Rollover Crashworthiness Research

National Highway Traffic Safety Administration
Problem Definition

- Average 9,123 rollover involved fatalities (FARS 95-99)
- Average 47,891 incapacitating injuries (NASS GES 92-96)
- 52% of 1999 rollover involved fatalities were ejected, partially or completely (FARS 1999)
- 39,000 to 50,000 annual non-ejected, rollover involved injuries (NASS GES 92-96)
  - 87% of which receive AIS 1 injuries
Rollover Crashworthiness Research

• Ejection Mitigation
  – Dynamic Head Protection Systems
  – Advanced Glazing
  – Door Latch

• Occupant Compartment Integrity
  – FMVSS 216 Roof Crush

• Mitigating Occupant Impacts
  – FMVSS 201 Upper Interior
  – Improved Restraints
# Ejection Fatalities

**Ejection Status for Occupant Fatalities in Light Passenger Vehicles in 1999 FARS**

<table>
<thead>
<tr>
<th>Event</th>
<th>Fatalities</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not ejected</td>
<td>23,113</td>
<td>72%</td>
</tr>
<tr>
<td>Completely ejected</td>
<td>7,144</td>
<td>22%</td>
</tr>
<tr>
<td>Partially ejected</td>
<td>1,719</td>
<td>5%</td>
</tr>
<tr>
<td>Unknown whether ejected</td>
<td>115</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32,091</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*NASS indicates twice as many partial ejections – 10%*
Rollover Ejection Fatalities

- Average of 419,813 light vehicles involved in rollover crashes, NASS 1995-1999
  - 9,123 NASS annual rollover fatalities (95-99)
    - 10,142 FARS rollover fatalities in 1999
      - 4,772 (of 9,123) NASS fatalities involved complete or partial ejection through glazing (52%, includes all windows and sunroofs)
### Ejection Route for Occupants Ejected from Light Passenger Vehicles,
Annual Average for 1995-1999 (NASS), Adjusted to 1999 FARS

<table>
<thead>
<tr>
<th>Route</th>
<th>Complete Ejection</th>
<th>Partial Ejection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Estimate</td>
</tr>
<tr>
<td>Windshield</td>
<td>67</td>
<td>2,465</td>
</tr>
<tr>
<td>Front Windows</td>
<td>420</td>
<td>9,684</td>
</tr>
<tr>
<td>Back Windows</td>
<td>75</td>
<td>2,243</td>
</tr>
<tr>
<td>Backlight</td>
<td>103</td>
<td>2,880</td>
</tr>
<tr>
<td>Roof Window</td>
<td>28</td>
<td>1,116</td>
</tr>
<tr>
<td>Other Glazing</td>
<td>7</td>
<td>122</td>
</tr>
<tr>
<td>Unknown Glazing</td>
<td>3</td>
<td>distributed</td>
</tr>
<tr>
<td>Not Glazing</td>
<td>488</td>
<td>13,992</td>
</tr>
<tr>
<td>Unknown Route</td>
<td>336</td>
<td>distributed</td>
</tr>
<tr>
<td>Subtotal-Glazing</td>
<td>703</td>
<td>18,508</td>
</tr>
<tr>
<td>Totals</td>
<td>1,527</td>
<td>32,501</td>
</tr>
</tbody>
</table>
Rollover and Ejection Mitigation

• Ejection accounts for over half of rollover fatalities

• A 1995 NHTSA matched pair analysis reported that preventing ejection in rollover crashes can sharply reduce the fatality rates
  – Estimating the Injury Reducing Benefits of Ejection Mitigation Glazing by Dr. John Winnicki
Full vehicle Rollover Testing of Side air bags

• Performed 5 FMVSS 208 dolly rollover tests
  – 1997 Ford Explorer
  – Prototype side curtain systems in front outboard positions
    • All tests showed significant potential for mitigating ejections
    • Established baseline kinematics for occupant interaction with side head air bags
    • Prototype systems provided by Simula ASD and TRW
208 Dolly Test
Dynamic Rollover Fixture

• A laboratory test method to reproduce an occupant ejection environment
  – Evaluate ejection countermeasures
    • Particularly to compare effectiveness of advanced glazing and inflatable devices
  – Evaluate potential occupant safety issues
  – Intended as a research tool
Dynamic Rollover Fixture

Capable of 0.5 to 1.5 revolutions per second

Accelerated controlled by adjustable weight stack

Currently using a C/K 1500 test buck.

Testing using 50th and 5th percentile dummies
Dynamic Rollover Fixture
Current Status

• Preliminary testing of side head air bag systems underway
  – Cooperative research agreements with Simula ASD, and TRW Automotive. Exploring others

• Preliminary testing of side glazing systems
  – Tempered, laminated glass, and polycarbonate side windows

• Restraints testing to resume in Fall / Winter
Glazing Research

- Started in late 1980’s
- Focused on ejection mitigation
  - Developed retention impact test
  - Lateral sled tests
  - FMVSS 201 impact testing
- Evaluated a wide range of glazing materials
- Status reports published in 1995 and 1999
Occupant Retention Testing

- Used 18 kg guided impactor to simulate load of an occupant’s head and neck
- Struck the window center and upper corner adjacent to the dummy’s head
- Evaluating maximum displacement and penetration of window glazing
- Impact speed 20 - 24 kmph
Retention Test Device
Impact Locations

Impact Points

T-Channel Constraint

Vehicle Belt Line
Results

• All of the tested materials could retain an impactor at 24 kmph
• The containment extent could be controlled based on the type and severity of modifications to the window / door system
• The center impacts were a more severe retention test than the corner impacts
Glazing Research Status

• Report to Congress to be released soon
• Final status report to follow this summer
  – Provides supporting data for the Report to Congress
• Research underway to test retention impactor on side head airbags
• The glazing ejection research is being merged with the side air bag work into a general ejection mitigation research program
  – Evaluation of motorcoach windows, laceration, entrapment, and harmonization issues will continue as required
Door Latch Research

• Develop test methods for sliding doors
  – Baseline tests conducted with Transport Canada
  – Evaluation criteria

• Investigate alternative test methods for FMVSS 206
  – Full door Lateral
  – Full door longitudinal
  – Bypass
Sliding Door Test
Transport Canada
Sliding Door Test
Door Latch Research Status

- Preliminary sliding door test developed
  - Need to formalize the test method and measurements
- Full door longitudinal, lateral and bypass test methods developed and evaluated
  - Some test procedures need to be clarified
  - Complexity of correlating benefits of component test method
Roof Crush Research

• Evaluation of testing alternatives for FMVSS 216
• Primary objective was to determine similarities and differences in quasi-static and dynamic roof crush testing
Roof Crush Status

• Preference for a static test due to repeatability of test procedures
  – Some correlation possible between static and dynamic test results

• Complexity of correlating benefits of test methods
  – Analysis of post crash head room and occupant injury is underway