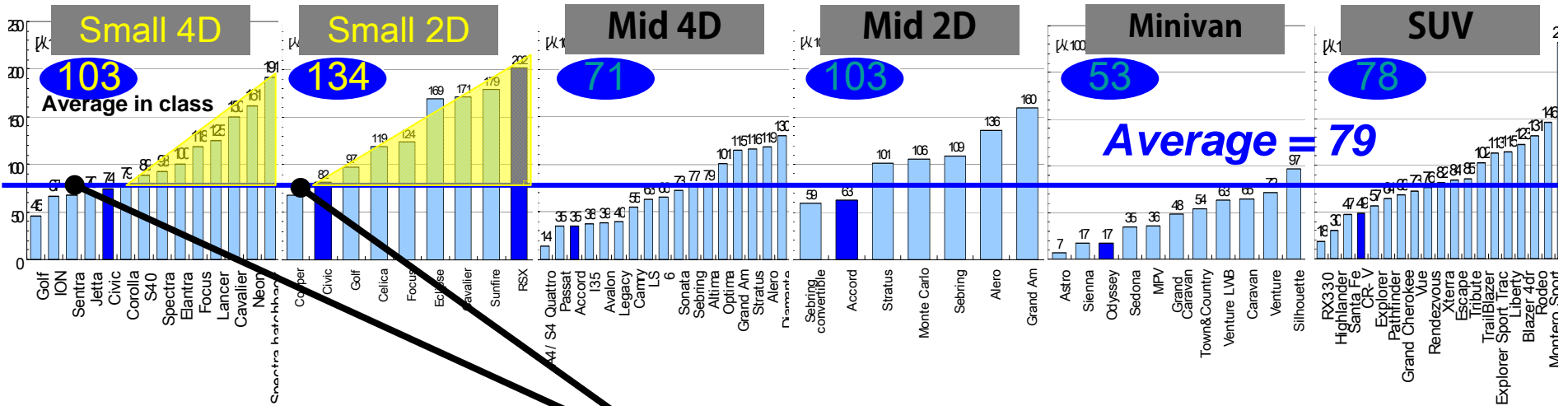
Vehicle compatibility (e.g. Car to SUV) represents a key opportunity to reduce fatalities

* 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

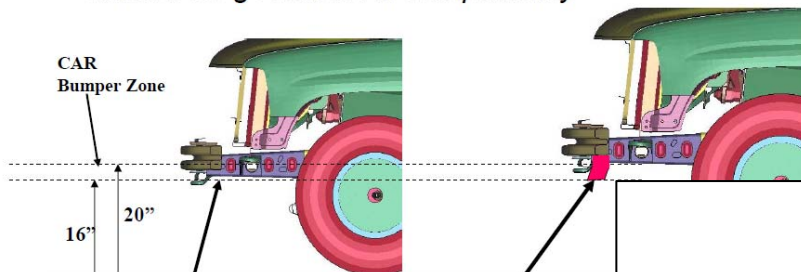
- We learned compatibility issues from *real world* accidents and crash test studies

Issue
Override / Underride
Horizontal Misalignment
Fork Effect
Stiffness Mismatch

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



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

Page 5

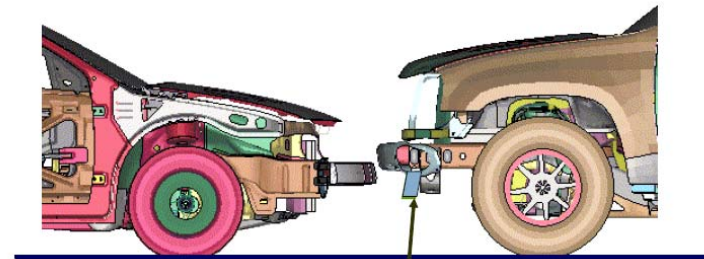
OR

Secondary be added reduce or passenger

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.”



Secondary Structure Added

Page 6

Compatibility Discussion Overview

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

Issue	Industry
Override / Underride	MOU
Horizontal Misalignment	
Fork Effect	
Stiffness Mismatch	

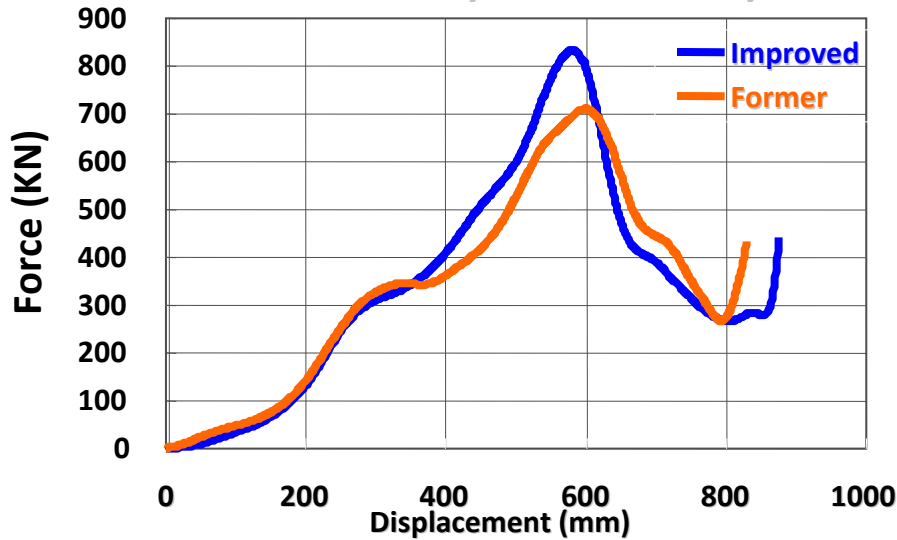
Compatibility Discussion Overview

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

Issue	Industry	Honda
Override / Underride	MOU	ACE
Horizontal Misalignment		ACE
Fork Effect		ACE
Stiffness Mismatch		ACE

ACE™ (Advanced Compatibility Engineering) Body Structure

Former Body vs. ACE™ Body

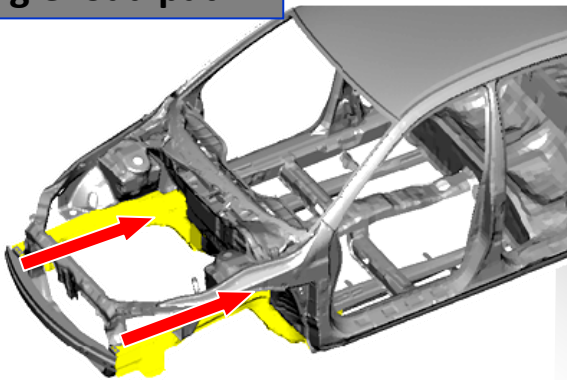


Achieving Highly Efficient Energy Absorption

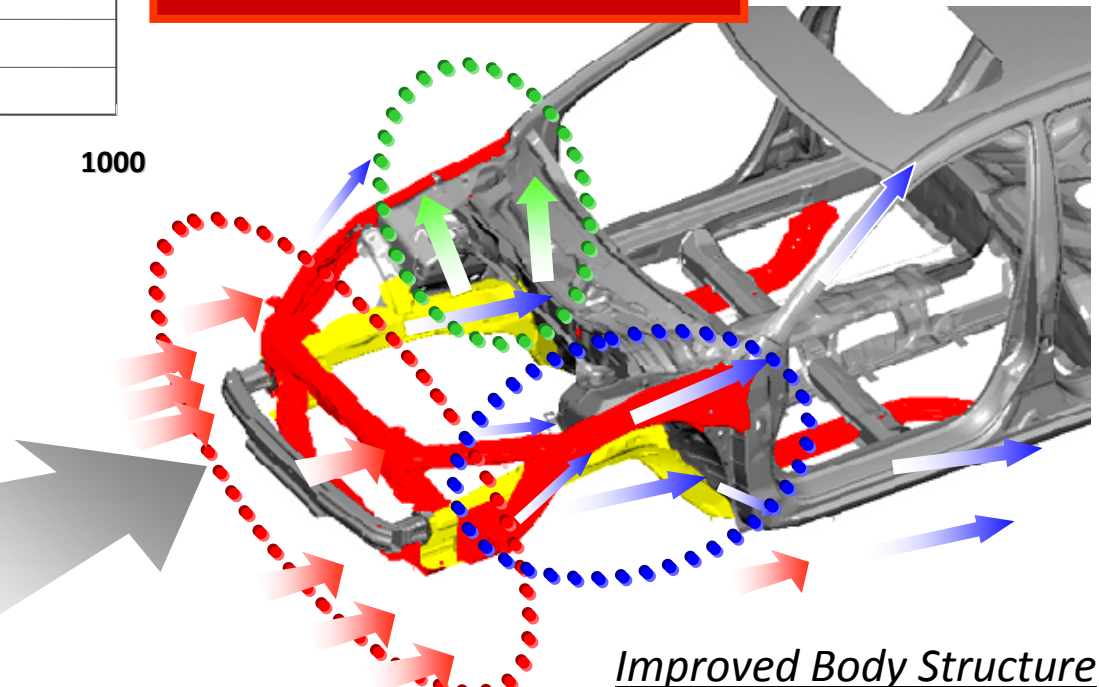
Load Dispersion

Preventing Misalignment with other Vehicle Bodies

Single load path



Former Body Structure

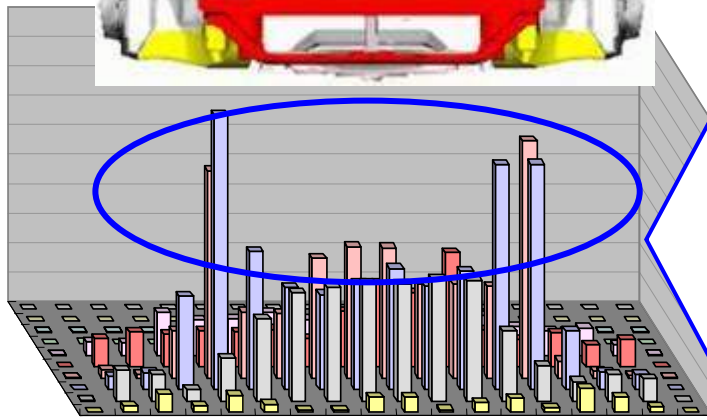
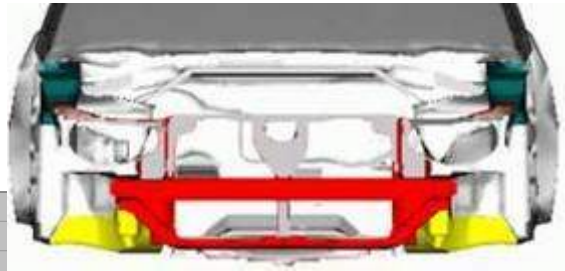


Multi-load path

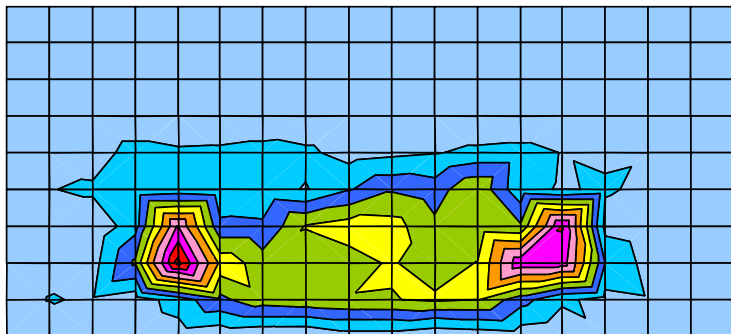
Improved Body Structure

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

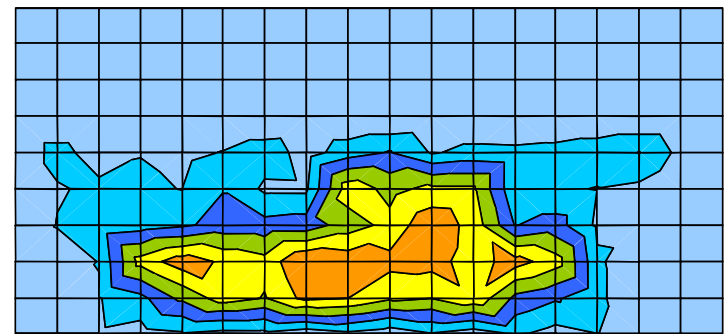
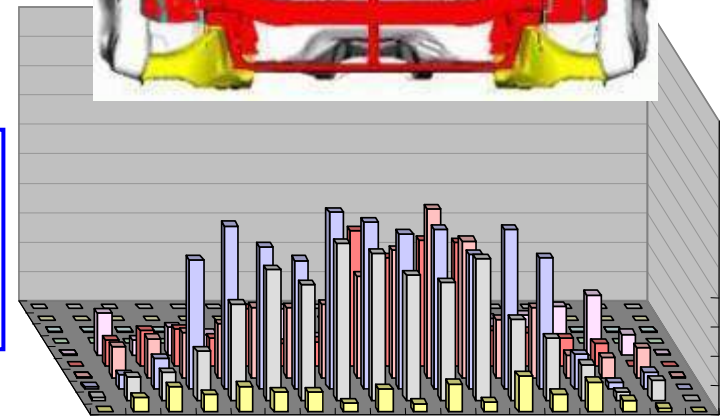
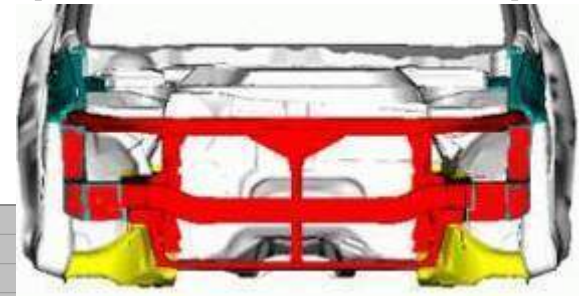
Conventional Structure



High Aggressivity from Frame Rail



Advanced Structure (Honda's ACE™)



**Improved structure showed more homogeneous in barrier force distribution.
Peak force can be reduced to improve partner protection.**

Car size and weight

SPECIAL ISSUE: CAR SIZE, WEIGHT, AND SAFETY

STATUS REPORT

INSURANCE INSTITUTE FOR HIGHWAY SAFETY
Vol. 44, No. 4, April 14, 2009

CAR SIZE AND WEIGHT ARE CRUCIAL

to protecting people in crashes. One way to see how crucial is to crash two cars that have a lot in common other than their size and weight differences. For example, crash a microcar or a minicar with good frontal crashworthiness ratings into a midsize

April 14, 2009

SIZE

When a car crashes into a solid barrier, the outcome depends in part on the size of the front end. If one car's front end is long enough to crush twice as much as another car's in a barrier crash at the same speed, its restrained occupants will experience half as much force as the people in the smaller car because it takes twice as long to stop.



WEIGHT

When two cars going the same speed crash front to front, the outcome depends in part on the cars' relative weights. The heavier car will push the lighter car backward during the impact, which means the velocity change of the heavier car will be much less than that of the lighter car. If the lighter car weighs half as much as the heavier car, the forces on its occupants will be twice as great.



ONE OF THESE CARS WEIGHS TWICE AS MUCH AS THE OTHER. WHEN THEY COLLIDE, EACH GOING 40 MPH, THE HEAVY CAR PUSHES THE LIGHT ONE BACKWARD AT 10 MPH. THE VELOCITY CHANGE OF THE LIGHT CAR (30 MPH) IS TWICE THAT OF THE HEAVIER CAR (20 MPH).

PHYSICS DICTATE CRASH OUTCOMES

The poor performance of all three micro and minicars in frontal impacts with midsize cars (see p. 1) isn't surprising. It reflects the laws of the physical universe, specifically principles related to force and distance.

Although the physics of frontal car crashes usually are described in terms of what happens to the vehicles, injuries depend on the forces that act on the occupants — and these forces are affected by two key physical factors. One is the weight of a crashing vehicle, which determines how much its velocity will change during impact. The greater the change in velocity, the greater the forces on the people inside and the higher the risk of injury.

The second physical factor affecting injury likelihood is vehicle size, specifically the dis-



tance from the front of a vehicle to its occupant compartment. The longer this is, the lower the forces on the occupants, provided vehicle designers take advantage of the extra length.

These two factors, size and weight, have separate effects, but they're highly correlated. In theory the lighter weights of smaller cars could be offset by increasing the sizes of their front ends, keeping weight down by using materials like aluminum, plastic, or titanium. But this typically doesn't occur because such materials cost so much.

Characteristics including the stiffness of a vehicle's front end also influence the outcomes of crashes. However, size and weight are the basic influences.





Size and weight affect injury likelihood in all kinds of crashes. In a collision involving two vehicles that differ in size and weight, the people in the smaller, lighter vehicle will be at a disadvantage. The bigger, heavier vehicle will push the smaller, lighter one backward during the impact. This means less force on the occupants of the heavier vehicle and more on the people in the lighter vehicle. Greater force means greater risk, so the people in the smaller, lighter vehicle are more likely to be injured.

Crash statistics confirm this. The death rate in 1-3-year-old minicars involved in multiple-vehicle crashes during 2007 was almost twice as high as the rate in very large cars.

"Some minicars are definitely more crashworthy than others," says David Zuby, Institute senior vice president for vehicle research. "So it pays to compare their safety ratings. But as a group mini-

Investigate quantitative evidence technically, not a hypothesis.

Crash Performance & Real World Insurance Losses

	Fit	Accord
POST TEST CABIN		
POST TEST A-PILLAR		
STRUCTURE	M	G
Personal injury protection	90	102
Medical payment	93	92
Body injury liability	84	84

	Fit	Accord
dummy dashboard		
I/P		
Head/Neck	A	G
Chest	G	G
Leg/Foot L	P	G
Leg/Foot R	P	G
Restraint	G	G
*test weight	1330kg	1630kg
*mass ratio	1:1.23	

average

worse than average

substantially worse than average

Fit performed well in the real world too.

Insurance Losses of Small Cars

2007-09 models

Size:

Mini

Small

Midsize

Large

Very large

Vehicle	ALL COVERAGES	Collision	Property damage liability	Comprehensive	Personal injury protection	Medical payment	Bodily injury liability
Chevrolet Aveo	132	126	114	108	173	201	146
Hyundai Accent	129	124	124	74	172	170	151
Kia Rio	134	120	131	80	177	215	159
Toyota Yaris	124	130	107	96	183	177	121
Toyota Yaris hatchback	—	51	—	75	—	—	—
Chevrolet Aveo	—	86	70	96	—	—	—
Honda Fit	84	81	67	108	90	93	84
Kia Rio	117	114	92	73	149	161	149

Compatibility Discussion Overview

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

Issue	Industry	Honda	Comment
Override / Underride	MOU	ACE	
Horizontal Misalignment		ACE	
Fork Effect		ACE	
Stiffness Mismatch		ACE	Need Additional Research & Industry MOU?

Weight Reduction & Vehicle Safety

Does Weight reduction also reduce vehicle safety?

Conceptual diagram of collision energy absorbing

Kinetic Energy

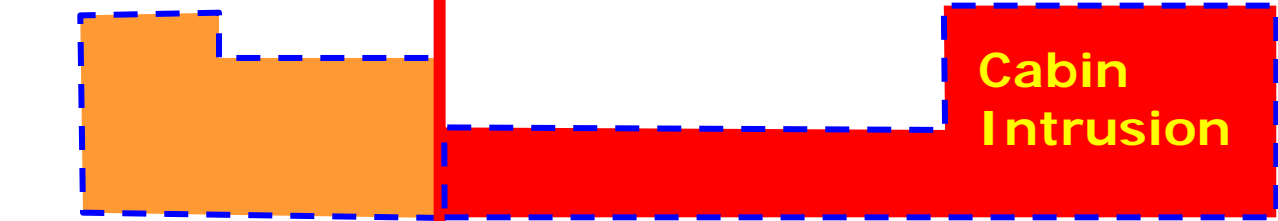


Energy absorbing

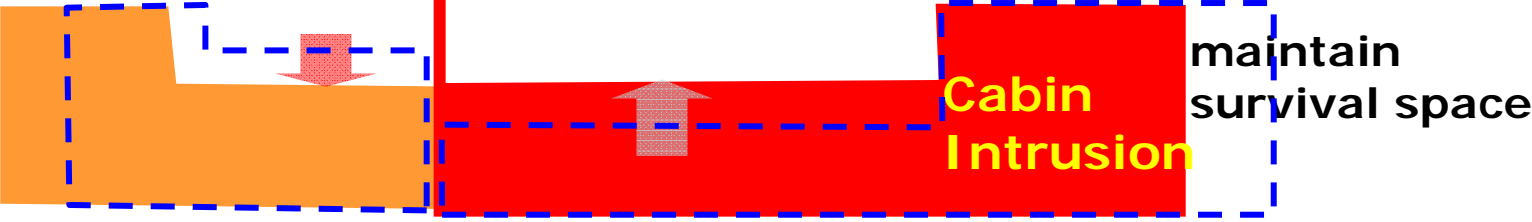


Better interaction and better balance of stiffness




Base line



Improved Compatibility



Compatibility Test Procedure Research is Needed

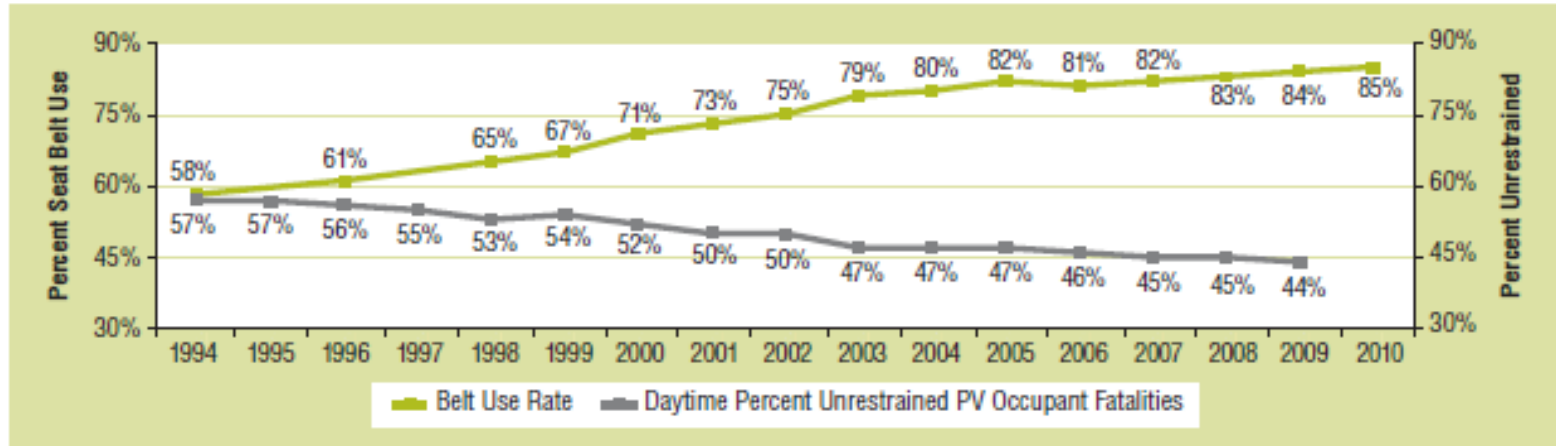
		Interaction With Geometry	Stiffness Matching With Geometry		Compartment stiffness (Strength)
			Local	Global	
<p>Honda recommends FWDB & PDB to develop compatibility standards</p>					
FWDB		Good	Good	Acceptable	Poor
FWRB		Limited	Limited	Acceptable	Poor
Offset	PDB 56-60kmh 	Poor	Poor	Acceptable No bottoming	Acceptable Severe for Small
	ODB 56-64kmh	Poor	Poor	Poor Bottoming	Acceptable Severe for Large

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?

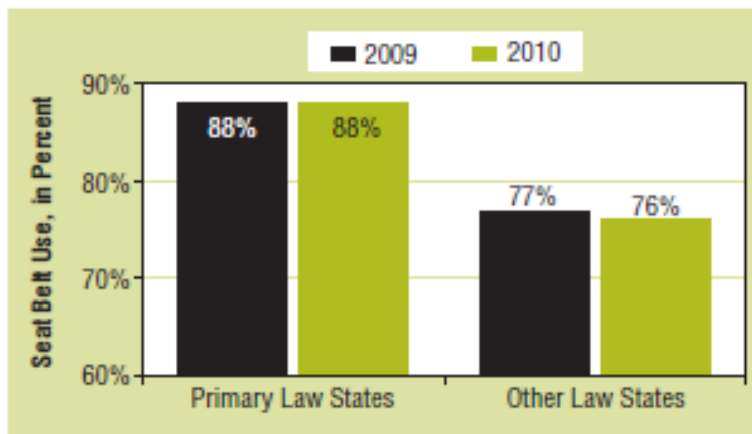
Seat Belt Use

Figure 1
NOPUS Seat Belt Use Rate and Daytime Percent of Unrestrained Passenger Vehicle Occupant Fatalities



(Source: NOPUS and FARS)

Figure 3
Seat Belt Use by Law Type (Source: NOPUS)



Potential to increase from 85% to 88% through wider acceptance of seat belt law enforcement

Effectiveness of Seat Belt Reminder

Table 3
Adjusted Driver Seat Belt Use in Passenger Vehicles With and Without Belt Reminders

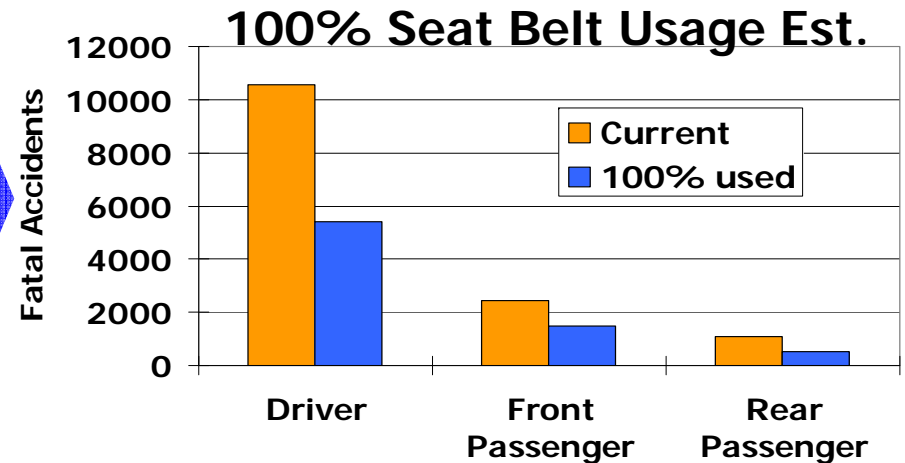
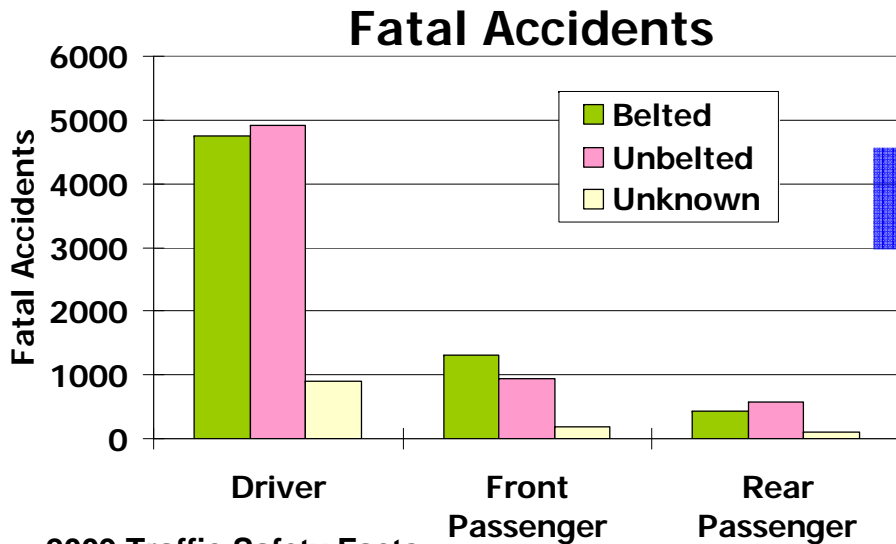
	Seat Belt Use Rates (Percent)		Difference	95 Percent Confidence Limits	
	No Reminder	Reminder		Lower Limit	Upper Limit
Vehicle type					
Car	83.6	88.1	4.5	0.0	9.1
Minivan	88.2	91.9	3.7	-3.6	11.1
Utility vehicle	82.9	92.3	9.4	3.5	15.2
Driver gender					
Male	82.5	88.3	5.8	0.9	10.7
Female	86.0	91.9	5.9	1.7	10.1
Overall	84.3	90.1	5.8	2.6	9.1

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.”

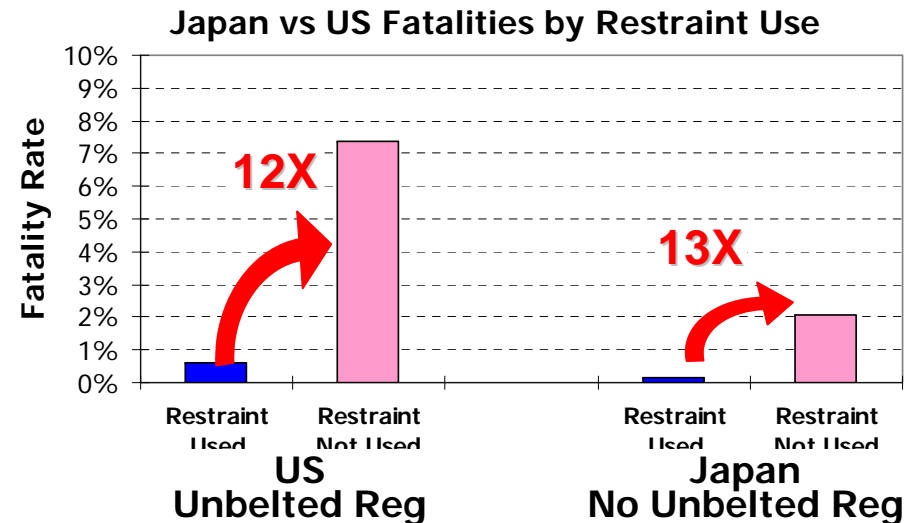
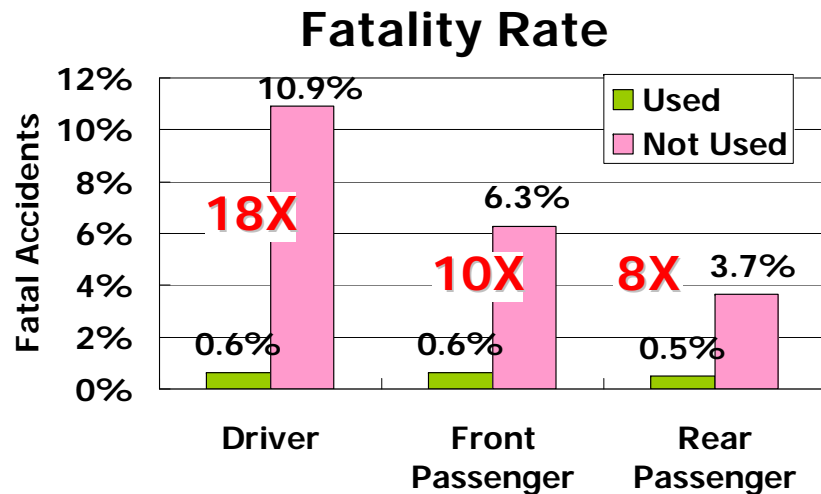
IIHS, 2006, Effectiveness and Driver Acceptance of the Honda Belt Reminder System

Unbelted Occupants Are Major Portion of Fatality Rates

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



2009 Traffic Safety Facts



FMVSS 208's Unbelted Occupant requirement seems to be ineffective

US and Jpn Fit Test Performance Comparison

JPN Honda Fit



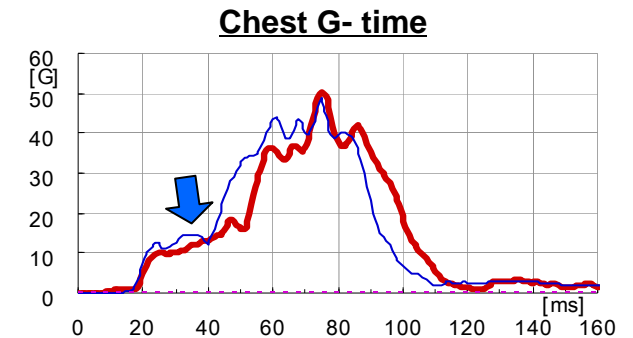
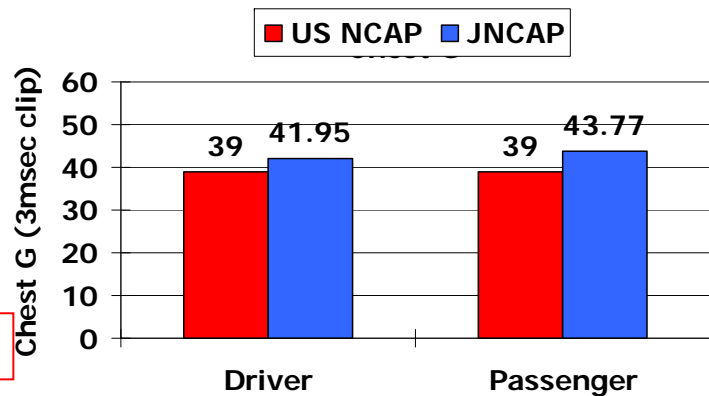
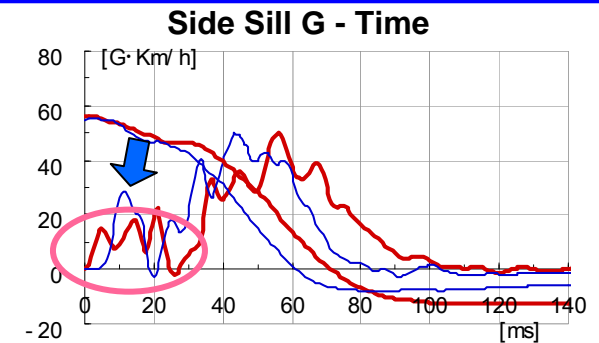
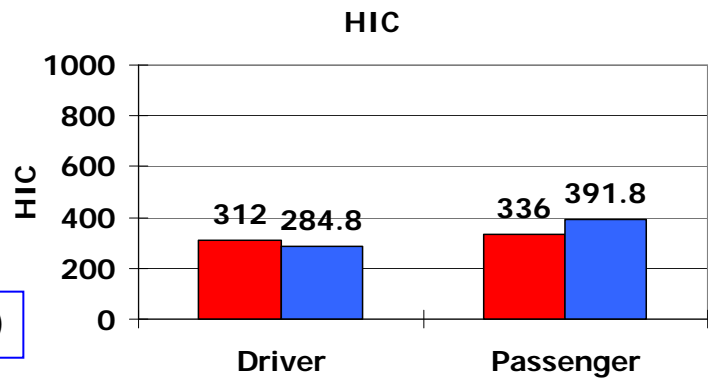
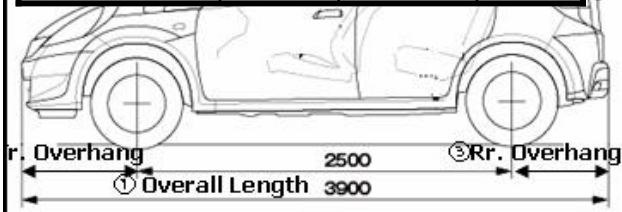
Highest NCAP Test (6 Stars)

US Honda Fit



Highest NCAP Test (5 Stars)

	US	Japan	Diff
Length	4105	3900	205
Fr Overhang	910	765	145
Weight	1168	1080	88



— Japanese Model
— U.S. Model

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.**

HONDA

The Power of Dreams