June 26, 2009

Mr. Ronald Medford
Acting Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Ave., SE
Washington D.C. 20590

RE: PETITION FOR RECONSIDERATION OF FMVSS 216 FINAL RULE

Dear Mr. Medford,

On May 12, 2009, the National Highway Traffic Safety Administration (NHTSA) issued its amended Final Rule on Federal Motor Vehicle Safety Standard (FMVSS) 216 in the Federal Register. The stated purpose of the rule is to reduce rollover injuries and fatalities. The Center for Injury Research (C*f*IR) has reviewed the rule as published and hereby submits the following petition for reconsideration.

Basis for Reconsideration

C*f*IR submits three basic reasons for NHTSA to reconsider the Final Rule.

1. The quasi-static test and criteria does not reasonably differentiate between the injury risk of compliant and non-compliant vehicles. Some compliant vehicles have substantially greater injury risk than some non-compliant vehicles and vice-versa, as shown by Insurance Institute for Highway Safety (IIHS) real world rollover statistics and Jordan Rollover System (JRS) dynamic test data.

2. Contrary to NHTSA assertions, the JRS dynamic test device has been available for two years and extensive test data submissions show it to be reliable, repeatable, validated to real world rollover injury risk and accurate in assessing comparative injury potential performance, as identified above.

3. Drivers and passengers of light trucks, SUVs and vans to 10,000 pound gross vehicle weight (GVW) deserve the same rollover protection as occupants of 6,000 pound GVW vehicles. They are often less stable, occupants are more vulnerable and the vehicles are used more frequently in off-road transportation.

1. Static Test and Compliance Criteria Deficiencies

NHTSA has known since the 1989 Kahane report to Congress that the FMVSS 216 static roof crush test has had no direct or significant effect on reducing rollover injuries and fatalities. NHTSA's Final Rule has as its basis a slightly modified static test and significantly increased criteria for compliance with only a statistically inferred cumulative damage effect on injury potential. The concern is that impact injuries are dynamic non-cumulative events and are a composite function of a vehicle's roll and pitch orientation, structural strength, geometry, elasticity and stiffness as well as occupant kinematics, interaction and the effectiveness of protection features. Only dynamic testing can accurately consider these variables and rate vehicles accordingly.

Under the new rule, 82% of the current vehicle population will need to be upgraded to the new SWR and some perhaps *unnecessarily*. Dynamic testing shows that some production roofs with SWRs of 2.6 protect occupants almost as well as vehicles with SWR of 4 or more. This comes from performance enhancements built in to the design and these are not considered in static testing, precluding manufacturers' design innovations and effectively requiring them to meet design criteria instead of performance criteria for compliance. The point here is that some vehicles compliant with the static final rule are ***more*** injurious than some non-compliant vehicles and vice-versa. (ref. #10 Appendix A). Also, numerous studies conclude that a rolling vehicle pitch angle of 10 degrees, which occurs often in rollovers, is more injurious than 5 degrees. Vehicles with static test results that meet the standard after being tested at 5 degrees of pitch will mislead consumers who don't know there's a difference.

2. Dynamic Test Device Availability

The new standard states that dynamic compliance testing was not an option due to limited evidence of a dynamic test rig that is repeatable and reliable. Perhaps C*f*IR was not sufficiently clear early in the evaluation process about the Jordan Rollover System's (JRS) ability to characterize the majority of rollover crashes and to measure the relative real world human injury potential of new vehicles with the reliability, repeatability and the same accuracy of NHTSA's dynamic frontal, offset frontal and side impact tests. With over 100 dynamic test runs of the JRS to date, it's clear that the rig tests vehicles in a repeatable and reliable way, with acceptable variances, to the inputs supplied by the test engineers or researchers as shown in the table below.

Average Operating Protocol, Actual Occurance, and % Variance of 27 JRS tests	Road Speed (mph)			Contact Pitch Angle (deg)			Contact Roll Angle (deg)		
	Protocol	Actual	% Var	Protocol	Actual	% Var	Protocol	Actual	% Var
	15.09	15.06	-0.19	7.96	8.18	2.78	145.00	144.07	-0.64

NHTSA's concerns that further studies are needed to define the optimum criteria for dynamic compliance are unfounded. Rollovers are too chaotic to define an optimum. If such an optimum could be defined (and we believe it unlikely) it could be easily incorporated into the flexible JRS protocol.

3. Large Vehicle Compliance Standard

While C*f*IR agrees that vehicles in the six to ten thousand pound range *should* be subject to the 216 standard, it also believes that reducing the standard from 3 to 1.5 for these vehicles is a mistake. These trucks, SUVs and Vans which accommodate 4 to 15 passengers, are primarily used by commercial operators, schools, social groups and non-profit entities. How can NHTSA justify a lower standard in light of the number of fatalities and injuries per rollover? Why should these occupants be less protected? This disparity in requirements will again lead to consumer misinformation and thwart industry innovations.

Conclusion

NHTSA's continued reliance on a static test to assess dynamic rollover occupant protection will negatively affect both consumer and industry interests. A dynamic standard or alternative must be required.

Information for Reconsideration

C*f*IR will show through a summary of docket submissions, test results and data that dynamic rollover tests for compliance and/or NCAP purposes are currently feasible with the Jordan Rollover System (JRS).

Dynamic Test Data Results

NHTSA seems to have stopped considering in 2004 the dynamic data it requested in 2001, which was submitted subsequent to and in response to comments in the 2005 NPRM, totaling 34 submissions and numerous briefings by C*f*IR. Included were data from 40 two-sided quasi-static roof crush tests and more than 50 Jordan Rollover System (JRS) dynamic tests for use in its determinations for quasi-static or dynamic compliance. These JRS dynamic data support and quantify NHTSA's statistical analysis of accident files relative to vehicle strength-to-weight ratio (SWR) on a test of each side of the roof. The result is 20 times the benefits originally claimed by NHTSA and affirms the injury rate claims and ratings separately analyzed by IIHS.

JRS dynamic test results can also be used to rate a vehicle's performance using multiple criteria including; the AIS injury scale and criteria derived from the NHTSA crush and crush speed consensus injury measures, dummy Injury Assessment Reference Values (IARV) for peak lower neck bending moment, and/or an Integrated Bending Moment (IBM) momentum exchange criteria. While the general results of these three independently derived evaluation methods correlate well, the individual vehicle ratings often do not. Only the JRS dynamic tests provide data and insights as to how to correct and improve performance. Even as applied to ratings by IIHS, the static test does not provide consumers with an accurate relative rating of injury risk which dynamic test data does.

Dynamic, Static and Real World Data Correlation

In its submission of March 27, 2008, IIHS reported on its statistical analysis of midsize SUVs. On February 4, 2009, it reported on a similar study of small passenger cars. These studies show a clear, direct relationship between SWR and the incapacitating and fatal injury rates in rollover crashes for belted, unbelted, and ejected drivers.

The IIHS studies involved 24 automobile and light truck lines that were involved in 42,000 rollover crashes. They indicate an average 21 percent reduction in injury rates for each unit increase in SWR. This strongly suggests that raising the average SWR from around 2 (the average SWR of most vehicles until recent years) to around 4 (the performance in a one-sided test necessary to ensure compliance with the new two-sided requirements with a reasonable margin) would reduce incapacitating and fatal injuries by nearly 50 percent. These studies have been extensively challenged but the IIHS and Highway Loss Data Institute (HLDI) responses have been compelling. Figure 1 is a chart from the IIHS statistical study of the relationship between injury risk and peak roof strength-to-weight ratio for mid size SUVs and small cars.

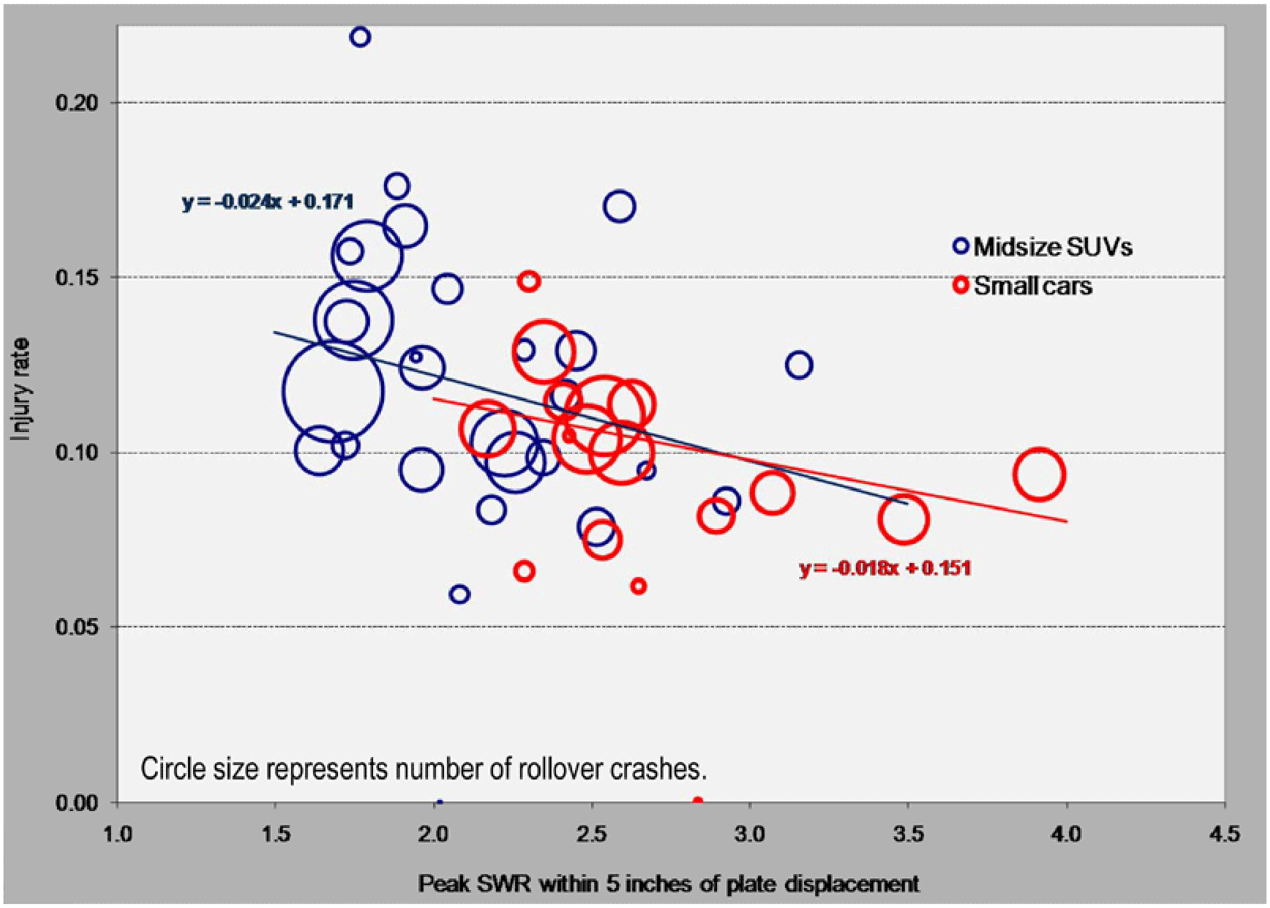


Figure 1. IIHS study of mid size SUVs (in blue) and small cars (in red).

On March 24, 2009, in contrast to its policy of using dynamic injury potential ratings for offset frontal and side impact testing, IIHS published its first set of roof crush performance ratings for new vehicles based on the FMVSS 216 quasi-static test procedure. IIHS rates a vehicle's roof crush performance as "good" if the SWR is greater than 4, "acceptable" if its SWR is greater than 3.25, "marginal" if its SWR is greater than 2.5 and "poor" if its SWR is less than 2.5. Although there is a general correlation with JRS tests, the National Accident Sampling System (NASS) and the IIHS statistical studies, the results of quasi-static roof crush resistance tests on individual vehicles can be inaccurate and misleading indicators of injury potential without a dynamic component to the test. (ref #9 Appendix A)

C*f*IR's March 27, 2008, docket submission in response to the SNPRM, showed that IIHS, NHTSA, and JRS test data all support the conclusion that, for the one-sided quasi-static test used in FMVSS 216, a minimum SWR of 3.5 to 4 was necessary to substantially reduce rollover casualties. JRS tests of 21 vehicles interpreted for this analysis used various injury criteria including NHTSA post crash negative headroom, head impact speed, window breakage (facilitating ejection) and biomechanical criteria. The data were presented at the International Research Council on the Biomechanics of Injury (IRCOBI) conference in 2008. Figure 2 is a chart summarizing the data.

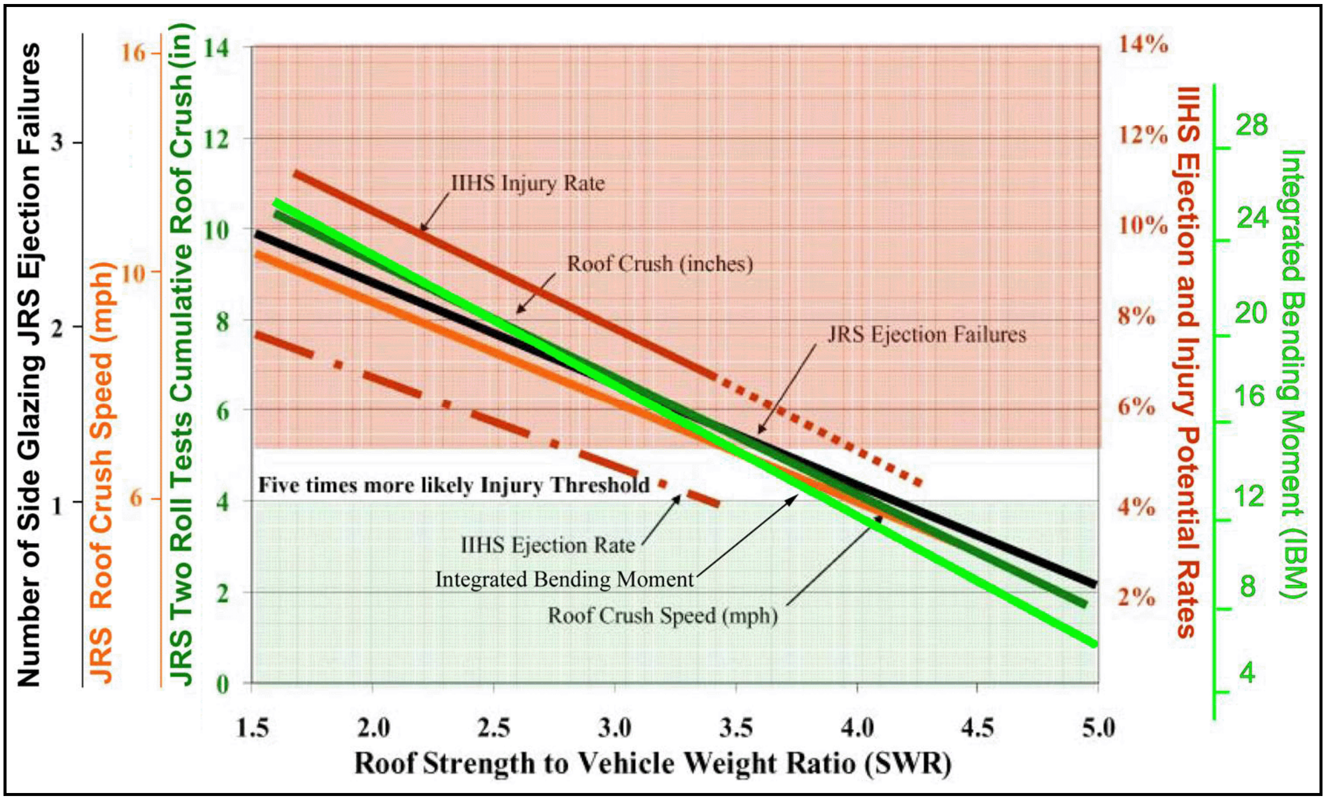


Figure 2. The relationship between rollover performance under various test protocols and crash data analyses, and the FMVSS 216 SWR showing how they relate to the potential for occupant injury.

Considerations

C*f*IR believes that the lack of transparency during rulemaking and the 4 year delay between notice/submissions and responses (2001 to 2005 and 2005 to 2009), the evaluation errors regarding dynamic testing, the long research history of quasi-static testing, and an objective to match typical (not seriously injurious) damage patterns rather than injury potential, appear to be the basis for the agency's decision to reject dynamic testing for regulatory compliance. Unfortunately, static testing will not reveal the true characteristics of a vehicles performance in a dynamic event.

It has been NHTSA's historical position for 36 years to provide a means of meeting injury potential performance criteria through the use of dynamic 208 tests, temporarily supplemented by static tests like 216. The JRS fixture, rollover analysis and research have prepared the way for rapid development and implementation of an upgraded FMVSS 208 alternative dynamic compliance or NCAP test. This will alleviate the need for the manufacturers with innovative designs that test well dynamically, to add weight, composite glazing and window curtain air bags, while at the same time being required to increase fuel economy, to meet the new static test requirements.

C*f*IR provides a summary of the status of our research and test ratings program, part of the basis for this petition for reconsideration, in Appendix A. Appendix B provides the details on errors and mis-interpretations of the C*f*IR submissions that shows that the JRS has been proven to be reliable, repeatable, available and an accurate way to measure a vehicle's real world incapacitating and fatal injury potential.

A careful reconsideration of this data should result in NHTSA finding that the JRS is an effective research tool whose use as an alternative test device or in an NCAP program is justified and that ultimately the Federal Motor Vehicle Safety Standard 216 will be a dynamic test.

While C*f*IR recognizes NHTSA's concern as to the timeliness of implementing an alternate dynamic standard and the current limited availability of test devices, we note that beginning implementation of the new rule is not until 2012 and full implementation is not until 2015 and 2017.

Requested Reconsiderations

CfIR requests that NHTSA review the data previously submitted and summarized here, and consider the following actions:

1. Adjust the final rule to allow for an alternate dynamic compliance test.
2. Propose and allow for an alternative dynamic test for NCAP ratings.
3. Allow for non-compliance or compliance exceptions based on submitted dynamic test evidence.
4. Correct the misleading and inaccurate statements NHTSA made in the rule regarding the JRS' repeatability and reliability in testing a vehicle's dynamic performance.
5. Apply the same SWR test criteria for vehicles under 6000 pounds to vehicles up to 10,000 pounds with passenger seating positions of three or more.

C*f*IR greatly appreciates NHTSA's effort in trying to do the right thing but believes, NHTSA, from its own past, knows a dynamic test is required to save lives.

Sincerely,

Donald Friedman
Center for Injury Research

Cc: John Maddox
Associate Administrator for Vehicle Safety Research

CfIR
Center for Injury Research

PETITION FOR RECONSIDERATION OF FMVSS 216 FINAL RULE

Appendix A:

History and Status of the CFIR / JRS Research and Test Ratings Program

The purpose of this Appendix is to summarize the status of dynamic testing prior to the issuance of the final rule, referencing the submissions of and after November of 2007.

In this November 2007 briefing [1] and slide submission we presented evidence in the form of repeatability tests of three Subaru Foresters each in two rolls, one without and one with a Hybrid III dummy. The results for all test conditions and injury measures were within about ten percent or 0.5 inches and consistent with previously acceptable criteria for frontal and side impact dynamic tests.

[1] NHTSA Memorandum, Subject: Ex.Parte Meeting with Xprts, LLC regarding FMVSS 216, November 7, 2007 (Docket No. 2005-22143-280.1) Representatives from Xprts, LLC included: C. Nash & S. Bozzin; NHTSA included: J. Kanianthra, D. Smith, J. Hinch, S. Summers, S. Ridella, L. Summers, D. Wilke, M. Sword, A. Louden, & S. Duffy.

In this December 2007 briefing [2] and subsequent submission [3], we provided data on an initial set of current model vehicles funded by the Santos foundation focused on rollover occupant protection rather than roof crush. It was our intention to initiate a dialog outside of the rulemaking effort to cooperatively conduct dynamic rollover research on occupant protection. We were asked to "wait until the notice comes out." When it did with no comment on dynamic testing, we inquired again and were told we would be advised. Subsequently in June of 2008, we were verbally advised that dynamic discussions were precluded by the rulemaking in process.

[2] NHTSA Memorandum, Subject: Ex.Parte Meeting with Center for Injury Research regarding FMVSS 216, December 18, 2007 (Docket No. 2005-22143-281) Representatives from Center for Injury Research included: D. Friedman & C. Nash; CAS included: C. Ditlow; NHTSA included: S. Summers, J. Kaninathra, S. Ridella,& C. Wiacek.

[3] CFIR Submission to SNPRM Roof Crush Docket 2008-0015, Subject: Comments with Supporting data concerning FMVSS 216, February 25, 2008 (Docket No. 2008-0015-9)

This submission [4] coordinated the NHTSA statistical results, the IIHS statistical results, and twenty one JRS tests of two rolls each relative to vehicle strength to weight ratio. It made the point that:

> *"It would be unconscionable to deny or ignore NHTSA's own data and analyses, and the information submitted by other reputable, independent researchers in the establishment of an effective roof crush standard."*

[4] CFIR Submission to SNPRM Roof Crush Docket 2008-0015, Subject: Comments with Supporting data concerning FMVSS 216, March 25, 2008 (Docket No. 2008-0015-70.1)

These four papers [5-8] summarized the results of dynamic injury potential criteria research and its relevance to human injury potential and the validation of the criteria by JRS tests of current production vehicles.

[5] "Rollover Crash Neck Injury Replication and Injury Potential Assessment" IRCOBI 2008, Sept 17-19, 2008, Bern, Switzerland, D. Friedman et al.

[6] "Rollover Roof Crush and Speed as Measures of Injury Potential vs the Hybrid III Dummy", ICRASH 2008, July 21-25, 2008, Kyoto, Japan, paper no 2008-088, D. Friedman et, al

[7] "Understanding Rollover Injuries" ICRASH 2008, July 21-25, 2008, Kyoto, Japan, paper no 2008-089, D. Friedman & T. Honikman

[8] "Development of Rollover Injury Assessment Instrumentation and Criteria", The 36TH NHTSA-sponsored International Workshop on Human Subjects for Biomechanical Research, November 1, 2008, J Paver, D Friedman, F Carlin, J Bish, & J Caplinger

In an April 2009 briefing [9] we discussed the above papers and their relevance to the rulemaking but were again advised that the Agency representatives could make no comment. We presented "In Press" copies of the ESV papers referenced below [10-11], which represent the latest conclusions from our research.

[9] NHTSA Briefing April 3, 2009, S Ridella, S Summers, D Friedman

[10] "Vehicle Roof Geometry and Its Effect On Rollover Roof Performance", D. Friedman, R. Grzebieta, ESV 2009, June 15-18, 2009 Stuttgart, Germany

[11] "A Proposed Rollover and Comprehensive Rating System", D. Friedman, R. Grzebieta, ESV 2009, June 15-18, 2009 Stuttgart, Germany

These ESV papers were summarized in our 10 minute oral presentation reproduced here as our simplest, briefest summary.

A Proposed Rollover And Comprehensive Rating System

Donald Friedman
Center for Injury Research

Raphael Grzebieta
NSW Injury Risk Management Research Centre
The University of New South Wales, Australia

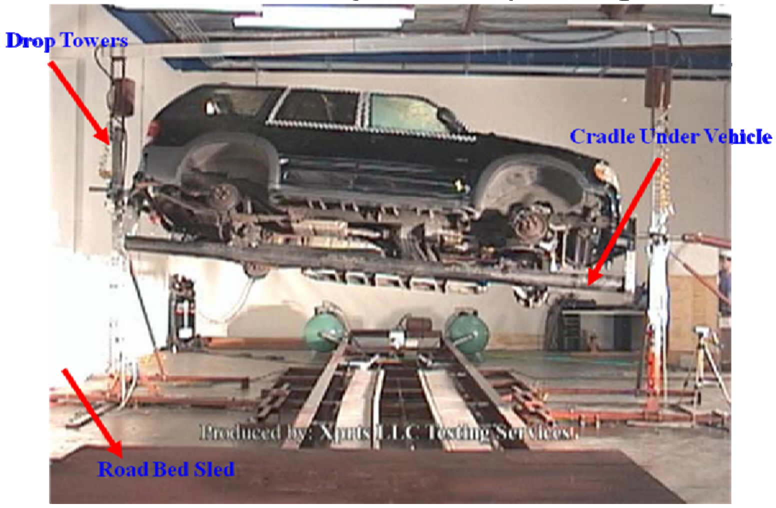
Paper No. 09-0515

Our two sided quasi-static and JRS dynamic rollover testing in conjunction with NHTSA and IIHS statistical analyses, plus some biomechanical injury correlation studies have resulted in an integrated picture of typical planar rollovers. Based on substantial data we believe we understand the factors, in addition to SWR, which influence rollover injury risk performance and characterize an injury potential rating system.

The New Car Assessment Program is thirty years old, and has been successful in getting automakers to improve safety performance of new vehicles. Unfortunately, there is no rating for rollover occupant protection, a crash mode that is responsible for one-third of all light vehicle occupant fatalities. NHTSA has upgraded the roof crush requirements for new cars, but the time is overdue for an NCAP rating on rollover survivability. We have conducted extensive testing that can provide a basis for such a rating. In particular, we have two-sided quasi-static and Jordan Rollover System dynamic rollover test results which, in conjunction with NHTSA and IIHS statistical analyses, and biomechanical injury correlation studies provide a basis for such a rating.

Slide 4

Jordan Rollover System Key Components



This is what the JRS test rig looks like.

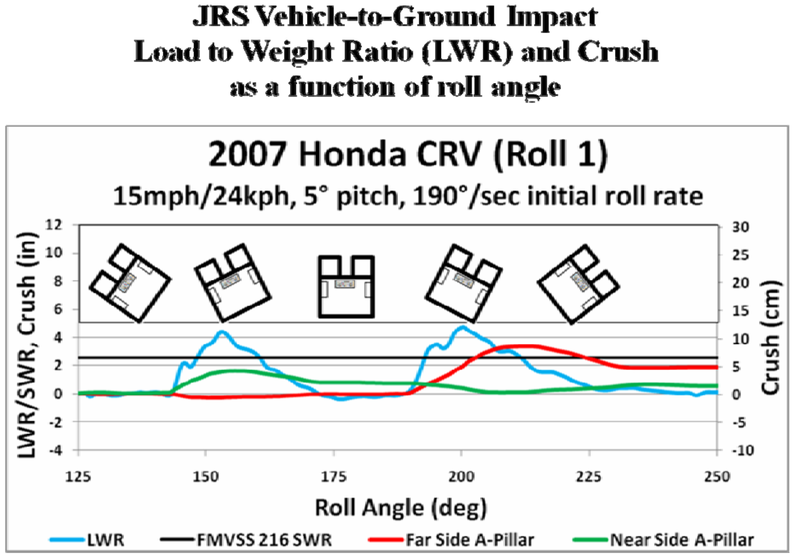
Slide 6

JRS Tests by Protocol that are the Basis for Ratings

- 37 vehicle tests @ 5 degrees of pitch and 15 mph.
- 11 vehicle tests @ 10 degrees of pitch and 15 mph.
- 9 vehicle tests @ 10 degrees of pitch and 18 mph
- 2 vehicle tests @ 10 degrees of pitch and 20 mph
- 26 additional tests of bucks and reinforced vehicles
- 14 tests identifying the effect of a range of parameters.

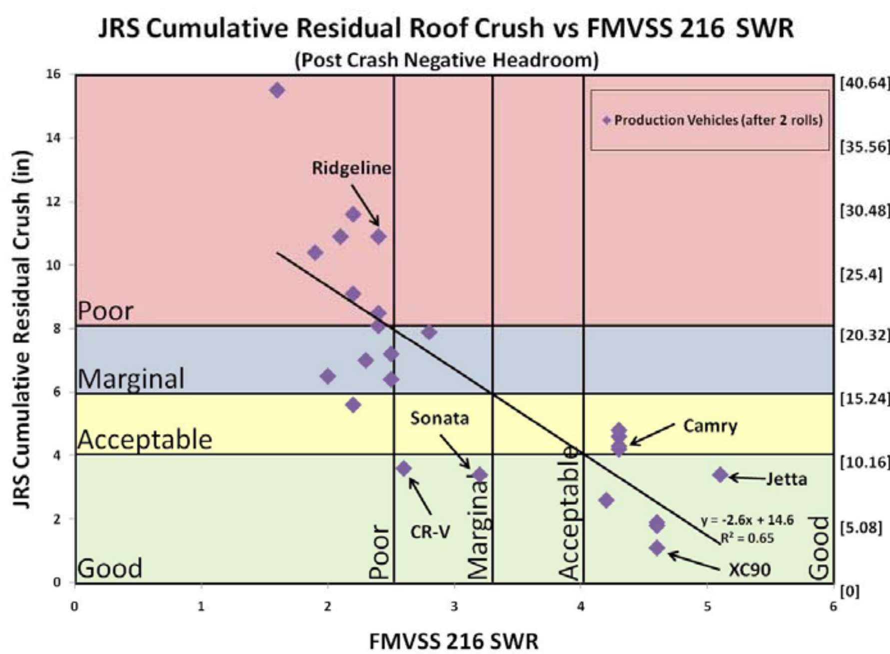
In addition to 40 two sided quasi-static tests, this slide identifies the 100 JRS tests already conducted according to the test protocol we used.

Slide 7



JRS dynamic test data provides a new never before opportunity to study the relationship between the vehicle to ground forces and the near and far side deformation in relation to the static SWR. This data is more fully detailed in a companion paper "Vehicle Roof Geometry and its Effect on Rollover Roof Performance" ESV 09-0513. The Honda CR-V, for example, did very well in the dynamic test despite its modest 2.6 SWR, which shows why the SWR can be a poor measure of rollover safety.

Slide 8

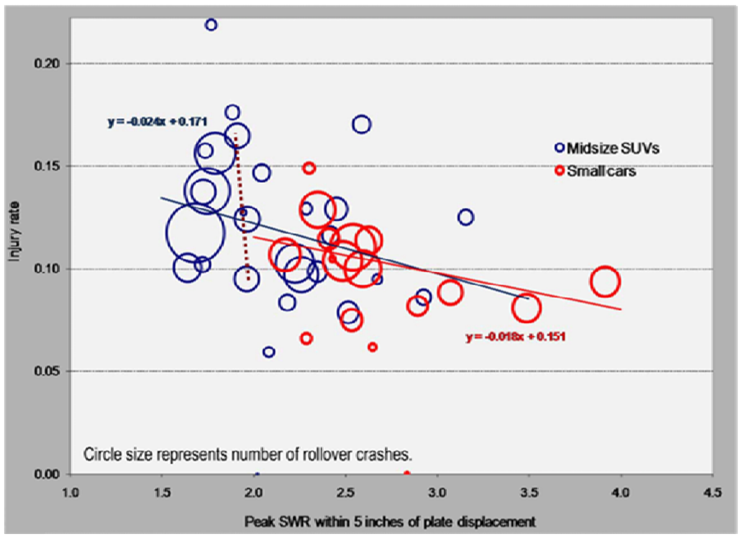


Here we have the relationship between SWR and the equivalent of NHTSA's post crash negative headroom expressed as cumulative residual crush. Pre-roll headroom of these vehicles is typically 4 to 6 inches, and according to NHTSA's statistical analysis if the post crash headroom is negative (i.e. the crush is more than the pre-roll headroom) it is 5 times more likely to be injurious. We would rate 4 inches of roof crush as good and 6 inches as acceptable because the level of injury is a function of the combination of crush and crush speed as described later.

For all protocols the slope is 26%. Notice there is a considerable disparity between the crush of vehicles with the same SWR.

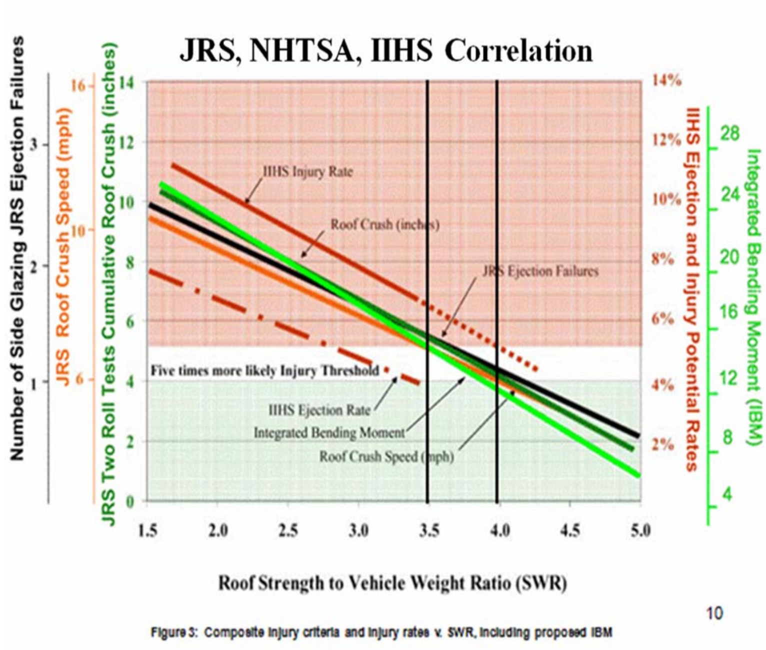
Slide 9

IIHS Statistically Based Ratings



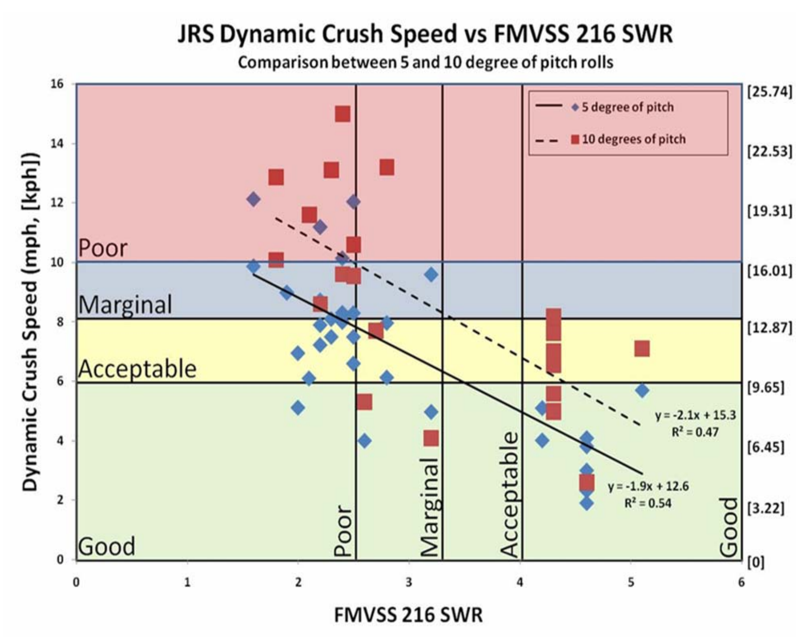
The dynamic JRS data also generally correlates with IIHS statistical analysis of incapacitating and fatal injury to belted, unbelted and ejected occupants. The average slope for SUVS is 24% and 18% for the higher SWR autos.
Notice that here also, there is a substantial injury rate disparity between vehicles of similar 216 SWR. We believe those disparities are related to four vehicle design factors: Roof Pitch SWR, Geometry, Stiffness and Elasticity

Slide 10



JRS Generic data results support IIHS ratings. This slide shows published generic correlation between JRS cumulative residual dynamic roof crush, various other injury criteria, and IIHS data versus SWR. It also identifies and confirms IIHS' target goal for "good "performance at an SWR of 4 or more.

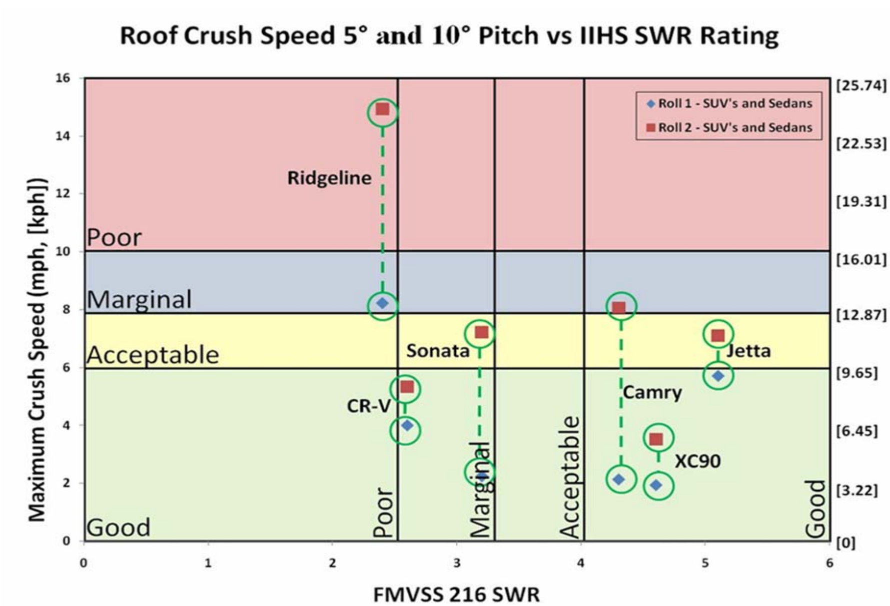
Slide 11



This slide shows FMVSS 216 SWR as a function of dynamic crush speed. The blue data is from the first roll at 5º of pitch while the red data shows the second roll at 10º. It is an indication of the speed of the impacts separated by rollovers with 5 and 10 degrees of pitch. There are two components to head or neck injury: the impact speed and the amount of crush. A consensus injury measure since 1978 for the onset of serious neck injury is 7 mph. Nusholtz and Sances found severe injury at about 10 mph. Allowing 1 mph for occupant motion toward the roof, we rated less than 6 mph as good and less than 8 as acceptable.

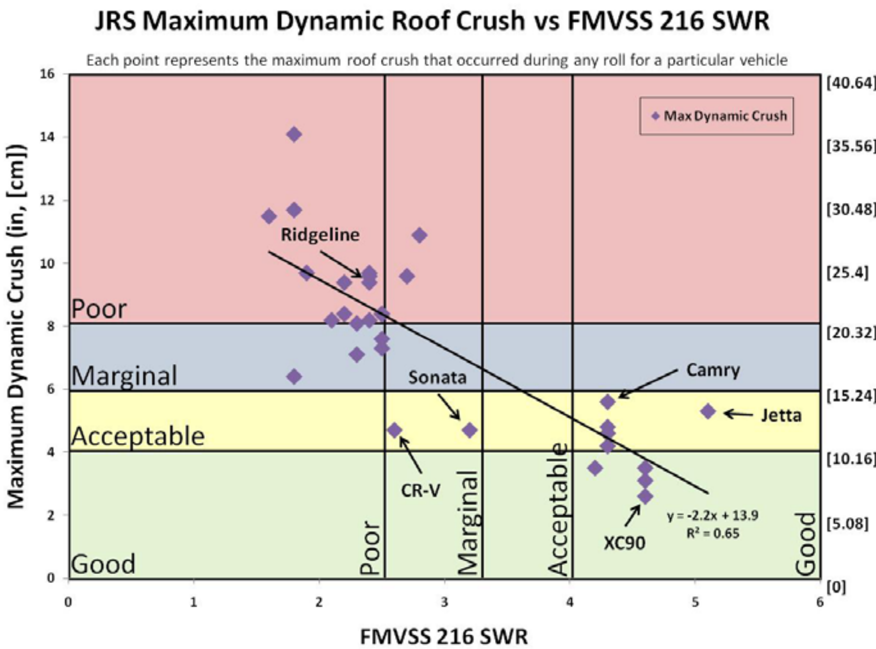
We found four factors besides SWR that influenced the real world dynamic injury potential rating: 1) The pitch at impact; 2) roof geometry; 3) structural stiffness; and 4) structural elasticity. As shown here, one of the four reasons for the injury rate disparity is the SWR of the roof at increased pitch. For instance at an SWR of 2.5 the impact crush speed is 50% higher at 10 degrees of pitch as compared to 5 degrees of pitch.

Slide 12



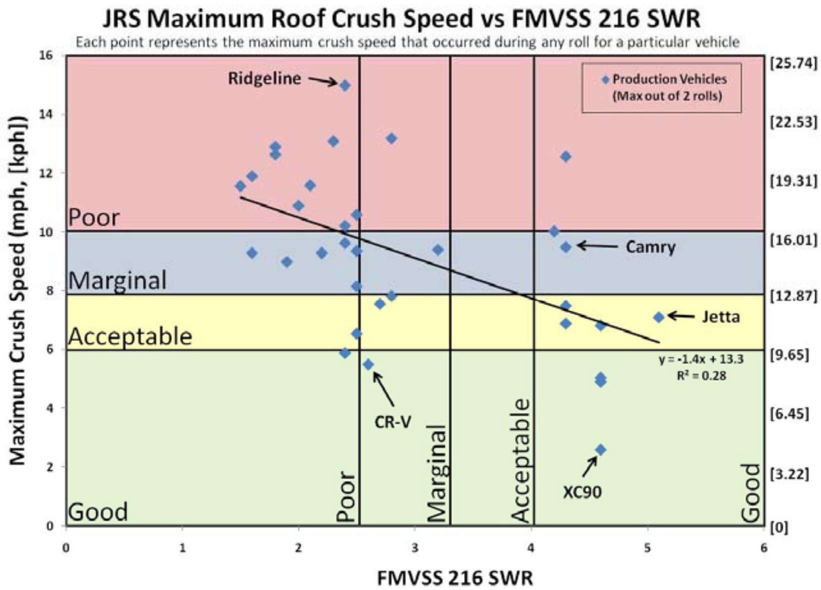
This now compares the JRS dynamic performance ratings with IIHS static based ratings and identifies the IIHS deficiencies. For instance of the last 10 current production vehicles studied with the same 5 and then 10 degree protocol, only the XC-90 gets the same “good” rating by dynamic test and IIHS SWR. The CR-V with a barely marginal IIHS rating has “good” dynamic performance. Vehicles recommended to consumers by IIHS as “good” like the Jetta and Camry are significantly downgraded by the dynamic test at 10 degrees of pitch showing weaknesses in the A pillar/windshield header area and poor elasticity in their structural response. A long line between the results of the two tests indicates significant degradation in the roof structure from the first impact. Not only that but for consumers and industry, dynamic testing is important to identify the reasons for the deficiencies in order to minimize weight, cost and improve occupant protection.

Slide 13



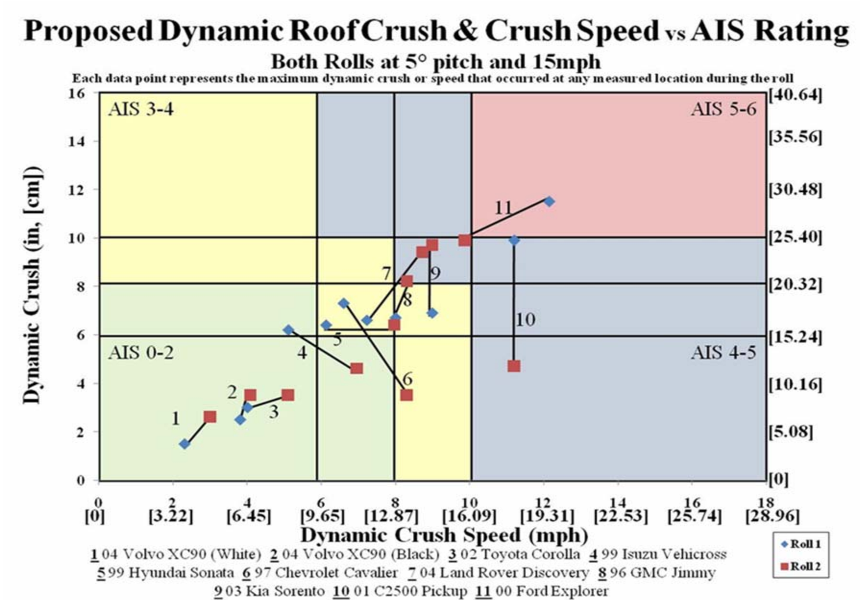
A common misconception is that rollover injuries are a function of the trip speed or the number of rolls or the amount of roof crush. Although those factors affect the opportunity to be injured, head and neck injury is the result of transferring sufficient impact momentum to the head by a combination of speed and crush stroke on any single roll. This chart shows the maximum dynamic crush component of injury.

Slide 14



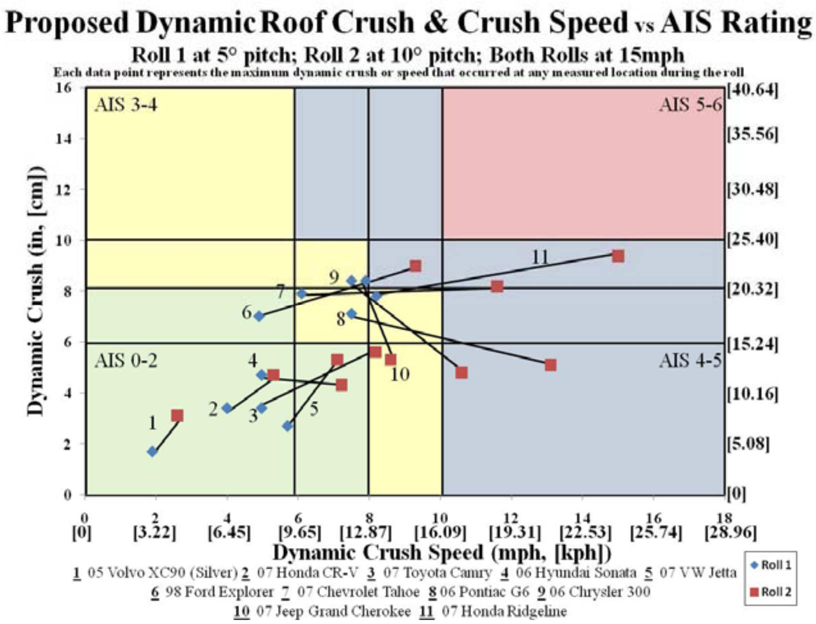
This is the other component of a momentum injury, the maximum dynamic speed.

Slide 15



On that background we have plotted the dynamic crush and crush speed for the first and second roll of 11 vehicles with both rolls at 5 degrees of pitch. Clearly the XC-90’s, the Corolla and even the Isuzu Vehicross do well, while the others are in the AIS 3-4 or worse range.

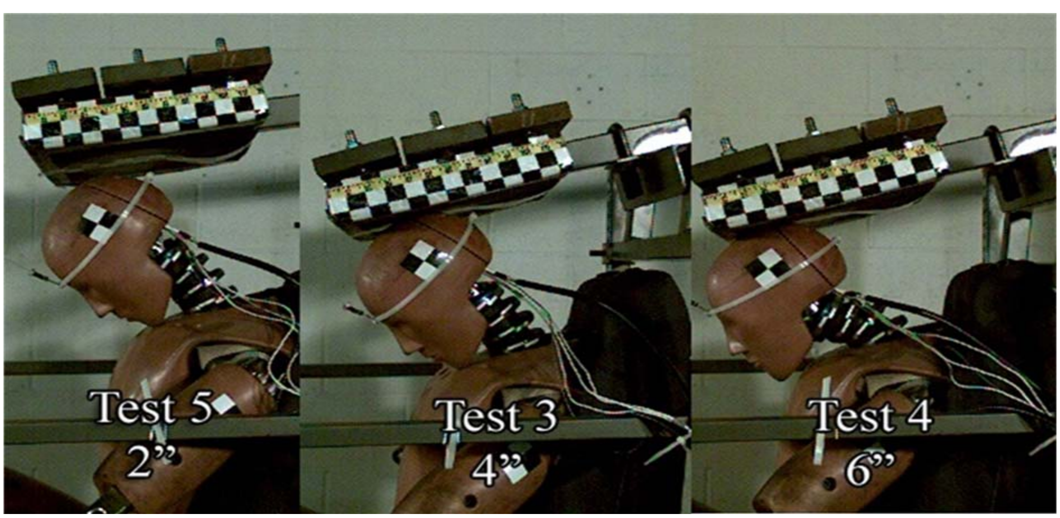
Slide 16



Here are 11 other vehicles tested and plotted on the same background with a 5 and then 10 degree pitch roll. Here we see the XC-90, the CR-V, the Sonata and the Jetta are in the green and the Camry almost makes it. The occupants of the others are susceptible to catastrophic injury.

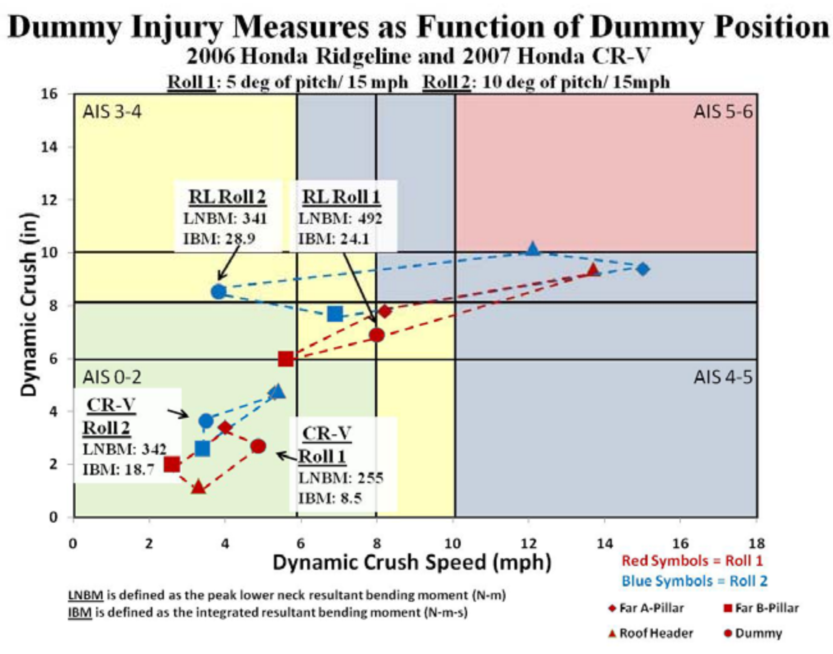
Slide 17

Biomechanical Dummy Bending Injury Measure Studies



The objective of any rating system is to identify the injury potential to human occupants not dummies. One way to do that is to develop a biofidelic dummy with representative stiffness and kinematic movements. Unfortunately the effect of musculature, positioning and size is grossly variable in a rollover, so that it is unlikely that agreement on the use of a more biofidelic dummy would result in more effective occupant protection devices and countermeasures. Another approach and the one we have used is to develop a transfer function for an injury criteria measurement in a cadaver to an injury measurement in a HYBRID III dummy. Several series of pendulum tests compared to the 1998 work of Pintar and Yogananda and other biomechanical references identified by Paver, resulted in the colored AIS background of the last slide. While there is more research work to be done we have calibrated a softer more realistic neck but like the human neck it tears when used with weak roofed vehicles. Nevertheless, this research has allowed us to preliminarily relate peak neck bending forces to IARV values and to a momentum exchange measure called the Integrated Bending Moment (IBM) as shown on the next slide.

Slide 18



These are plots of crush and crush speed at various locations and at the dummy's head for the Honda CR-V and Honda Ridgeline. The lower neck peak resultant bending moment (IARV=380 NM) and Integrated bending moment (IBM=14) have been roughly correlated to human bending injury. The data identifies how the injury measures would change if the dummy were located elsewhere relative to inboard of the mid roof rail.

Slide 19

Conclusions

•The JRS dynamic test rig is capable of evaluating injury potential which matches real world rollover injury potential that has been validated by the IIHS statistical data.

•The dynamic rating system proposed is capable of distinguishing the variations disparities between vehicles which a quasi-static roof crush test cannot achieve.

•A dynamic test such as the JRS can evaluate the injury potential effects of occupant protection systems (e.g. seat belts, etc) which static SWR tests do not.

•A comprehensive rating system based on dynamic front, side, rear, and rollover by fatality rate is now possible.

THE END

At our latest NHTSA briefing on May 22, 2009, we met with Stephan Summers, in regards to the release of the final rule. This was preceded by an e-mail asking for advice as to how to correct the dynamic discussion content in the ruling. We received no suggestions, nor much insight as to where the agency was going with dynamic research. We again advised the Agency of our interest in a cooperative research program with them, GWU, and CFIR.

Center for Injury Research

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Appendix B:

Notable errors* regarding the JRS in the body of the Federal Register Ruling and Appendix A – Analysis of Comments Concerning Dynamic Testing

***All errors are referenced from the text in the Federal Register Vol. 74, No. 90 Tuesday, May 12, 2009, Rules and Regulations. This document is available on NHTSA Docket 2009-0083-1 on www.regulations.gov.**

Docket Submissions - Although CFIR made 34 data submissions and briefed the Agency at least once a year between 2001 and 2009, the lack of transparency in rulemaking in progress, precluded any meaningful feedback. A requested response to our November and December 2007 briefings to the Associate Administrator for Research on occupant protection repeatability, outside of the roof crush rulemaking process, were specifically blocked by the Chief Counsel and Rulemaking. As a result, there has not been a response regarding the applicability of the JRS to research. The final rulemaking notice discounts the JRS for compliance and ignores the repeatability data. Furthermore, the response in the final notice ignores or discounts most of the submissions with flawed or trivial tests such as the response to the M216 two sided test data and the effect of some roof racks.

Discussion on roof racks - The Agency observed that the roof racks they looked at had no appreciable effect on SWR (Federal Register, pg 22371, sec 5), but they ignored our submissions on the substantial Nissan Xterra (and Land Rover Discovery) tubular racks and the panel mounted Jeep Grand Cherokee racks which focus loading and created deep intruding buckles. (NHTSA Docket Submission 2005-22143-267 and 271)

Discussion on effected population and benefits - Contrary to submitted JRS evidence of the benefits of reduced roof crush in preserving side windows and avoiding ejection portals, the agency predicts only 667 lives saved. They justify the prediction by characterizing the effect of their own statistical injury potential data and ignoring the comparable IIHS ejection, and a general 50% reduction of incapacitating injury benefit to restrained, unrestrained and ejected occupants.

Direct comments and corrections from the Federal Register:

The JRS comments begin on page 22389 of the Federal Register. The statements of the Agency are repeated below with our comments [***Bolded in Brackets***] and highlighted in italics.

(Federal Register Vol. 74, No. 90, Tuesday, May 12, 2009, page 22389, bottom column 3)

Jordan Rollover System (JRS)

"There were a range of comments related to the Jordan Rollover System (JRS) test. The JRS device rotates a vehicle body structure on a rotating apparatus (“spit”) while the road surface platform moves a track underneath the vehicle and contacts the roof structure. Comments on the JRS were submitted by the following groups: Advocates, CFIR, DVExperts, Xprts, [***CAS,***] and Public Citizen. Some commenters recommended developing a safety standard using the test procedure, while others recommended that the agency undertake a research program and investigate the JRS fully.

“Advocates recommended using the JRS procedure. CFIR provided information concerning the JRS test procedure and addressing repeatability of the initial conditions, including data from their JRS research program. DVExperts claimed the JRS is a repeatable, practical, and scientifically valid dynamic rollover test procedure. Xprts submitted summary results from JRS testing of a Jeep Grand Cherokee [***in 2006***]. It identified roof intrusion velocities and roof deformation behavior (buckling) as important criteria for determining injury. Public Citizen commented that NHTSA should thoroughly investigate the JRS [***in 2006***]. Public Citizen and CFIR also commented that the JRS test can be conducted with dummies that demonstrate whether vehicle roof performance meets objective injury and ejection criteria for belted and unbelted occupants.

"CFIR also recommended [***an Injury Assessment Reference Value IARV)***] a maximum axial neck load injury measurement (Fz) of 7,000 N [50] (1,574 pounds) using the Hybrid III dummy in the JRS [***in 2006***]. The recommendation was based on cadaver and dummy drop and impact tests. CFIR also acknowledged that the Hybrid III dummy has poor biofidelity in the rollover mode. As an alternative, it recommended using the roof velocity and intrusion amplitude, as measured by an array of string potentiometers attached to the roof. The criteria were based on its axial neck load research. CFIR claimed to have found a good correlation between [***lower***] neck [***bending***] injury and the [***upper neck force and***] speed of head impact [***in 2008***].

"In response to the SNPRM, CAS and CFIR submitted [***21 tests of which the agency asked for the electronic data for 8***] additional instrumented test data using the JRS[51] equipped with a Hybrid III dummy. [***The 21 vehicle set correlated various JRS injury potential performance criteria to the Agency's post crash negative headroom injury criteria and to the IIHS real world injury rate as a function of SWR.***] The test vehicles [***requested***] were selected from the agency's fleet evaluation. They argued, based upon the data, the JRS is highly controlled and repeatable. They further suggested that the equipment and the test costs are modest. The test conditions can be widely varied to emulate actual rollover conditions.

"Mr. Nash provided an analysis of NASS rollover cases. He concluded that the FMVSS No. 216 platen test would not stress the windshield header and create the type of buckling shown in the NASS cases. Mr. Nash claimed that the dynamic JRS test would identify the header deformation."

Agency response (page 22390, bottom column 1)

"While a number of commenters indicated support for the JRS dynamic test procedure, and the developers submitted data for multiple tests, the agency has remaining questions regarding the setup, conduct, and evaluation of the JRS test procedure despite witnessing the JRS testing in February 2007 and multiple other meetings. All commenters relied on the JRS tests conducted and reported by CFIR and Xprts."

"After considering the data [***requested***] submitted, we believe there are <u>a large number of unresolved technical issues related to the JRS with respect to whether it would be suitable as a potential test procedure to replicate real-world crash damage patterns for a safety standard evaluating vehicle roof crush structural integrity.</u> These include:"

[***As we understand this statement, NHTSA rejected the JRS dynamic test for compliance purposes because CFIR's objective was not to replicate roof crush, but to replicate real world occupant injury potential as a result of roof crush in a low speed standardized dynamic test.***]

50 Friedman D., Nash C.E., ''Advanced Roof Design for Occupant Protection,'' 17th ESV Conference, Amsterdam, 2002

51 See Docket NHTSA 2008-0015: 2003 Subaru Forester, 2004 Subaru Forest, 2004 Volvo XC90, 2006 Chrysler 300, 2006 Hyundai Sonata 174

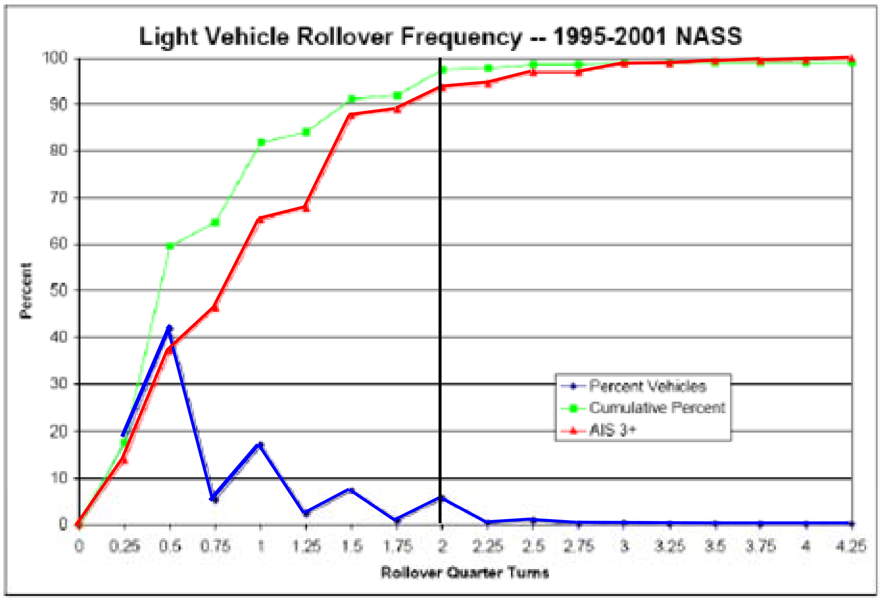
Test parameters (page 22390, top column 2)

- "Determination of the drop height (for different vehicles) – The JRS releases the test vehicle from a predetermined drop height to fall onto a moving roadway. The ideal drop height is not known. If the drop height is not correlated with real world data, some vehicles could be overloaded beyond what would be representative of real world crashes. Other vehicles could be under-exercised based on accident conditions. A specific drop height or drop height methodology would need to be sensitive to the vehicle types and crash conditions in the fleet"

  [***Evaluating the real world occupant injury potential of different vehicles requires a reasonably common protocol which has been derived from accident data (just as it was for frontal and side impact compliance tests). The choice of a low speed and low drop height protocol was to differentiate injurious performance of production vehicles at the lowest levels of severity. Severity was gauged from the cumulative frequency of quarter turn rollovers and serous injuries, which are discussed further below. Variations from the base protocol identify their effect on injury potential. The JRS occupant injury potential (as measured with NHTSA and other consensus injury criteria) correlates well with IIHS statistical analysis of real world rollover crashes as a function of SWR in spite of these protocol variations as shown in Figure 1, of the letter. Furthermore, a few existing production vehicles demonstrated low injury risk performance using this protocol while most vehicles performed poorly.***]

  [***In the following paragraphs, the agency repeatedly asks for correlation of test parameters to real world data which they claim they don't have. The minor variations in the protocol used in JRS tests of some 50 vehicles are based on the following data: The chart below characterizes the cumulative percent of vehicles and serious to fatal injuries by quarter turns in rollovers. Since about half occurred in one roll and 95% in two rolls, a two roll choice was made. A one roll traveling speed trip was estimated at 12 to 15 mph and a two roll traveling speed trip at 20 to 25 mph. These inputs were translated into a sequence of two 15 mph rolls. NASS files suggested that most serious injury rollovers involve more than 10 degrees of pitch, so***

one roll is run at 5 degrees and the other at 10 degrees of pitch. Planar dolly rollover tests, as characterized in FMVSS 208, were measured to involve initial near side effective drop heights of about 3 to 4 inches and 4" was adopted into the base protocol. Bosch conducted trip tests at Dekra on various soil surfaces and found the JRS typical angular acceleration <u>within range</u>.]



- "Determination of the roll rate and roll angle at vehicle release (for different vehicles) – The JRS releases the test vehicle at a predetermined roll rate. The roll rate, drop height, and angle at which the vehicle is released are carefully coordinated to obtain an initial contact between the vehicle and the moving roadway at the nearside A-pillar/roof junction. While advocates of the test present anecdotal support for the test conditions, the appropriateness of the specific test conditions is not clear. There may be many vehicles that miss contacting the near side A-pillar/roof junction and have first contact with the far side of the roof. Roll rate has a role in the duration of the load on the roof and could have a significant effect on the roof performance during the test. If the roll rate is too slow, intrusion could be minimal. If the roll rate is too fast, intrusion could be excessive. We believe there is a need to correlate these parameters to real world data, which we do not have."

  [***It appears that the Agency is so focused on matching roof crush test damage to real world single roll damage patterns that they ignore their own authenticated statistical injury potential data and desire a JRS test protocol tailored to different vehicles.***]

- **“**Determination of the roadway speed and road surface – The JRS drops the vehicle onto an instrumented moving roadway that is covered with sandpaper to represent the vehicle-to-ground interaction. The roadway speed and the vehicle-to-ground friction play a significant role in controlling the transfer of momentum between the rotating vehicle and the moving roadway. Changing the roadway speed may affect how the vehicle interacts with the ground for the far side contact. Research would be necessary to understand this interaction and how the initial contact conditions affect the JRS test kinematics.”

- **“**Repeatability of the drop height, roll rate, release angle, initial contact with the roadway and roadway speed – Any regulatory test needs to be repeatable and enforceable. The agency does not have any experience with the JRS to know what its operating tolerances are. [***This was the subject of a detailed briefing on repeatability in November of 2007 with the Agency publishing the presentation slides in the docket in January of 2008(NHTSA Docket Submission 2005-22143-280.1). The results were comparable to the justification for the IIHS offset frontal and side impact test tolerances.***]

		Road Speed (mph)			**Contact Pitch Angle (deg)**			**Contact Roll Angle (deg)**		
Vehicle	Roll #	Protocol	Actual	% Variance	Protocol	Actual	% Variance	Protocol	Actual	% Variance
2003 Subaru Forester	1	18	17.9	-0.6	10	10.2	2.0	145	147	1.4
2003 Subaru Forester	2	12.8	12.4	-3.1	10	9.8	-2.0	145	143	-1.4
2003 Subaru Forester	1	18	17.7	-1.7	10	10.2	2.0	145	147	1.4
2003 Subaru Forester	2	12.8	12.5	-2.3	10	10.3	3.0	145	151	4.1
2004 Subaru Forester	1	18	18	0.0	10	10.3	3.0	145	147	1.4
2004 Subaru Forester	2	12.8	12.7	-0.8	10	11.1	11.0	145	150	3.4
2005 Volvo XC90	1	15	14.9	-0.7	5	5.6	12.0	145	143	-1.4
2005 Volvo XC90	2	15	14.9	-0.7	10	10.6	6.0	145	139	-4.1
2007 Honda CR-V	1	15	15.1	0.7	5	5.3	6.0	145	143	-1.4
2007 Honda CR-V	2	15	15.1	0.7	10	10.6	6.0	145	141	-2.8
2007 Chevy Tahoe	1	15	15.2	1.3	5	4.8	-4.0	145	142	-2.1
2007 Chevy Tahoe	2	15	15.2	1.3	10	9.7	-3.0	145	143	-1.4
2007 Jeep Grand Cherokee	1	15	15	0.0	5	5.4	8.0	145	147	1.4
2007 Jeep Grand Cherokee	2	15	15.2	1.3	10	8.7	-13.0	145	149	2.8
2007 Pontiac G6	1	15	14.8	-1.3	5	4.8	-4.0	145	142	-2.1
2006 Honda Ridgeline	1	15	15.1	0.7	5	5.4	8.0	145	145	0.0
2006 Honda Ridgeline	2	15	15.1	0.7	10	10.5	5.0	145	145	0.0
2006 Pontiac G6	1	15	15	0.0	5	5.8	16.0	145	139	-4.1
2006 Pontiac G6	2	15	14.9	-0.7	10	10.6	6.0	145	140	-3.4
2007 VW Jetta	1	15	14.7	-2.0	5	4.8	-4.0	145	142	-2.1
2007 VW Jetta	2	15	15.2	1.3	10	10.1	1.0	145	143	-1.4
2006 Chrysler 300	1	15	15.2	1.3	5	4.8	-4.0	145	146	0.7
2006 Chrysler 300	2	15	15.1	0.7	10	9.9	-1.0	145	147	1.4
2006 Hundai Sonata	1	15	15	0.0	5	5.2	4.0	145	143	-1.4
2006 Hundai Sonata	2	15	14.8	-1.3	10	10.2	2.0	145	145	0.0
2007 Toyota Camry	1	15	15	0.0	5	5.2	4.0	145	141	-2.8
2007 Toyota Camry	2	15	15	0.0	10	10.5	5.0	145	140	-3.4
Average		15.09	15.06	-0.19	7.96	8.18	2.78	145.00	144.07	-0.64

If it is possible to first determine optimum or representative conditions, it is then necessary to determine the accuracy and repeatability that a test device can provide for those conditions using a wide variety of vehicle sizes and shapes. For example, there are some concerns about whether some vehicle sizes or shapes (such as the Sprinter van) would be suitable for testing with a JRS device."

- **"**Vehicle performance criteria and instrumentation – There are no generally accepted criteria to evaluate vehicle performance in rollover crashes. [***On the contrary NHTSA, IIHS, and consensus biomechanical performance criteria have been established and generally accepted.***] We would need to investigate measurement devices for relevancy with the JRS."

- **"**Initial lateral acceleration **–** The JRS does not take into account the initial lateral acceleration in a real world rollover. This may have implications when testing with a dummy and potentially measuring performance related to some safety countermeasures (e.g., ejection containment side curtain bags and pretensioners). If a dummy's position in the test is not correlated to real-world rollovers, then the assessment of pretensioners and side window air bags in the JRS test is put into question."

  [***The angular acceleration rate is acceptable for near side window curtain deployment and we have pre-positioned the far side dummy to simulate the lateral acceleration of the pre-roll yaw and trip and have measured the motion of the dummy buttocks and head during roll initiation and window curtain deployment. We have not yet run rollover activated occupant protection system tests, but we believe initial pre-positioning will be effective in evaluating such systems and ejection mitigation. Additional instrumentation is available for measuring whole body injury potential performance of belted and unbelted occupants. The quarter turn ramp rollovers of GM provide much less performance data particularly in subsequent quarter rolls.***]

Lack of real-world data to feed into the test parameters (pg 22390 top column 3)

- "At this time, NHTSA has only limited event data recorder (EDR) data from rollover sensor-equipped vehicles. It is hoped that data from these vehicles can provide a better understanding of the range of initial roll rate and trip angles for real world rollover crashes. As voluntarily-installed EDRs continue to be installed in the fleet, the agency will gather an increasing amount of data on real world rollover crashes. Currently, the agency does not have enough of these data to evaluate how the JRS test might be optimized to real world rollover conditions."

[***Considering the infinite variety of rollovers, it is not likely that a single set of test parameters can be optimized. More likely the test parameters should be selected, as we have, to provide comparative performance for all vehicles relative to real world injury data such as derived from IIHS statistical studies.***]

- "The ongoing implementation of ESC systems complicates the evaluation of real world rollover crashes. ESC systems are anticipated to be highly effective in reducing single vehicle rollover crashes. These crashes tend to have the highest number of quarter turns. The federally mandated implementation of ESC systems is expected to dramatically alter the distribution of rollover crash conditions."

- "Assuming that real world representative test conditions could be established, NHTSA would still need to conduct a fleet study to examine the safety performance in a JRS test, evaluate how well the test results relate to real world safety performance, and determine whether or not there would be any appreciable safety improvement beyond existing FMVSSs."

  [***This is exactly what we are doing in resolving the disparities between JRS test results and IIHS individual vehicle rollover ratings using single sided 216 SWR results. In that regard we have identified three measurable correction factors:***
    1. ***roof geometry***
    2. ***stiffness and***
    3. ***elasticity.***]

  [***The correlation between JRS test results and real world injuries of individual vehicle injury rates will be a secondary benefit of resolving the rating system disparities with IIHS. As an alternative NCAC could determine the injury rate (in the manner of IIHS) for comparison with the injury performance of vehicles which have been JRS tested***.]

  [***All FMVSS compliance tests have established a single protocol that is independent of the vehicle being tested. In its critique of the JRS, NHTSA appears to be suggesting that in the case of rollover, this norm should for some reason be modified, and different protocols be established for each different vehicle.***]

Test dummy issues (pg 22390 bottom column 3)

- "Lack of test dummy and injury criteria – At this time, no anthropomorphic test device (ATD) or crash test dummy, has been designed for use in rollover crash tests. Existing ATDs used in rollover crash tests, such as the Hybrid III dummy lack lateral kinematic behavior as well as lateral impact biofidelity. In addition, new injury criteria beyond those currently developed for frontal and side impacts would need to be developed for the types of loading conditions that result in head, neck, and face injuries associated with roof contact."

[***Much of that research (including limb, spine and thorax injury instrumentation) has already been done; the Hybrid III dummy has been modified, IARV have been established, and are in use by GM in their ramp rollover testing.***]

- "Repeatability of test dummy and initial restraint positioning – Because the JRS is spinning prior to initiating the vehicle test, there are concerns about how to establish the initial belt position on the ATD in a manner that is consistent with real world conditions. The lateral acceleration prior to rollover initiation (as discussed previously) can cause a belted occupant to introduce slack in the belt. There is also the additional complication of the timing for firing the rollover curtains and/or pretensioners in the JRS pre-spin cycle." [***This is a reference to the CRIS test and is not appropriate to the JRS.***]

"There are also issues concerning the biomechanical basis for the CFIR recommended performance criteria.

(pg 22391 top column 1)

"Specifically, we have concerns about CFIR recommended axial neck load criteria, and the surrogate (intrusion speed and amplitude), having potential to predict neck injury in the real world. We note that in response to CFIR's injury metrics, Nissan submitted an analysis conducted by David C. Viano, Ph.D. from ProBiomechanics evaluating their findings. Viano found no correlation between impact force and head impact velocity based upon the available cadaver data CFIR used in its analysis. We believe this is an important issue, and believe that lateral moments may be equally or more significant than axial force in predicting cervical spine injuries. Absent other information we believe further research would be needed as to whether the recommended neck axial loads and/or roof intrusion velocity are appropriate criteria."

[***This comment focuses on an axial neck injury criteria, which we (Jacqueline Paver and I) reject as nothing more than an impact speed indicator in four data filled papers in 2008 (ICRASH, IRCOBI, IMECE and HUMAN) at least two where Steve Ridella was the session chairman. The 7 mph, 7,000 N speed criteria was established as the onset of neck injury by McElhaney and Paver from diving injuries in 1978-1998. The roof crush***

criterion is NHTSA's post crash negative headroom. As Steve Ridella said at our last meeting, Paver took a lot of flack at the HUMAN symposium pre-Stapp, from industry types, because <u>we proposed, pendulum tested, and JRS validated, Hybrid III lower neck bending (lateral and flexion) injury criteria.</u>]

"As to the issue raised by Mr. Nash, the agency reviewed the Toyota NASS cases he provided, and the damage patterns to the roof were consistent with other cases the agency has analyzed. Neither the agency nor Mr. Nash identified a catastrophic collapse of the header. The integrity of the roof was maintained in all but one of the crash events cited. NHTSA also reviewed the JRS 2007 Toyota Camry tests and compared the results to the NASS data. The Camry was tested twice on the driver's side of the vehicle. When the driver's side was tested the first time, there was no appreciable damage to the header. The driver's side of the same vehicle was then tested again and showed some minor header damage. This test methodology is inconsistent with a real world rollover as the far side of the vehicle was not damaged in either JRS test and yet the driver's side was tested twice."

[***This comment finds the lack of catastrophic damage in NASS cases of the Toyota Camry (SWR=4.3) <u>inconsistent</u> with the lack of far side damage in two sequential JRS rolls of the same vehicle. The relative lack of damage in a vehicle with a strong roof should not be surprising. NHTSA's focus on correlating damage precludes a focus on injury potential.***]

"While we appreciate the information provided by the commenters, we do not believe that the information is sufficient for consideration of the JRS as a possible test device for a Federal motor vehicle safety standard at this time. The concept and the ability of the fixture to rotate a vehicle and contact the roadway have been demonstrated. However, as indicated above, there are numerous technical issues related to the test and potential parameters as well as a suitable ATD and associated injury criteria or other metric."

[***These comments and responses may require discussion between technical people precluded by the lack of transparency. These interpretive disagreements are about extensive data submissions involving thousands of hours of test and analytical study as requested by the Agency in 2001 and are not about rhetoric. We request an opportunity to explain our data submissions and conclusions to an objective professional technical review group to resolve the discrepancies, if NHTSA finds these written comments inadequate.***]

[***Such a review group of 15 former NHTSA professionals, academic from around the world, real world statistical data analysts and vehicle test and design experts are in the final stages of report writing after 6 months of such a study. The members of this group do not include advocates or proponents of the Jordan Rollover system device.***]

In conclusion, we believe answers have been provided to all of NHTSA concerns for a dynamic injury potential compliance or NCAP test, but not for a compliance match with roof crush damage which inexplicably seems to be what they desire. Of course, there is a need for further research, for others to check the results and to disseminate results worldwide. The JRS is not in its infancy, it is a preliminary but fully developed scientific system, awaiting distribution of JRS fixtures to achieve industry wide acceptability.