Statement of Donald Friedman, co-founder of the Center For Injury Research and Xprts, LLC.

Thirty years ago, I designed, built and NHTSA extensively tested the Minicars Research Safety Vehicle which would now rate 5 stars in all crashworthiness categories. Frontal, side and rear impact protection was developed to injury criteria by testing under dynamic repeatable conditions. Test facilities for conducting repeatable tests did not exist for rollovers. So the RSV rollover protection was designed by engineering judgment, with a very strong roof, lots of padding, a good rolling shape and large windshield-like side windows that wouldn't break and which precluded ejection of unbelted occupants in a rollover.

Five years ago, the nonprofit Center For Injury Research and Xprts, LLC, working on behalf of victims, developed the Jordan Rollover System or JRS, a machine on which many research oriented, dynamic repeatable rollover tests have been conducted.

Those tests allow the development and evaluation of occupant protection alternatives under a wide, but repeatable range of dynamic rollover conditions. It can also provide an injury probability comparison of different vehicles and alternative designs with the potential to protect occupants in rollovers under identical conditions.

For example, two roll, low severity, JRS tests of a 2000 Ford Explorer, the most popular SUV in America, were conducted. The Explorer, with the wheels removed, was mounted front and back on drop towers with about 5 degrees of pitch. When the test started, the vehicle was rotated so the passenger side impacted first in coordination with a 15 mph moving road bed which moved under the vehicle as it fell. The passenger side roof (in this test, the near side roof) impacted and continued to roll over the roof past the driver's side (in this test, the far side roof) before it was stopped from hitting the tracks of the moving road bed. The far side roof crushed extensively. Then the same vehicle was reset in the machine and the test was repeated again with further extensive crush.

For comparison's sake, the same sequence of tests were conducted on a 2004 Volvo XC90. All the test circumstances were the same as in the Explorer tests, but there wasn't any appreciable roof crush on either of the two Volvo tests. All the measurements which affect occupant injury are made on the inside during both the near and far side roof impacts.

High speed video cameras inside the vehicle document the motion of the interior of the roof in the two Volvo tests. Because that camera and the vehicle are rolling together, only the dynamic effect of the interior crush is seen. The last frames of the first video are the residual interior crush at the end of one roll. That is followed by the second roll. In the Volvo tests, the crush is so little, it is hard to realize that the vehicle is rolling.

The same high speed videos of the interior of the Explorer tell another story. The near side (in this test, the passenger side) hits and crushes as the roll starts. Then the center part of the roof collapses and the far side roof forms a wedge that penetrates the area where the driver's head would be. On the second roll, the amount of crush and the depth of the wedge is increased.

The video is not very easily quantified, but there are thin cables that run from six points on the driver's side, the far side of the roof, to the center of rotation of the vehicle. Those cables measure the change in inches and the speed of the roof moving towards the vehicle center.

2000 Ford Explorer 4dr Roll 1	Crush (in)		Peak Crush Speed
Location	Peak	End of Test	(mph)
A-Pillar	-8.7	-5.9	-6.3
Mid Point Between A and B Pillar	-9.1	-5.9	-6.7
B-Pillar	-6.7	-3.9	-5.5
Inboard of A-Pillar	-7.0	-4.9	-5.8
Inboard of Roof Rail Midpoint	-11.5	-8.5	-12.1
Inboard of B-Pillar	-8.7	-6.2	-9.1
Center of Roof	-8.2	-6.3	-7.6
Near Side A-Pillar	-4.2	-2.0	-3.8

2000 Ford Explorer 4dr Roll 2	Crush (in)			Peak Crush Speed
Location	Peak	End of Test	Cumulative	(mph)
A-Pillar	-9.2	-6.4	-12.3	-9.6
Mid Point Between A and B Pillar	-9.9	-7.0	-12.9	-9.3
B-Pillar	-9.9	-6.7	-10.6	-8.8
Inboard of A-Pillar	-6.3	-4.2	-9.1	-7.0
Inboard of Roof Rail Midpoint	-9.5	-6.0	-14.5	-9.9
Inboard of B-Pillar	-8.9	-5.6	-11.8	-8.1
Center of Roof	-5.7	-3.1	-9.3	-8.5
Near Side A-Pillar	-2.4	1.0	-1.0	-4.1

2000 Ford Explorer 2 Roll JRS Test Series

Peak Dynamic Crush – 11.5 inches

Peak Cumulative Crush – 14.5 inches

Peak Crush Speed – 12.1 mph

2004 Volvo XC90 2 Roll JRS Test Series

Peak Dynamic Crush* – 2.6 inches

Peak Cumulative Crush* – 1.1 inches

Peak Crush Speed* – 3.0 mph

* Far side only

2004 Volvo XC90 Roll 1	Crush (in)		Peak Crush Speed
Location	Peak	End of Test	(mph)
A-Pillar	-1.0	-0.1	-1.5
Mid Point Between A and B Pillar	-1.5	-0.3	-2.2
B Pillar	-1.2	-0.1	-1.9
Header Inboard of A-Pillar	-0.6	0.0	-1.2
Front of Sunroof	-1.1	-0.4	-1.8
Side of Sunroof	-1.5	-0.3	-2.3
Near Side A-Pillar	-2.1	-0.9	-3.3
Near Side B-Pillar	-3.2	-1.1	-3.7

2004 Volvo XC90 Roll 2	Crush (in)			Peak Crush Speed
Location	Peak	End of Test	Cumulative	(mph)
A-Pillar	-1.9	-0.5	-0.6	-2.0
Mid Point Between A and B Pillar	-2.6	-0.7	-1.0	-2.9
B Pillar	-2.6	-0.7	-0.9	-3.0
Header Inboard of A-Pillar	-1.2	-0.3	-0.3	-1.4
Front of Sunroof	-1.6	-0.5	-0.8	-2.1
Side of Sunroof	-2.5	-0.7	-1.1	-2.9
Near Side A-Pillar	-0.3	0.2	-0.7	-1.1
Near Side B-Pillar	-0.9	0.3	-0.8	-1.8

These are the measurements for each of the two rolls of the Explorer and Volvo. Notice that the highest measured speed of the driver's roof in the two Explorer tests was 12.1 mph, while the same speed measurement of the Volvo was 3.0 mph.

Because the injury criteria indicates that serious injury is probable at head impact speeds of 7 to 10 mph, and severe to fatal injury is probable at more than 10 mph, it is easy to see which vehicle is safer.

CFIR and XPRTS have also conducted two roll, 15 mph, JRS tests of 8 other production vehicles. These equal severity tests also provide the basis for an injury severity probability evaluation shown below. Note that the probability of injury is not directly related to increased roof Strength to Weight Ratio (SWR), making clear that the NHTSA current and proposed roof crush SWR requirements are meaningless. The SAFE probability is awarded only to those vehicles which meet the crush speed criteria and do not create ejection portals.

Two JRS 15 mph Dynamic Rolls in Sequence Ordered by Max. Roof Crush Speed at any Point for Injury Severity Evaluation

Model Years	Model Types	216 SWR	Max Crush (Inches)	MAX Speed (MPH)	Injury Probability	Case Injury
2002-2006	Volvo XC90 SUV	3.6	3.2	3.7	SAFE	NA
1999-2005	Hyundai Sonata Sedan	1.8	6.4	8.0	Serious	Quadriplegia
2003-2006	Kia Sorrento SUV	1.9	6.9	9.0	Severe	Quadriplegia
1995-1999	Nissan Sentra Sedan	3.2	9.1	9.6	Severe	Quadriplegia
1995-2001	GMC Jimmy SUV	2.4	6.7	9.8	Severe	Quadriplegia
1995-2005	Chevy Blazer SUV	2.4	9.6	10.1	Catastrophic	Quadriplegia
1999-2001	Isuzu VehiCross SUV	NA	6.8	11.1	Catastrophic	Brain Injury
2001-2006	C2500 HD Reg Cab Pickup	2.2	9.9	11.2	Catastrophic	Fatal
1995-2001	Ford Explorer SUV	1.6	11.5	11.9	Catastrophic	Quadriplegia
1994-1999	Mitsubishi Eclipse Sedan	2.5	7.6	12.1	Catastrophic	Fatal

(Criteria: SAFE = < 6mph and no ejection portals; Good = < 6 mph ; Serious = < 8 mph; Severe = < 10 mph; Catastrophic = > 10mph)

In conclusion: "The JRS can compare the injury and ejection potential of vehicles in rollovers and can definitively identify vehicle safety component defects and their causal relationship to death and injury in accidents." In other words "Roof crush causes injury."

The JRS system has been proven to be able to distinguish between safe and unsafe vehicles in rollovers. Its tests are highly repeatable. It is inexpensive and compact. It is the test system that the industry has claimed does not exist. It is the test system that NHTSA should use in its upgrade of FMVSS 216.