Rollover Rates and Severity - Dynamic Testing Results

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Outline of Presentation

- FARS and NASS Data on Rollover
- Dynamic Test Results
Fatality Trends in US by Crash Type
Distribution of Fatalities by Crash Direction – FARS 2001-2005

- Front: 39%
- Rear: 3%
- Side: 25%
- Roll: 12%
- Front-Roll: 15%
- Side-Roll: 6%
- Pure Roll: 25%
Rollover Data from 2007 ESV

• Authors
  – Ana Eigen – NHTSA
  – Ken Digges – GWU

• Data Analysis
  – NASS/CDS 1995-2005 (NHTSA’s Accident Data)
  – Belted front seat occupants in rollovers

• The Data to Follow
  – Single vehicle rollovers
  – Injured belted occupants
Definition of Vehicle Inversions

0 Inversions – 1 Quarter-turn

No roof contact
Definition of Vehicle Inversions

0 Inversions – 1 Quarter-turn

1st Inversion – 2 Quarter-turn = 1st Upside-down
**Definition of Vehicle Inversions**

0 Inversions – 1 Quarter-turn

1 Inversion – 1st Upside-down + next 3 Quarter-turns

Quarter-turns 3, 4, and 5 do not have a higher injury risk than quarter-turn 2
Definition of Vehicle Inversions

0 Inversions – 1 Quarter-turn

1 Inversion – 2 thru 5 Quarter-turns

2 Inversions – 6 thru 9 Quarter-turns
Injury Rate in Rollovers by Crash Severity

MAIS 3+F Injury Rate

Number of Vehicle Inversions

Injured per 100 Exposed

0-1 Inv  2 Inv  3+ Inv
Rollover MAIS 3+F by Crash Severity

MAIS 3+F in Single Vehicle Rollovers

Number of Vehicle Inversions

Percent MAIS 3+F

0-1 Inv 2 Inv 3+ Inv

0% 20% 40% 60% 80%
Observations

• *Number of Vehicle Inversions* is a good severity metric
• *Two Inversions* account for more than 60% of the MAIS 3+F among belted front occupants in single vehicle rollovers
Rollover Testing

Static Test

Dynamic Test
FMVSS 216 Roof Crush Test

Must support X times vehicle weight within 127 mm (5 in.) of deflection

Old 216     X=1.5
New 216     X=3.0
IIHS Test   X=4.0
Roof Crush Phase 2 - Results

Vehicle Tests

Percent of Vehicle Weight vs. Displacement
To 254 mm Load Plate Displacement

Current (Old) FMVSS 216 Requirement X=1.5

Test Data
Roof Crush
Phase 2 - Results

Vehicle Tests

Percent of Vehicle Weight vs. Displacement
To 254 mm Load Plate Displacement

FMVSS 216 Final Rule
X=3.0

Test Data
Roof Crush
Phase 2 - Results

Vehicle Tests

Percent of Vehicle Weight vs. Displacement
To 254 mm Load Plate Displacement

- 1997 Dodge Grand Caravan
- 1998 Chevrolet S10 Pickup
- 2002 Ford Explorer
- 2002 Dodge Ram 1500 Pickup
- 2002 Toyota Camry
- 2002 Ford Mustang
- 2001 Chevrolet Tahoe
- 1989 Ford E150 Van

High

Loss of Roof Strength

Low
NCAC Research Tests for Roof Crush

Drop Height = 6” (152mm)
Pickup Roof Drop from 6”

1st Roof Impact

2nd Roof Impact
1\textsuperscript{st} and 2\textsuperscript{nd} Drop Comparison

- 1\textsuperscript{st} Drop Maximum Roof Crush
- 2\textsuperscript{nd} Drop Maximum Roof Crush

- Rear Window Broken
- Rear Window OK
- Side Window Broken
Loss of Glass Integrity in Rollovers

Glass Disintegration in Rollovers

Number of Quarter Turns

Percent Glass Breakage

NASS Analysis by Malliaris, ESV 1991
Observations

• Glass breakage can influence roof strength and ejection potential
• Research testing should include two vehicle inversions
Jordan Dynamic Rollover System (JRS)
Rollover Safety Measurements

• Without Dummies
  – Visual Inspection
  – Residual Headroom
  – Max Crush
  – Max Crush Velocity
Rollover Safety Measurements

• With Dummies
  – Visual Inspection
  – Existing Injury Criteria
  – New Injury Criteria
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Initial Conditions</th>
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</thead>
<tbody>
<tr>
<td>Road Speed</td>
<td>24 k/hr</td>
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<tr>
<td>Roll Rate</td>
<td>190 deg/sec</td>
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<tr>
<td>Pitch</td>
<td>5° (1st Roll); 10° (2nd Roll)</td>
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<tr>
<td>Impact Angle</td>
<td>145°</td>
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<tr>
<td>Drop Height</td>
<td>10 centimeters</td>
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<tr>
<td>Yaw</td>
<td>10°</td>
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</tbody>
</table>
Variations in Vehicle Shape and Roof Strength

2007 Honda CRV
SWR 2.4

2008 Scion XB
SWR 6.8
Residual Roof Crush after Two Dynamic Rolls

2007 Honda CRV
SWR 2.4

2007 Scion XB
SWR 6.8
New Vehicle vs. Residual Crush After 2 Rolls

2007 Camry Hybrid
Vehicle tested had strengthened header

No Side Window Breakage

C-pillar Deformation
Rear Window Breakage
Tests of Laminated Glass Side Windows

New 2008 Chevy Malibu with Laminated Glass

Glass Remained Intact
Observations – Dynamic Testing

• Vehicle shape can influence test results – static vs. dynamic tests
• Hybrid vehicles may load the roof differently from conventional vehicles
• Laminated glass may provide ejection benefits even after severe roof distortion
Conclusions

• Number of vehicle inversions is a good measure of rollover severity for belted occupants
• 60% of MAIS 3+F belted in rollovers without pre-roll impacts involve 2+ vehicle inversions
• Dynamic testing provides added insights into vehicle performance in rollover
• JRS provides a repeatable test that permits exposing vehicles to 2 inversions
  – Loads both sides of the roof
  – Allows a wide range of initial conditions
  – Encourages designs that resist the forces of real world rollovers
Reports on present and future rollover research may be found on website: autosafetyrsearch.com/reports
Click on: rollover and/or farside

Questions?