Deficiencies of NHTSA's Current and Proposed Static, One-Sided Test of Roof Strength, FMVSS 216

Remarks of Don Friedman

April 11, 2005

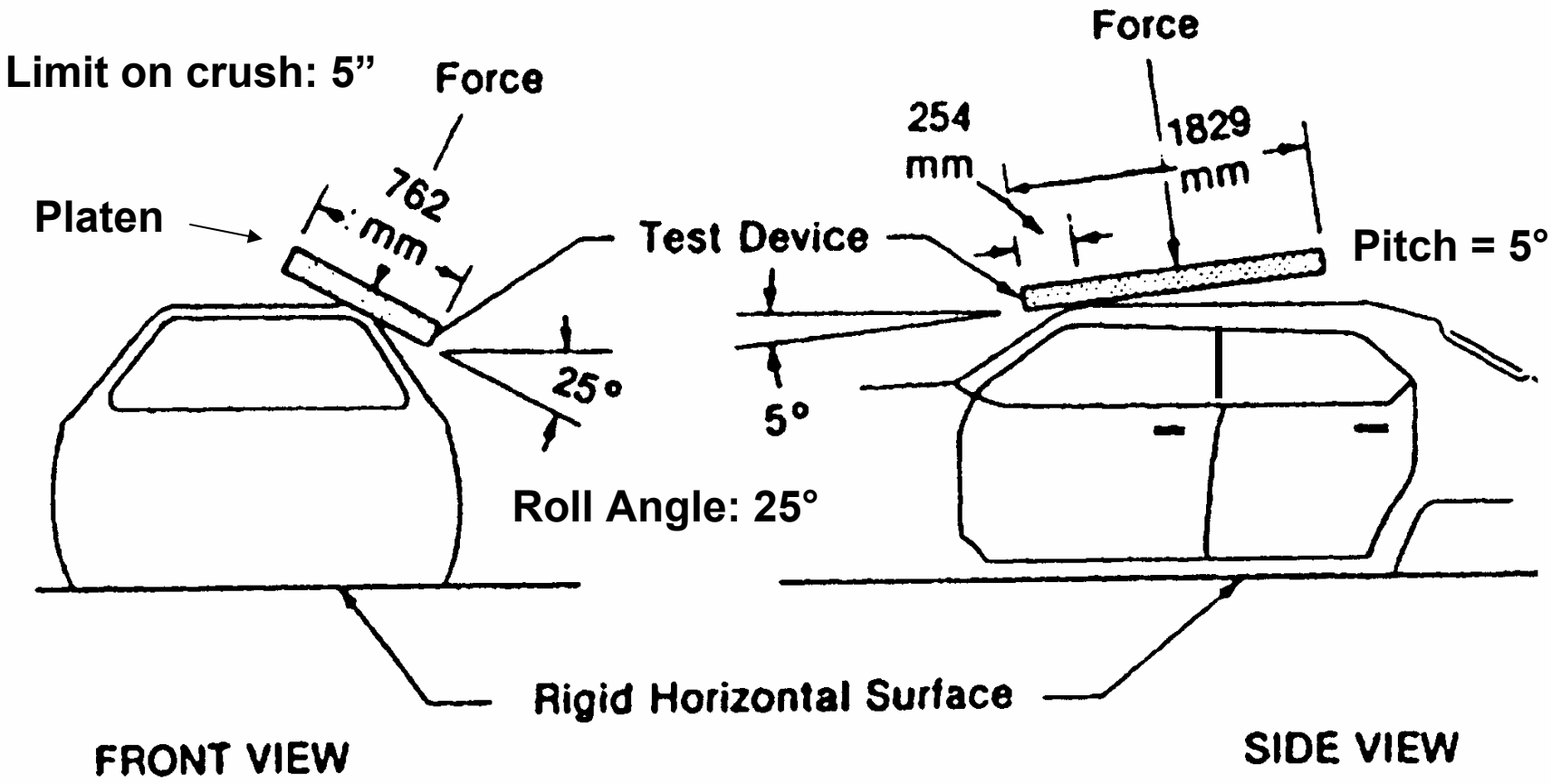
Key Points on Rollover/Roof Crush Risks

- **The major sources of the most serious rollover injuries are: 1) roof intrusion – causing severe head and neck injuries; and 2) full and partial ejection, primarily through broken side windows.**
- **Even belted occupants suffer partial ejection of their arms and heads, while unbelted occupants can be completely ejected.**
- **The new NHTSA standard addresses neither of these major causes of injury to far side occupants, and would leave even belted near side occupants exposed to risks from ejection.**

NHTSA Ignores Relationship Between Roof Strength and Ejection

- Because weak roofs permit window and windshield glass to break in a rollover, a major benefit of a strong roof is **ejection prevention.**
- Yet NHTSA's analysis of the benefits of roof strength **ignores the strong relationship between roof strength, window failures and ejection.**
- **NHTSA's assessment of the potential benefits** of roofs with substantially stronger A pillars, windshield headers and roof rails **is incomplete.**

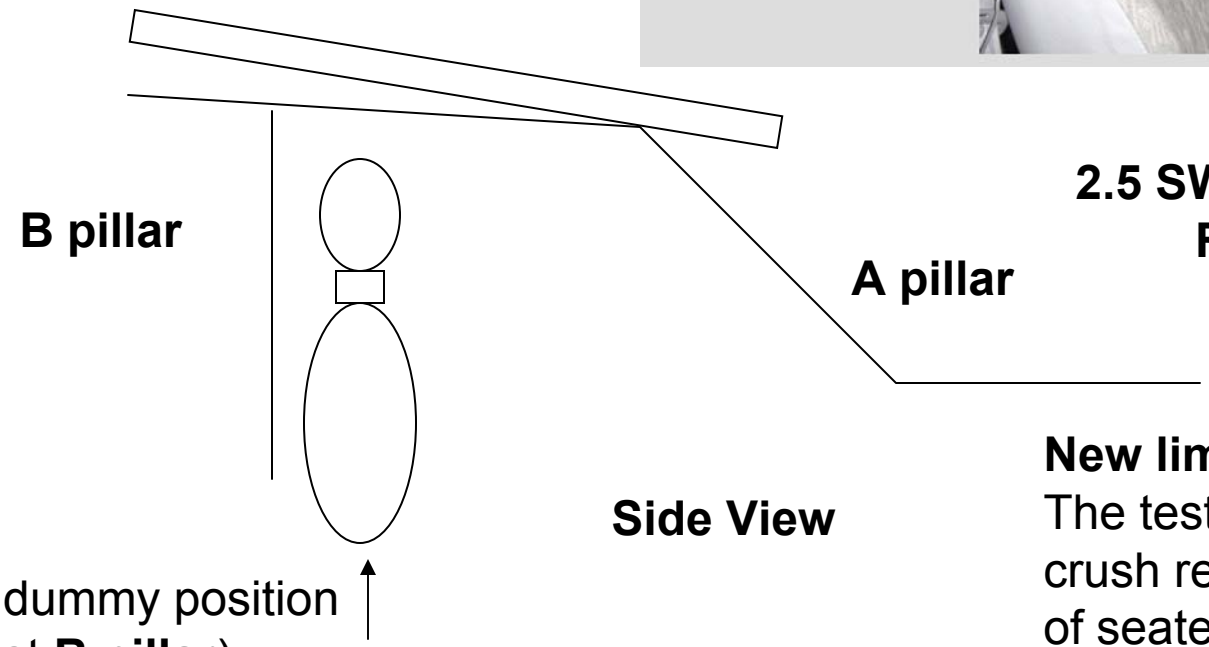
Current Roof Strength Test



Anticipated NHTSA Proposal: Static One-Sided Test

- Hybrid-III 50th Male
- Positioned per FMVSS 208
- Arms and Legs Removed
- Contact Switch on Head and Liner





Side View

2.5 SWR, Pitch = 5°
Roll Angle = 25°

New limit:
The test stops when crush reaches head of seated dummy.

Minimal Increase in Force of Test Will Not Improve Most Vehicles Now on Road

- **The strength-to-weight ratio (SWR) of vehicles on the road ranges from 1.55 to 3.5, with an average of about 2.3 as measured by the current FMVSS 216.**
- **NHTSA tests in 2003 of recent models found that 8 of 10 vehicles would pass the anticipated new standard.**

Xprts Rollover/Roof Strength Tests

- **Extensive testing of SUVs and pickups, including Ford Explorers, Chevy Blazers. Surburbans and other vehicles have been performed.**
- **Testing includes dynamic testing using the Jordan Rollover System (JRS) fixture as well as two-sided quasi-static testing and encompasses dozens of tests.**
- **We also conducted in-depth investigations of over 400 rollover accidents.**

A Repeatable Rollover Fixture – The JRS (Jordan Rollover System)





A repeatable, dynamic rollover crashworthiness test that quantifies the strength of the roof and allows examination of:

- ✓ Vehicle damage
- ✓ Injury causation
- ✓ Belt performance
- ✓ Partial ejection
- ✓ Structural Performance
  - ✓ Various SWRs
  - ✓ Sequential testing

Key Problems in the NHTSA Test

The test is unrealistic when compared to actual rollover events because it:

1) **Tests one side only, ignoring the far side impact, where the majority of occupants seriously injured are located;**
2) **The test conditions permit a weak A pillar, which collapses at speeds dangerous to occupants;**
3) **Both omissions allow ejection risks, and the benefits of reducing ejection, to be ignored.**

I. The Problem of Far Side Impacts:

In rollovers the roof is mainly crushed and people seriously injured on the FAR side, opposite to the direction of roll (or NEAR side).



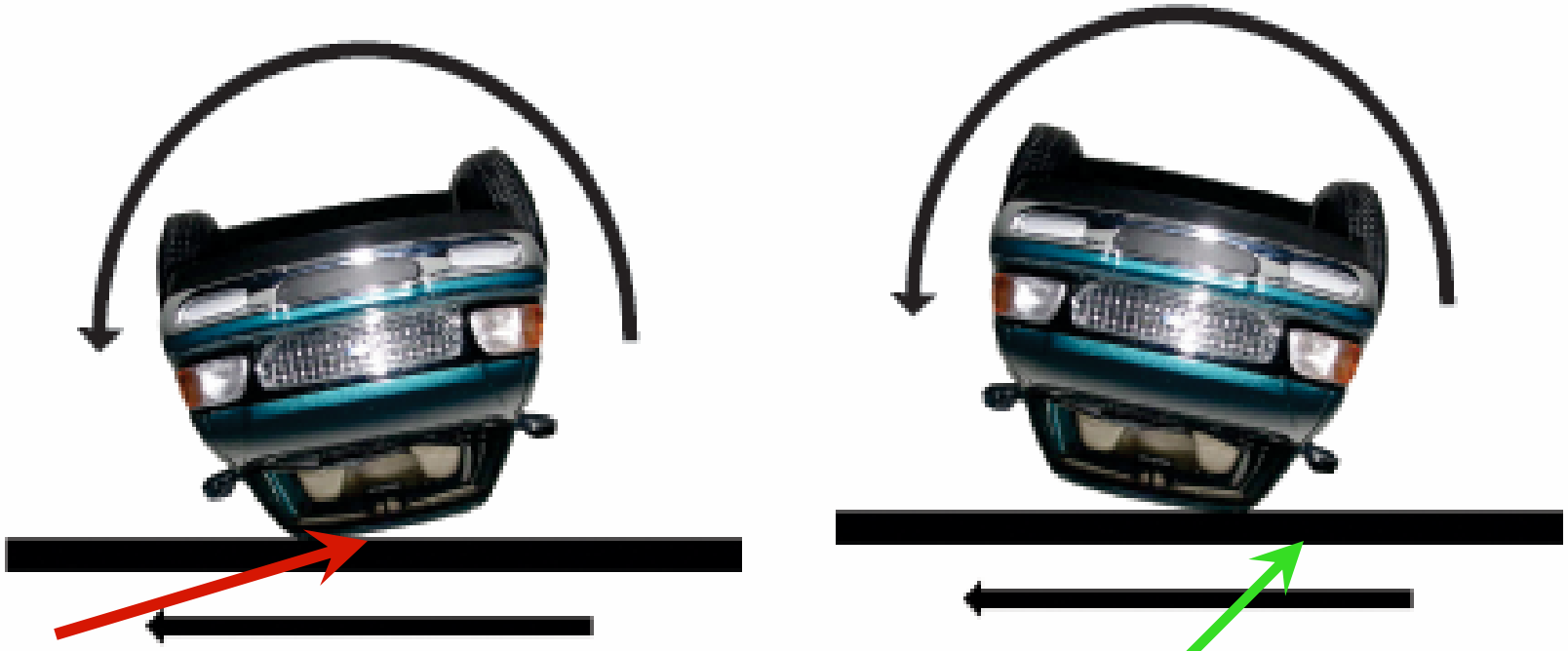
Passenger (far side) injury



Driver (far side) injury

Road Contact Resultant Roof Forces

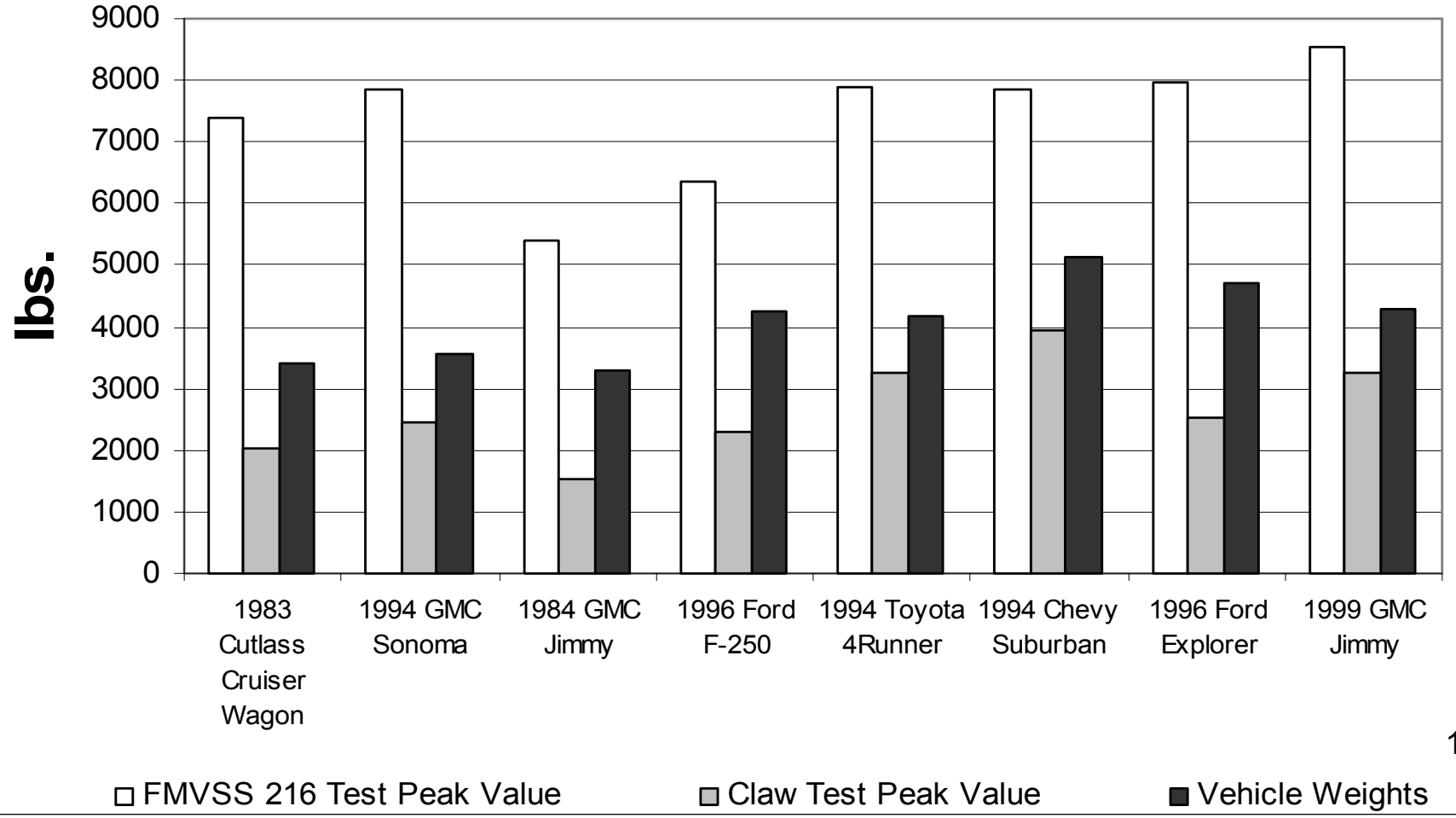
are similar in pitch but more lateral – pushing along roofline – on the far side



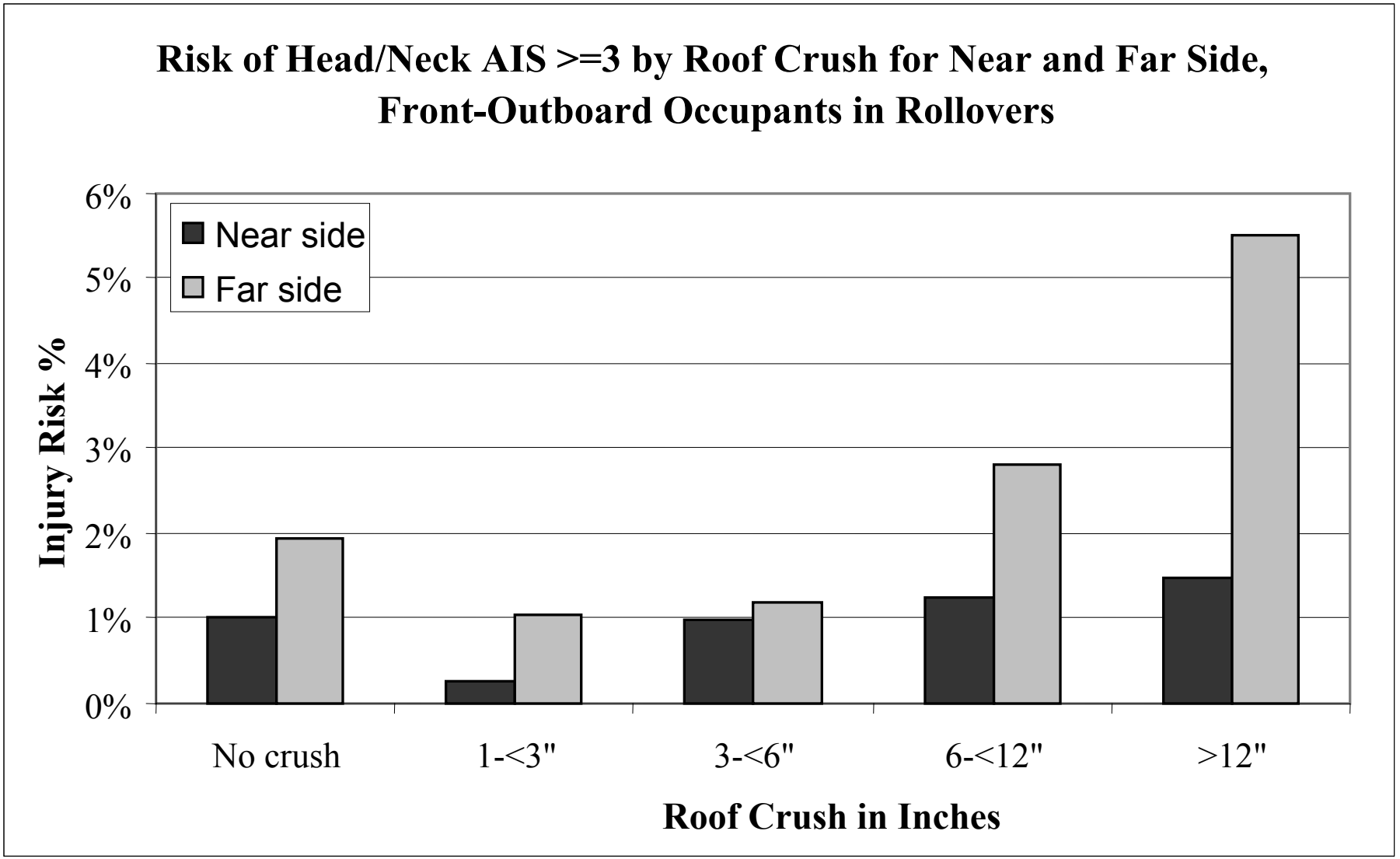
Far Side **Near Side**

Far side roof strength is reduced as much as 30 percent by near side windshield breaks, plus an additional 40 percent by the more lateral loading.

A 50+ vehicle survey conducted by Xprts confirms that at far side impact angles, roofs can barely support the vehicle's weight, and not 1.5X the weight of the vehicle.



Injury Risk in Rollovers Correlates with Roof Crush and Seating Position



1992 to 2002 NASS/CDS Data

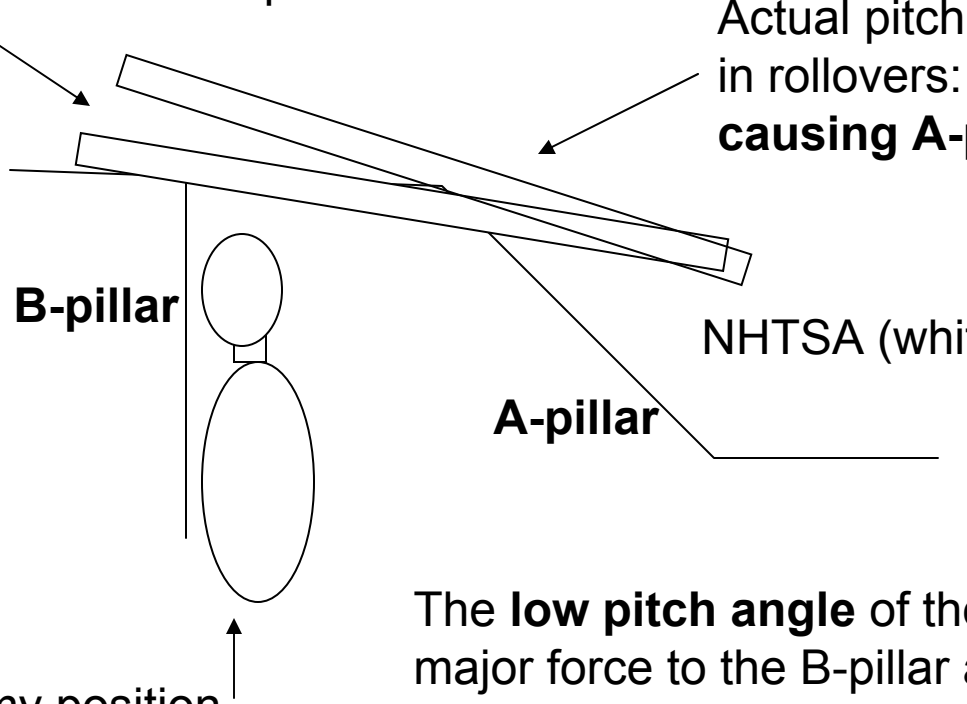
II. A Weak A-Pillar, and Harm to Occupants, Allowed by NHTSA Test

There are three major problems related to the A pillar and NHTSA's anticipated new roof crush test:

1) **The 5° pitch angle is not realistic.** Most vehicles in a study by NHTSA published last fall showed damage to the vehicle's front fenders. SUVs and pickups have a pitch of least 10° during a rollover, as shown in dynamic testing.
2) **The dummy's head position is unrealistic.** In actual rollovers, witness marks show that a human head is closer to the roof rail and A-pillar when the roof crushed. In that location, the neck is more vulnerable to injury from roof crush.
3) **The test does not measure roof intrusion speed** which can exceed 20 mph when a weak A pillar buckles – a speed that will inflict severe injury.

Load Placed on B-Pillar in Test Conceals A-Pillar Failure

B pillar strength: Focus of NHTSA test, but masks role of the A-pillar.



Actual pitch angle (grey platen) in rollovers: **10° or more – causing A-pillar collapse.**

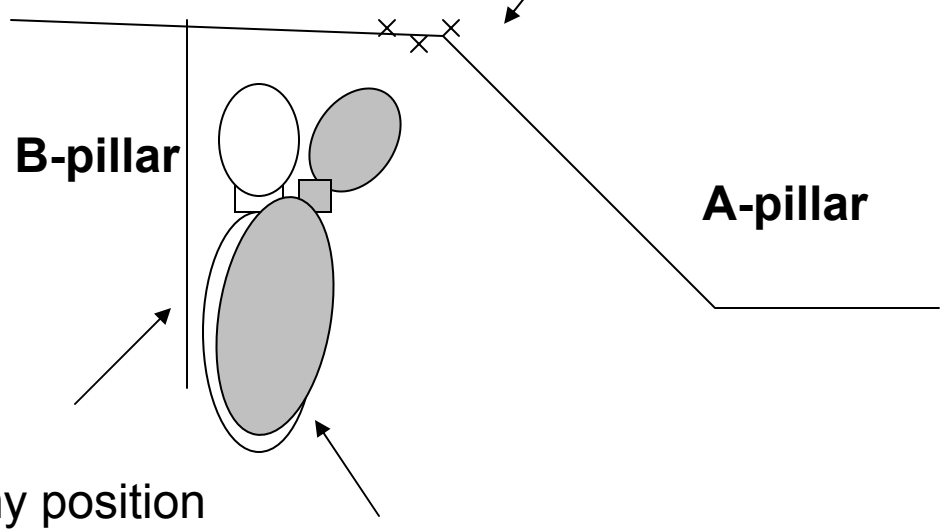
NHTSA (white) platen: **5° pitch**

NHTSA dummy position (seated at **B pillar**)

The **low pitch angle** of the platen applies major force to the B-pillar after the windshield breaks in the early part of the test, **distributing the load onto the B-pillar more than occurs in actual rollovers**.

NHTSA Dummy Position Focuses Incorrectly on B-Pillar Strength, Ignores Intrusion Velocity

Rapid collapse of **A-pillar** on second Impact causes injury (**intrusion velocity on far side can reach 22 mph**).





White dummy:
NHTSA dummy position
(seated at **B-pillar**)

Grey dummy: Occupants' actual position in rollover crashes (up and forward, with neck flexed).

× Indicates witness marks showing occupant impacts in actual rollover crashes.

Ford Data on On-Road SWR Misleads Agency and Public

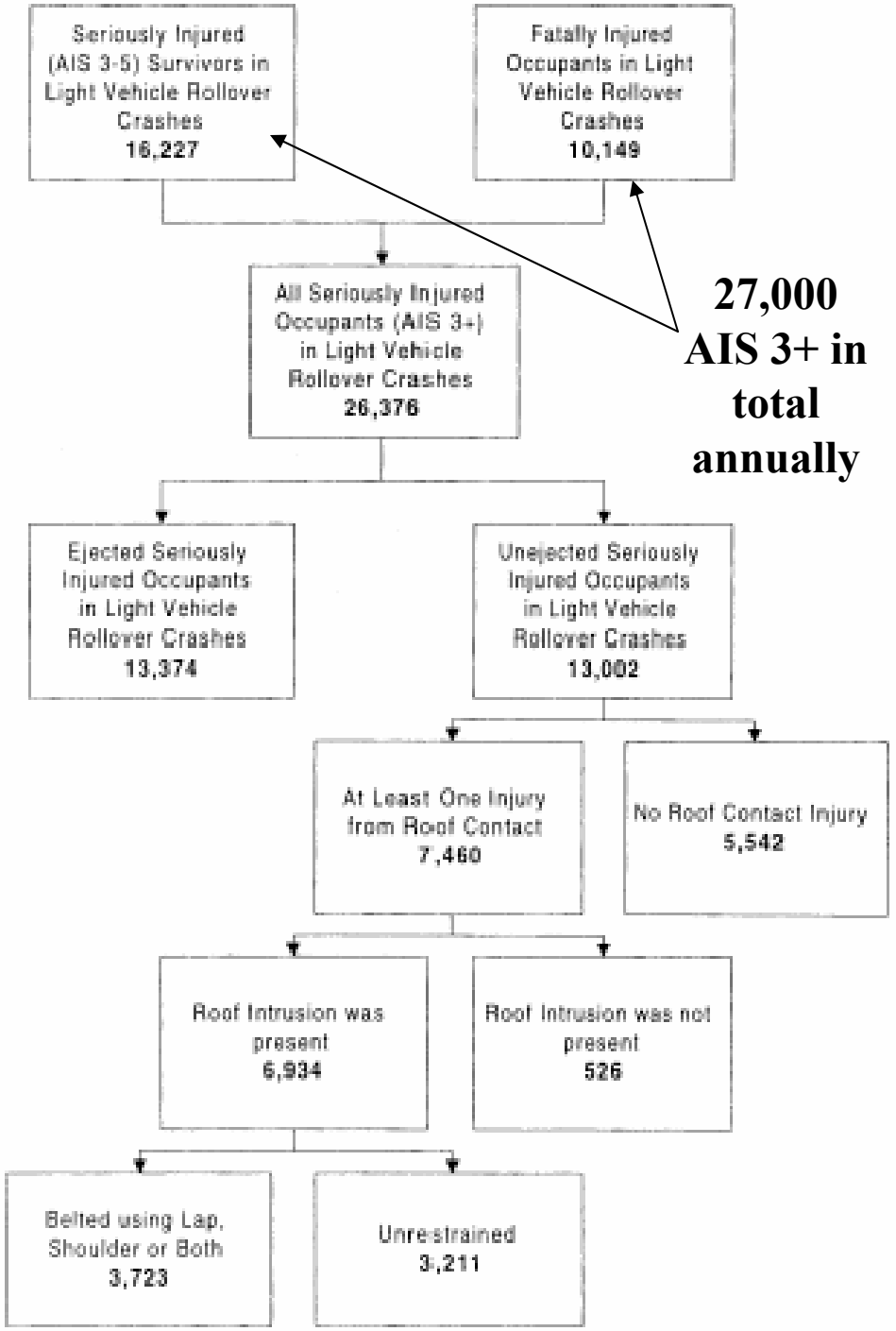
- Ford points to a lack of correlation between SWR measures and injury in real-world crashes.
- For all of the reasons above, vehicle SWR (as measured in FMVSS 216) does not predict the level of occupant injury in rollover crashes.

Roof Strength/ Ejection Relationship Ignored

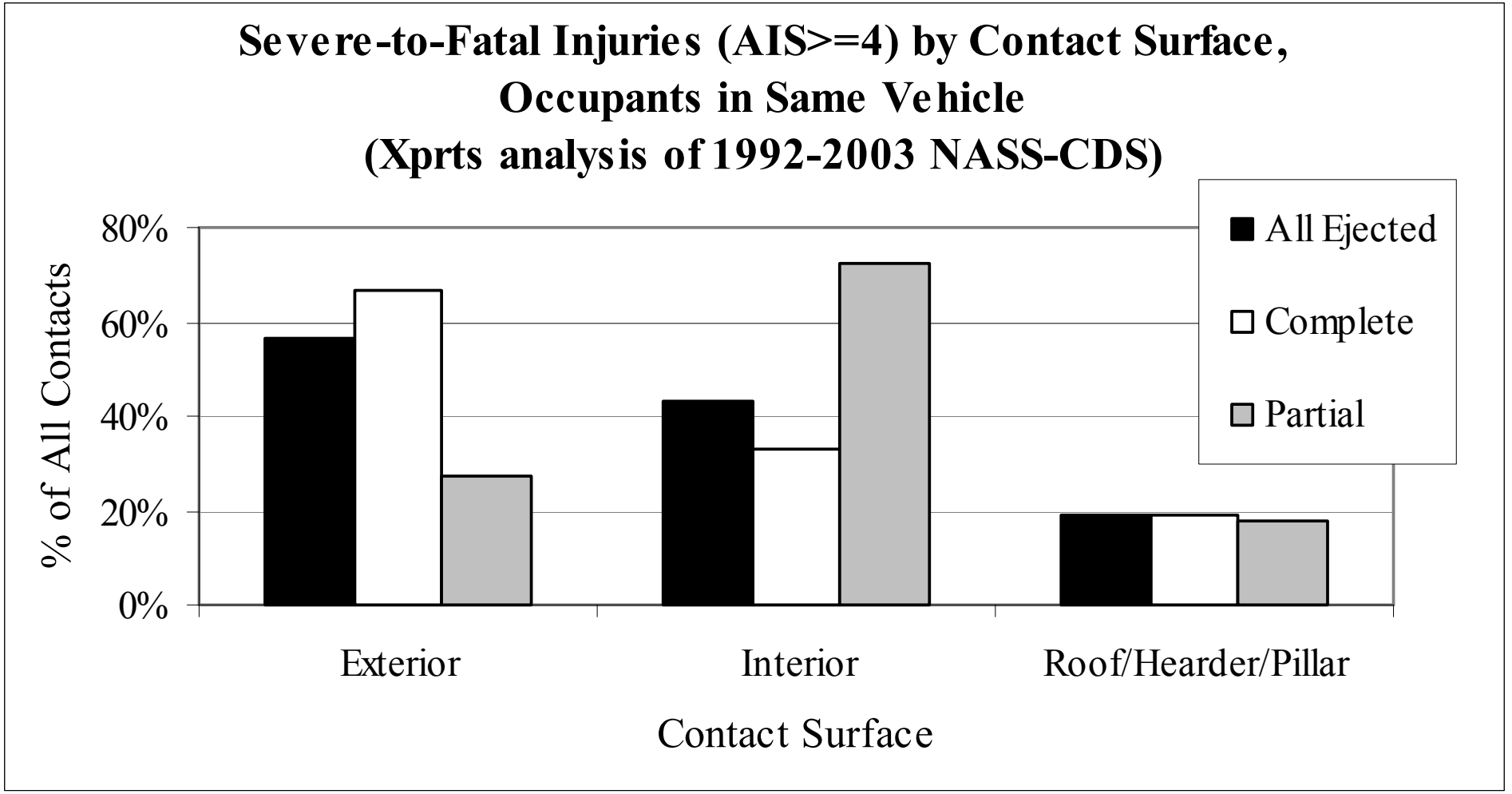
NHTSA Underestimates Roof Strength Benefits:

Serious Injuries Analysis
(from Request for Comments)

NHTSA excludes ejected occupants, and assumes that occupants **were not injured by roof crush prior to ejection**.



NHTSA Data: 45 Percent of Partially or Fully Ejected Occupants Contacted Inside of Vehicle Prior to Ejection



GM Documents Prove Ejection-Roof Strength Relationship

- In 1982, GM began a study of rollover occupant ejection and roof strength.
- GM engineer Arums found that the roof lost about ⅓ of its strength when the bonded windshield broke.
- Arums estimated a 23 percent reduction in ejections with tempered glass and a stronger roof.
- GM failed to tell NHTSA about these results when asked by the agency.

GM: A Strong Roof Is Critical to Prevent Ejection

Memo by GM Engineer Ivar Arums:

Attachment to Memo, 4-13-83
C/K-Truck Crashworthiness Dev

L A B O R A T O R Y SIMULATION
OF OCCUPANT EJECTION THROUGH WINDOWS

* THE DESIGN OF A TEST FACILITY OR TESTING METHOD FOR OCCUPANT EJECTION THROUGH WINDOWS SHOULD SIMULATE THE PERTINENT PORTIONS OF THE ACCIDENT. IT SHOULD DEFINE H O W T O T E S T AND YET BE INDEPENDENT OF V E H I C L E D E S I G N.

THE EJECTION PHENOMENON APPEARS TO HAVE TWO ASSOCIATED COMPONENTS WHICH NEED TO BE ADRESSED IN ANY TEST PROGRAM:

V E H I C L E STRUCTURAL DEFORMATION	O C C U P A N T EXIT AREA
* NONE	* ADJACENT WINDOW (near side)
* ABOVE WINDOW	* OPPOSITE WINDOW (far side)
* BELOW WINDOW	* NON-SIDE WINDOW (backlight)
* CORNER OF WINDOW	* NON-WINDOW (door)

** ALTHOUGH IT MAY BE TECHNICALLY CHALLENGING TO MITIGATE EJECTION BY DEVELOPING ALTERNATIVES TO GLAZING MATERIALS IT SHOULD BE KEPT IN MIND THAT PARTIAL EJECTION REDUCTION AND POST ACCIDENT EGRESS/ACCESS ARE SIGNIFICANT ASPECTS OF VEHICLE DESIGN.

** THEREFORE IT IS NECESSARY TO TEST THE STRUCTURE AVAILABLE TO RETAIN THE GLAZING AS WELL AS TESTING THE OCCUPANT RETENTION CAPABILITIES OF THE GLAZING .

IT IS WITH THESE TWO POINTS IN MIND THAT THE FOLLOWING TESTS ARE PROPOSED TO ENABLE DEVELOPING AND TESTING ALTERNATIVE GLAZING SYSTEMS DESIGNED TO MITIGATE EJECTIONS.

Roof Improvements Save Lives

- JRS tests show that **if the roof does not distort more than 3 or 4 inches, the rollover will not break the windows, and people cannot be ejected.**
- A standard that **limits crush to about 4 inches** in a dynamic test, such as the dolly rollover now part of FMVSS 208, would reduce ejections at least 50 percent – preventing at least **6,500 deaths and serious injuries, or 125 per week.** Roof intrusion injury would also be greatly reduced, preventing **another 100 deaths and serious injuries each week and bringing the total number to 10,000 each year.**
- NHTSA should make the now-voluntary **FMVSS 208 dolly rollover test mandatory**.
- At a minimum, **a two-sided test with greater pitch and roll angles should be required by the agency**, and verified with dynamic testing.

Dynamic Test Show Pattern of More Severe Impacts on Far Side Dummy



Blazer Dynamic Rollover Test
Shows Pitch Angles on Far Side Exceed 10°



Human Rollover Kinematics Show Neck Is Flexed and Forward of B-Pillar

