Compatibility Research Plan

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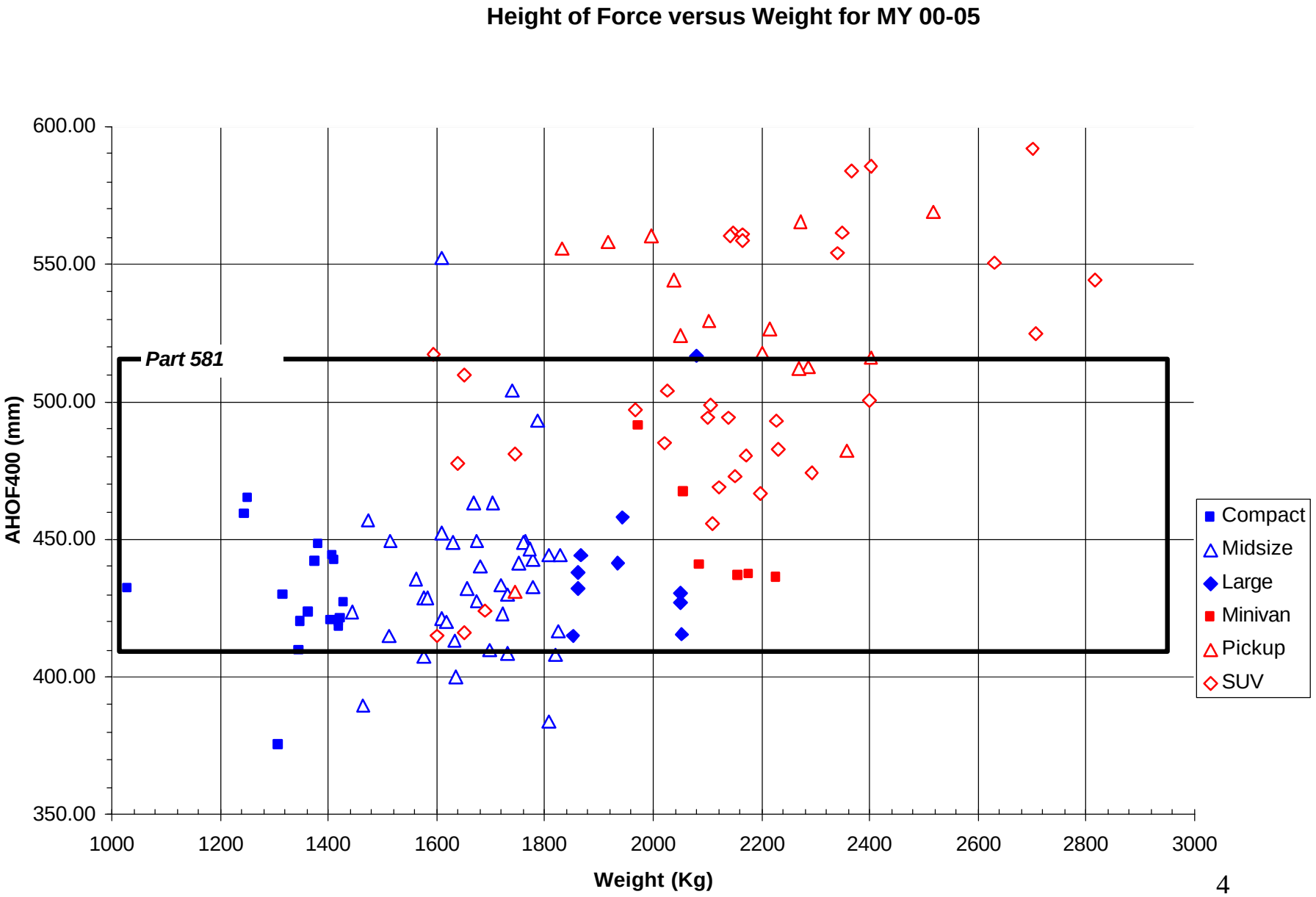
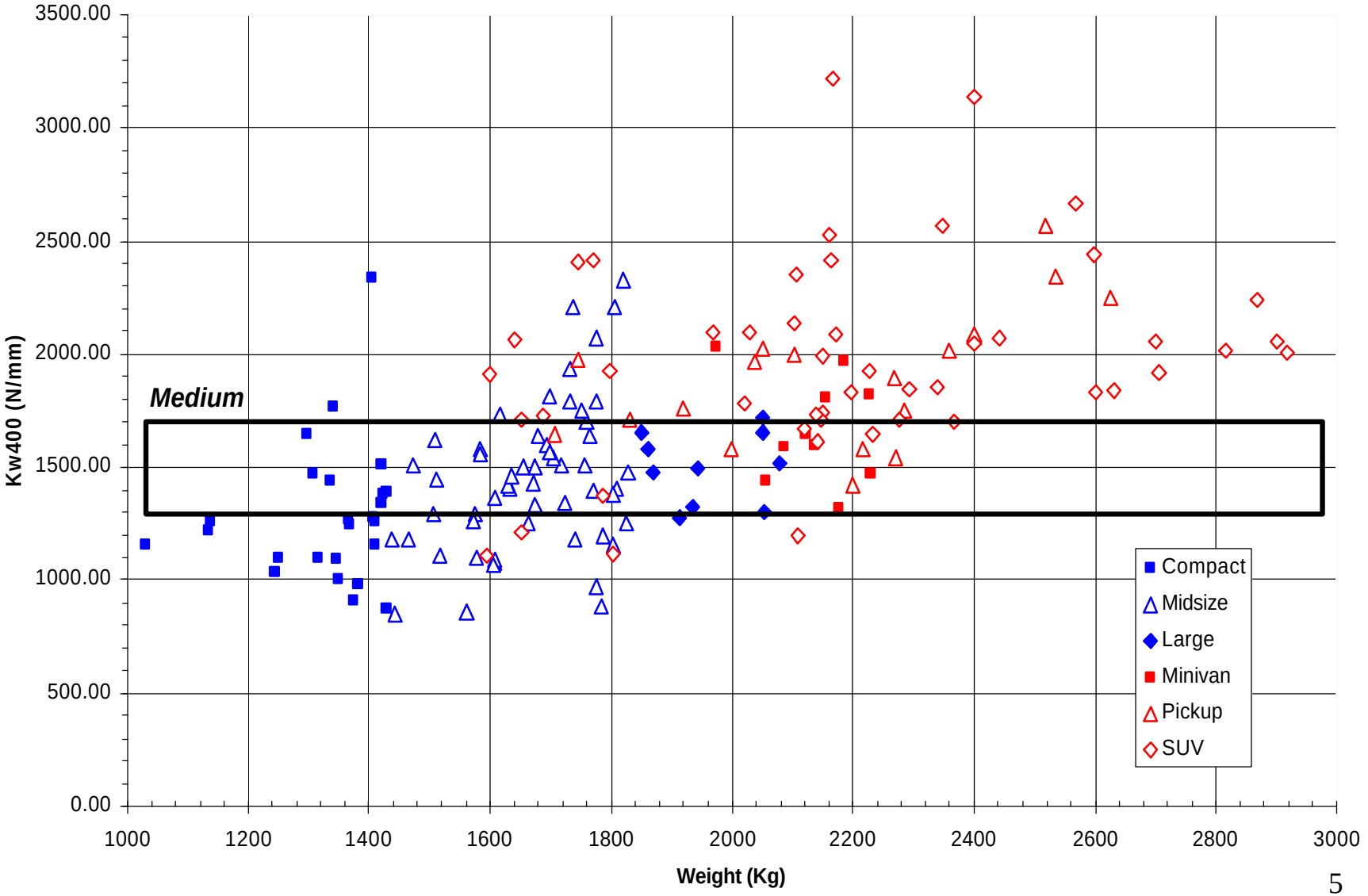
Objective and Scope

- Objective: To lay the basis for a decision on near term rulemaking.
- Scope: Offset and compatibility research programs support one another, compatibility is focused on full frontal.
  - An offset test for occupant compartment stiffness to reduce lower extremity injuries.
  - A Compatibility test for matching frontal structure stiffness and height of forces to reduce all injuries. Good design for full frontal is good design for offset compatibility.

The Metrics of Compatibility

- Initial stiffness, Ks
  - Initial slope of the force-deflection curve from NCAP tests over about 200 mm of crush (Kahane, 2003)
- Work stiffness, Kw
  - Area under the force-deflection curve from NCAP tests, hence work or energy absorbed.
  - More reliable, less design restrictive than Ks.
  - Kw400 = during first 400 mm of crush.
- Average Height of Force
  - Height of force averaged over the crush.
  - AHOF400 = during first 400 mm of crush.


Height of Force versus Weight for MY 00-05
AHOF400 (mm)
600.00
550.00
500.00
450.00
400.00
350.00
Part 581
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Weight (Kg)
Compact
Midsize
Large
Minivan
Pickup
SUV

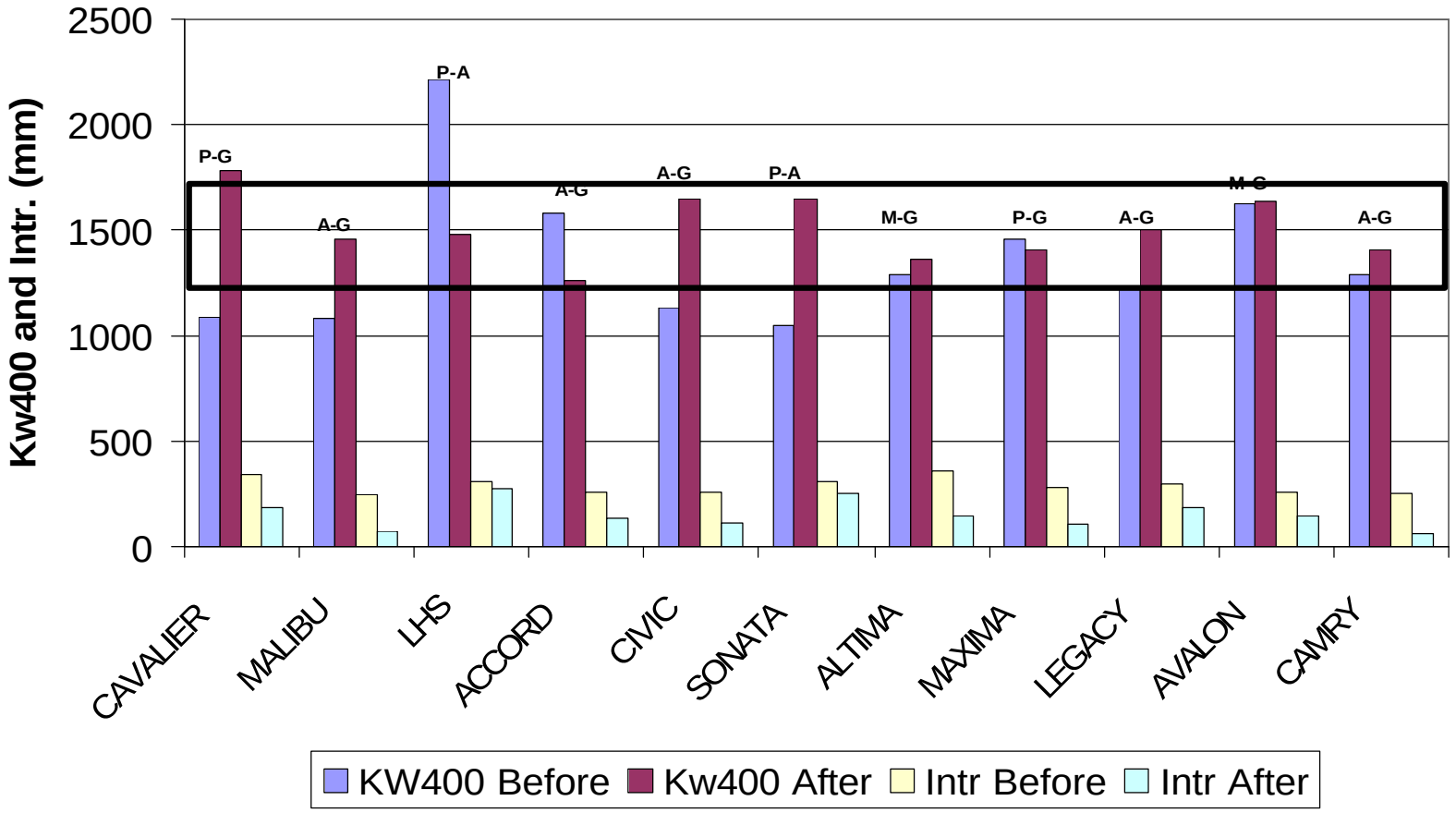

Work Stiffness versus Weight for MY 00-05
Kw400 (N/mm)
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
Medium
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
Weight (Kg)
Compact
Midsize
Large
Minivan
Pickup
SUV

Preliminary AHOF400 & Kw400 Matching in CDS

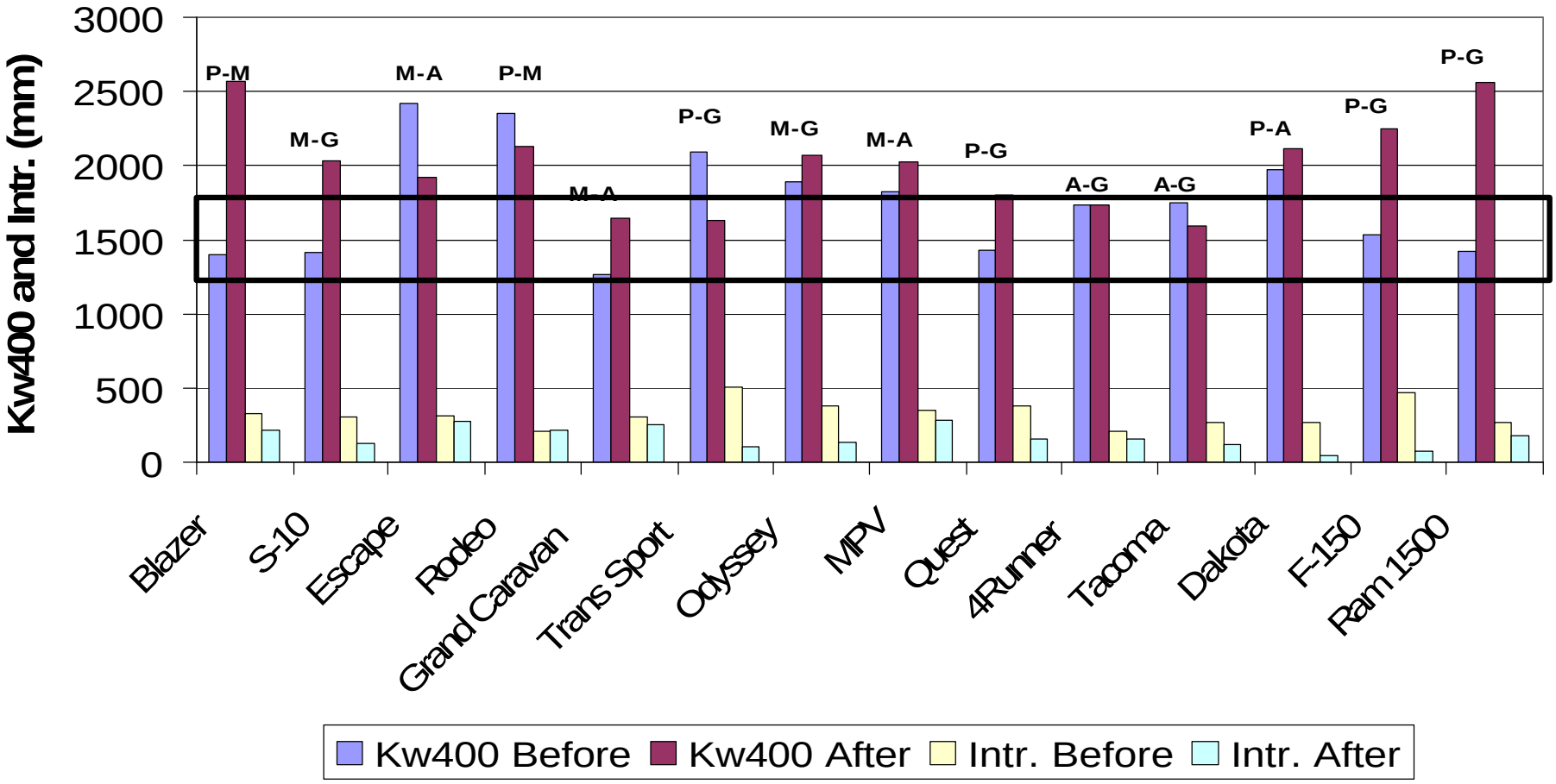
(Combined offset and full frontal, belted car drivers only)

Car AHOF	Other AHOF	Car Stiffness	Other Stiffness	AIS 3+ Prob. Inj.	AIS 2+ Prob. Inj.	Cases
Med.	Med.	Low	Low	1.1%	2.4%	31
Med.	Med.	Low	Med.	9.2%	19.4%	23
Med.	Med.	Med.	Low	16.5%	18.9%	12
Med.	Med.	Med.	Med.	1.9%	6.8%	12
Med.	High	Low	High	4.0%	74.2%	11

Cars Before and After the IIHS Offset Test



LTVs Before and After the IIHS Offset Test



Next Steps in Analytical Work

- Additional analyses of CDS data to better understand injury outcomes for Kw and AHOF.
- Analyses of FARS data to better understand fatality outcomes for Kw and AHOF.
- Analyses of crashes with objects for Kw and AHOF.
- Optimization study to select Kw limits.
- CDS case study and CIREN analyses to better understand injury patterns.

Vehicle Testing Approach

Full Frontal Collinear

1. IPT test series called for in the IPT Report, 6/03.
   - Initial stiffness, Ks, matched pairs.
   - Work stiffness, Kw, matched pairs to match energy absorption.
2. Begin to compare various frontal constructions
   - Option 1 LTVs – Body on frame, Advanced Compatibility Engineering (ACE), and Unibody structures.
   - Option 2 LTVs – Secondary Energy Absorbing Structure (SEAS) to engage cars.
3. High Resolution Rigid Barrier (HRRB) Tests

Ks Matching Results

- Vehicles matched AHOF. LTV weights were ballasted to match.
  - 03 Silverado, Ks = 2541 N/mm, aggressive.
  - 05 Town&Country, Ks = 1244 N/mm, compatible.
  - 02 Focus, Ks = 1304 N/mm.
- High test speeds were chosen to show relation of injury to structural matches, Focus deltaV = 45 mph.
- Crash tests showed a significant improvement (10 – 20%) in the risk of serious injury with matched height and low initial stiffness.
- Improvement was seen in both the LTV and passenger car.

Kw Matching Approach

- Same test conditions as the Ks series to compare results.

	K_w400 Work Stiffness	***AHOF400 Height of Force***	***W Weight***
03 Silverado	**2019 N/mm**	**470 mm**	**2359 Kg**
05 T&C	**1469 N/mm**	**477 mm**	**2229 Kg (Ballast to Silverado 2359)**
01 Civic 2 Dr Coupe	**1433 N/mm**	**415 mm**	**1335 Kg (Ballast to Focus 1410 kg)**

Begin to Compare Frontal Constructions, vehicle-vehicle tests

- Same test conditions as previously (mass, speed, target) and compare injury outcomes.
- ACE structure – MY03/05 Honda Odyssey before and after ACE against 02 Focus.
- Unibody structure – MY05 Honda Ridgeline against 02 Focus.
- SEAS structure – MY06 F-250 with and without SEAS against 02 Focus.

Begin to Compare Frontal Structures – High Resolution Rigid Barrier (HRRB) Tests

To get more accurate data for the test design metrics and better understand the vehicle-vehicle crash test results

- 02 Focus
- 01 Civic 2 Dr coupe
- 03 Silverado
- 05 Town and Country
- 03 Odyssey (without ACE)
- 05 Odyssey (with ACE)
- 05 Ridgeline
- 06 F-250 (with SEAS)

Perform a Progressive Deformable Barrier (PDB) Test Series

Memo of Cooperation with the French signed in 2004.

- Tests now being co-designed with the French, and co-funded.
- Selected LTVs to match our vehicle-vehicle IPT test series, 03 Silverado and 05 Town and Country.
- Evaluate how well the barrier distinguishes between the two frontal structures - one aggressive, the other compatible.

Dynamic Test Approach

- Rigid barrier 208 approach is the best near term option.
  - Self protection comes from 208 and NCAP.
  - Partner protection comes from Kw400 and AHOF400 measured during 208 tests at 35 mph. (cases of concern car-car, Opt.1 LTV-car, LTV-LTV)
  - Barrier instrumentation will be designed using an 04 earmark to GWU/NCAC and finite element analysis.
- A new rigid barrier will be needed for the new Option 2 LTVs to ensure SEAS compatibility with passenger cars.
  - Alliance override rigid barrier (ORB)

ORB Tests and the SEAS

- The Alliance override rigid barrier extends out from the rigid wall about 1.2 m and upward to engage the SEAS.
  - Force height and energy absorption need to be evaluated to ensure car compatibility.
- An override barrier will be fabricated at VRTC for test and evaluation.
  - Load cell dimensions and metrics will be developed.
  - Tests on the Ridgeline and F-250 will be conducted.

Advanced Technology for Compatibility

- Investigate crash mitigation systems.
  - Perhaps automatic braking to bleed LTV energy, real-time ride height adjustments, real-time stiffness adjustments, belt and bag preparations, others.
  - Identify the most promising protection system(s) and prototype them.
  - Develop objective tests and preliminary benefits.
- Parallel research with Volpe to develop a preliminary benefits methodology that can bridge the gap between these crashworthiness systems and crash avoidance benefits.

Summary

- All work will be started in FY2006.
- Some work will extend beyond FY2006.
  - The GWU 2004 earmark joint with FHWA on F-250 modeling and SEAS virtual testing extends into 2007.
  - The advanced technology research goes till 2009.
- More research may be needed if the results show continued promise.
- A milestone in Q4 of FY2006 exists to brief the results of this plan. A new plan will be proposed at that time, if needed.