NHTSA Compatibility Research Update

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Fatalities in Car-LTV Frontal Crashes

FARS Year	*LTV Occupants*	*Car Occupants*	*Driver Fatality Ratio*
2001 (IPT data)	375	1,365	1:3.9
2003	346	1,312	1:3.8
2004	307	1,323	1:4.6
2004 – MY 2002 LTV and later	44	302	1:7.6

How to Accomplish Compatibility?

- Match frontal structures to ensure sharing of frontal crash energy. (TWG=height of PEAS matching)
- Match crash energy absorption of frontal structures.
- Don’t sacrifice self protection to accomplish partner protection.

- Current NHTSA working concept:
  - Proposed side impact rulemaking addresses side compatibility.
  - Current research is focused on full frontal crashes. Better frontal design will also have benefits in offset.
  - No new dynamic tests, if possible.
  - Use a dynamic test metric to measure height of force.
  - Use a dynamic test metric to measure energy absorbed.

Metrics for Compatibility

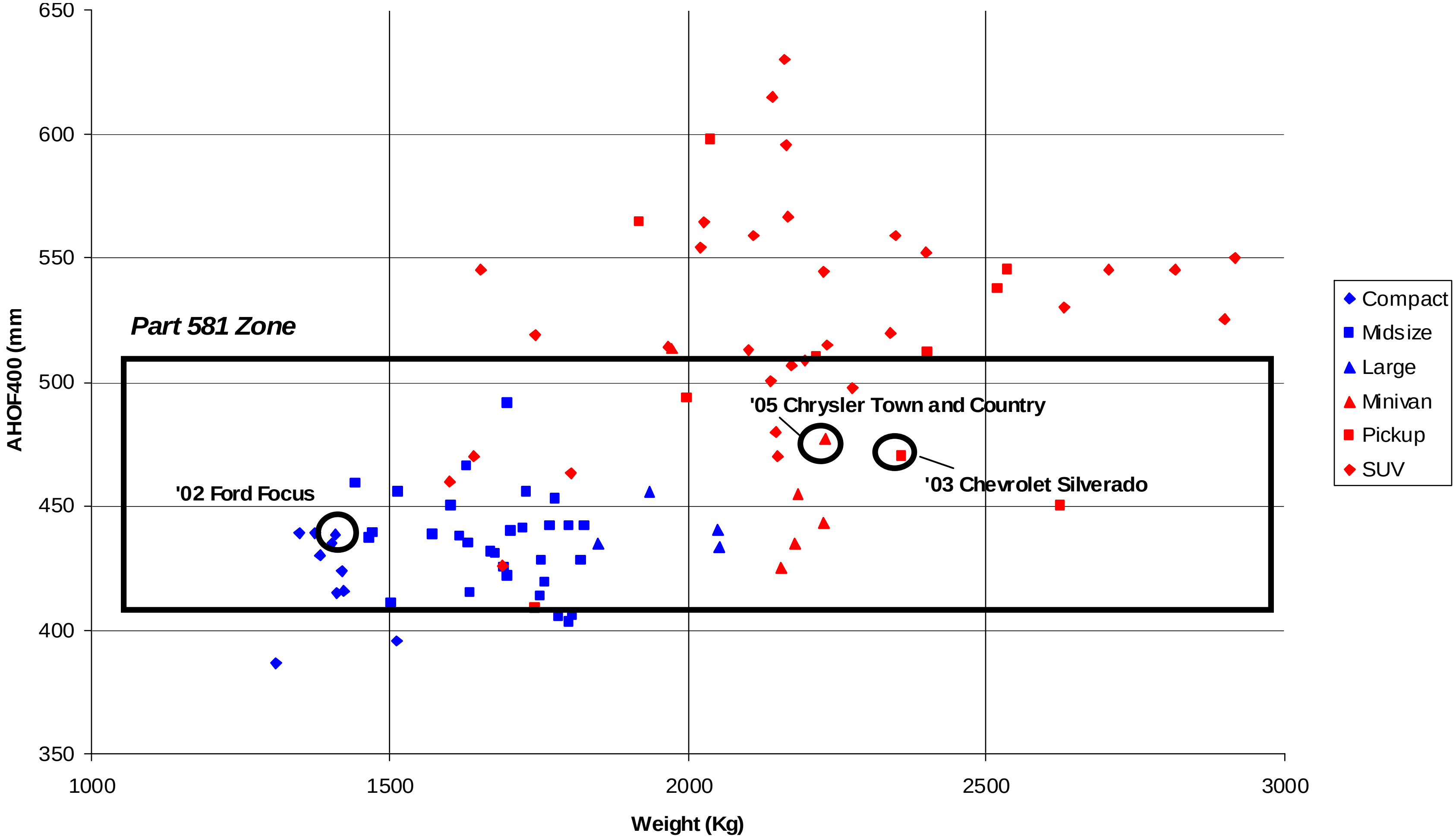
- Approach: Evaluate the first 400 mm of the crush for compatibility.
  - Average height of force over first 400 mm of crush (AHOF400).

    AHOF400 from rigid barrier 35 mph test does an adequate job of locating the height of the interacting frontal structure.
- Energy absorbed.
  - Same as work done to crush front end. Focus on work to crush first 400 mm of vehicle (Kw400).

    Kw400 from rigid barrier 35 mph test does good job of replicating worst case of rail engagement (highest stiffness, highest work to crush). Control the worst case of stiffness.
- Current compatibility concept: match vehicles by matching medium values in metrics
  - AHOF400 in Part 581 Bumper Zone.
  - Kw400 in 1300-1700 N/mm.

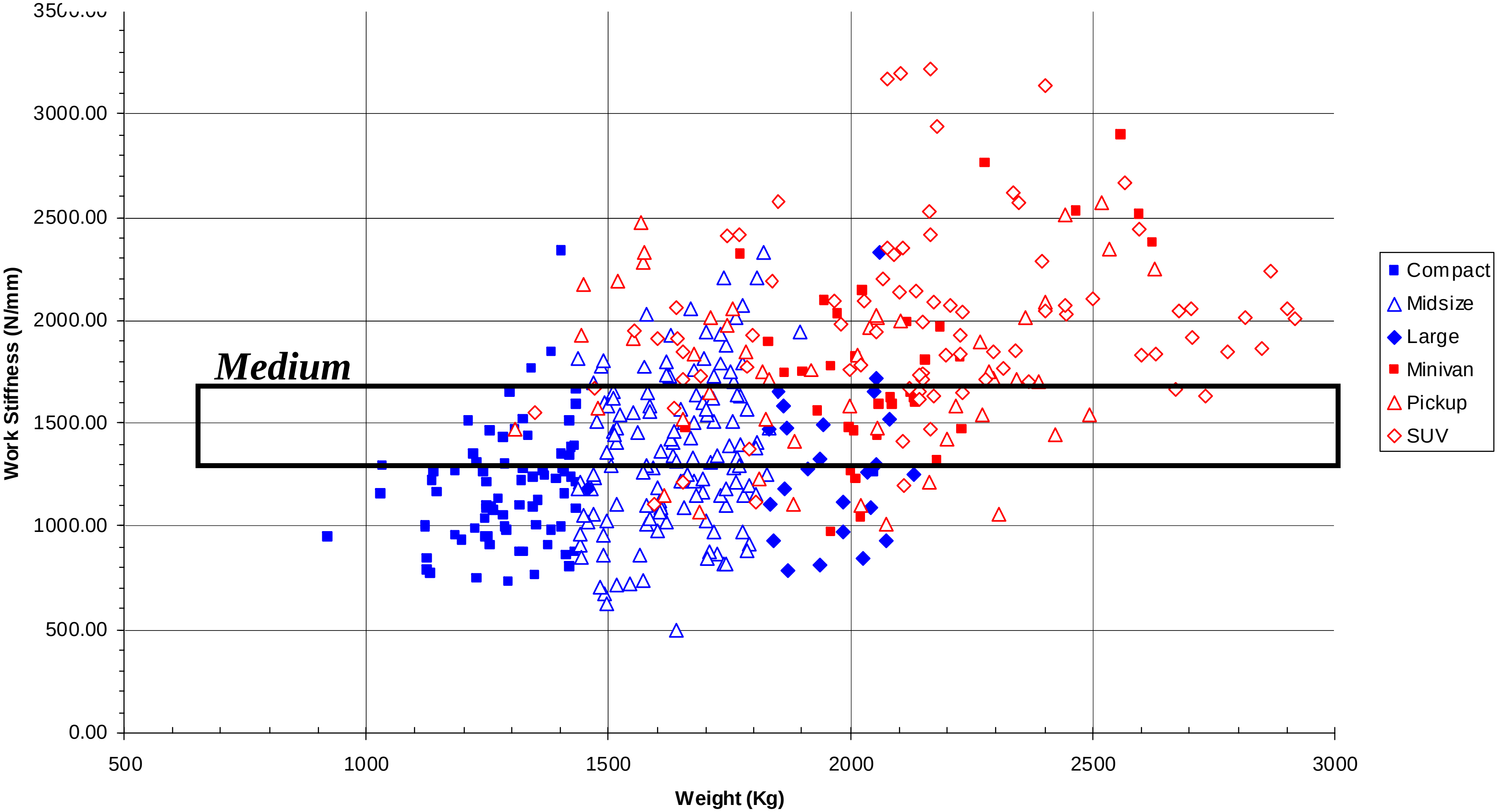
Height Matching – AHOF400

MY 02-05   Medium = Part 581 Bumper Zone



Energy Matching – Kw400

MY 91-04 Medium = 1300-1700 N/mm



Preliminary Analyses:
Matched CDS Crashes Have the Lowest Injury Rates

(Combined offset and full frontal 96-04 CDS, MY 96-04, two light vehicles only, injury rates in belted subject car drivers)

Subj. A400	*Other LV A400*	*Subj. Kw400*	*Other LV Kw400*	*AIS 3+ Prob. Inj.*	*AIS 2+ Prob. Inj.*	*Cases*
Med.	Med.	Low	Low	1.1%	2.4%	31
Med.	Med.	Med.	Low	16.5%	18.9%	12
Med.	Med.	Low	Med.	9.2%	19.4%	23
Med.	Med.	Med.	Med.	1.9%	6.8%	12
Med.	High	Low	High	4.0%	74.2%	11

Override

What is the Effect of Kw400 for Aligned Structures?

LTV Work Stiffness, Kw400

Compact Work Stiffness	***Low*** *None* *MY00 - 04*	***Medium*** *05 T&C* *1470 N/mm*	***High*** *03 Silverado* *2019 N/mm*
Low *02Focus* *1157 N/mm*		02Focus-05T&C	02Focus-03Silverado
Medium *01Civic2Dr* *1433 N/mm*		01Civic2Dr-05T&C	01Civic2Dr-03Silverado
High *Model TBD*		(maybe in 07)	(maybe in 07)

Initial Crash Test Approach

- This is not benefits testing, but a way to compare frontal energy absorption.
- Phase I, determine the test speed at 75mph
  - Run Focus-Silverado (aggressor) at 70, 75, 80 mph closing.
  - Examine the injury metrics to see where they fall on the 208 probability of injury curves.
  - Select the test speed such that the injury metrics are just over the IARV levels.
- Phase II, run crash tests to measure injury with various frontal interactions.
  - Hold masses the same, ballast as necessary.
  - Hold delta V on the target the same.
- Compare injury risk to compare frontal performance.

Focus Occupants Have Less Risk with Better Matching

(Silverado/T&C MAIS 3+ injury risk)	*Focus Driver (50% M)*	*Passenger (5% F)*
HIC15	***17% Improvement*** (42/35) Still above IARV	*No Change* (0/5)
Nij	*No Change* (11/11)	***60% Improvement*** (30/12) Moved below IARV
Chest Gs	***13% Improvement*** (92/80) Still above IARV	*No Change* (50/50) Below IARV

LTV Occupants Have Less Risk with Better Matching

(Silverado/T&C MAIS 3+ injury risk)	*LTV Driver (50% M)*	*LTV Passenger (5% F)*
HIC15	*No Change* (3/1)	***92% Improvement*** (12/1) Moved below IARV
Nij	*No Change* (9/6) Below IARV	*No Change* (10/8) Below IARV
Chest Gs	***32% Improvement*** (41/28) Both below IARV	***24% Improvement*** (41/31) Both below IARV

The Best Match Produced the Lowest Probability of Injury

All results are for a 50th M belted target driver, 75 mph closing	*2005 Town and Country* *1469 N/mm*	*2003 Silverado* *2019 N/mm*
2002 Focus *1157 N/mm*	*Matched force-deflection slope* HIC15 = 1267 Chest g = 72	*Aggressor LTV* HIC15 = 1482 Chest g = 88
2001 Civic 2Dr *1433 N/mm*	*Matched energy absorption* HIC15 = 802 Chest g = 66	*OVERRIDE* *(structures not aligned)*

Other V-V Test Results

50th Male Focus Driver, 75mph Closing, Ballasted

	2005 F250 with SEAS	*2005 F250 w/o SEAS*	*2003 Odyssey*	*2005 Odyssey (ACE)*	*2006 Ridgeline (Unibody, SEAS)*
2002 Focus Driver	**HIC = 1023** **Ch g = 86**	**HIC = 1583** **Ch g = 99**	**HIC = 1689** **Ch g = 90**	**HIC = 1950** **Ch g = 90**	**HIC = 3448** **Ch g = 106**

Next Steps in FY06

Further Testing

- Run High Resolution Barrier tests on all crash test vehicles to verify AHOF and Kw metrics
  - 125x125mm linear load cell matrix.
- Rerun the Civic-Silverado(lowered) pair to complete the matrix of Kw400 for height-matched structures. Match height of structures using:
  - Lowered Silverado AHOF400 to match Civic AHOF400.
  - Engineering analysis and judgment.
- Run a PDB test series with French/UTAC
  - Silverado and Town&Country to see if this barrier can discriminate between aggressive and compatible Option 1 LTVs.
  - Full width and offset tests are planned.

Next Steps in FY06

Statistical Analysis

- Complete the problem definition and preliminary benefits estimates for AHOF400 and Kw400 (Volpe report in September 2006).
  - Identify target populations for AHOF400 and Kw400 matching.
  - Define the frequency counts and injury patterns for car-LTV, LTV-LTV, car-car, and obstacle compatibility crashes.
  - Estimate benefits/disbenefits for AHOF400 and Kw400 matching.
- Develop an approach to optimizing AHOF-x and Kw-x and use it to improve the outcomes of AHOF and Kw in terms of injury (Volpe report in 2007).

Thank You

Computing the Dynamic Metrics

- Average Height of Force (AHOF)
  - *Use Full Width Rigid Barrier data (FWRB)*
  - *HOF =* $\Sigma(F_i\, h_i)/\Sigma F_i$ *= average over barrier face.*
  - *Average HOF =* $\Sigma(HOF_n\, d_n)/\Sigma d_n$ *= average over the crush.*
- Work Stiffness (Kw)
  - *Use FWRB data*
  - *Equate an ideal spring to the work of the crush*
  - $\frac{1}{2} Kw\,(D_f^2 - D_i^2) = \Sigma(F_n\, \Delta D)$ *work starts when* $D_i = 25$*mm.*

    $Kw = 2\, \Sigma(F_n\, \Delta D) / (D_f^2 - D_i^2)$
  - *Kw is a direct measure of the energy absorbed by a vehicle front.*
  - *If D is chosen the same for all vehicles, it is an energy-based comparative metric.*
- Evaluate over the first 400 mm of crush from 35 mph rigid wall test. Metrics are AHOF400 and Kw400.