Status of NHTSA’s Ejection Mitigation Research

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Ejection Mitigation
Problem Definition

• **52,897 Annual Ejections (1995-2003)**
  – 1% of all crash-involved occupants

• **10,210 Annual Ejected Fatalities**
  – 32% of all fatalities
  – 6,124 through side windows

• **10,177 Annual Rollover Fatalities**
  – 3,703 ejected through side windows
Ejection Mitigation
Research Program Goals

• **Demonstrate Countermeasure Feasibility**
  – Evaluate ejection mitigation capability of prototype and current production systems
  – Evaluate injury-causing potential

• **Develop Occupant Retention Test**
  – Full-scale rollover tests not repeatable

• **Develop Rollover Sensor Performance Test**
Ejection Mitigation
Guided Impactor

- **18 kg Mass**
- **Featureless Headform**
  - Average of front & side of head geometries
  - More uniform shape
- **Measures Displacement**
- **Positioned Inside Vehicle**
- **Impact a Variety of Locations**
Ejection Mitigation Systems Evaluated

- **Inflatable Systems**
  - Production Window Curtains
    - 2003 Lincoln Navigator
    - 2004 Volvo XC90
  - Advanced Head Protection Curtain (AHPC)
    - Zodiac Automotive US

- **Inflatable/Laminated Glazing Combination**
  - 2003 Lincoln Navigator (front only)
  - 2004 Volvo XC90
Ejection Mitigation
Pre-Broken Glazing
Ejection Mitigation
Front Side Window Impact Locations
<table>
<thead>
<tr>
<th>Impactor Deflection Beyond Window Plane (mm)</th>
<th>Impact Location on Side Window Area</th>
<th>16 km/h 6 sec</th>
<th>20 km/h 1.5 sec</th>
<th>24 km/h 1.5 sec</th>
<th>16 km/h 6 sec</th>
<th>20 km/h 1.5 sec</th>
<th>24 km/h 1.5 sec</th>
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<th>24 km/h 1.5 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lincoln Navigator (Open Window)</td>
<td>243*</td>
<td>74</td>
<td>186*</td>
<td>196*</td>
<td>211*</td>
<td>229*</td>
<td>-30</td>
<td>-37</td>
<td>-22</td>
<td></td>
</tr>
<tr>
<td>Lincoln Navigator With Side Laminate (pre-broken)</td>
<td>157</td>
<td>-14</td>
<td>6</td>
<td>35</td>
<td>137</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volvo XC90 (Open Window)</td>
<td>154 167</td>
<td>93</td>
<td>84</td>
<td>193*</td>
<td>78</td>
<td>131</td>
<td>130</td>
<td>-22</td>
<td>-3</td>
<td>18</td>
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<tr>
<td>Volvo XC90 With Side Laminate (pre-broken)</td>
<td>58 105 86</td>
<td>26</td>
<td>27</td>
<td>44</td>
<td>59</td>
<td>97</td>
<td>118</td>
<td></td>
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<tr>
<td>Zodiac AHPC (Open Window)</td>
<td>135 122 150 143</td>
<td>49</td>
<td>38</td>
<td>54</td>
<td>81</td>
<td>76</td>
<td>96</td>
<td>-0.2</td>
<td>-9</td>
<td>24</td>
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<tr>
<td>Zodiac AHPC With Side Laminate (pre-broken)</td>
<td>104</td>
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<td>70</td>
<td>97</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

* Impactor reached physical stops
Ejection Mitigation
Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Open Window

- Displacement (mm)
- Impact Position

1. 16 kmph/6 sec
2. 20 kmph/1.6 sec
3. 24 kmph/1.5 sec
Ejection Mitigation
Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Pre-Broken Side Laminate

Impact Position

Displacement (mm)

-50
-25
0
25
50
75
100
125
150
175
200
225
250

16 kmph/6 sec
20 kmph/1.6 sec
24 kmph/1.6 sec
Ejection Mitigation
Impactor Results – Front Window

Maximum Excursion Beyond Window Plane
Lincoln Navigator - Open Window

Displacement (mm)

Impact Position

1
2
3
4

16 kmph/6 sec
20 kmph/1.5 sec
24 kmph/1.5 sec
Maximum Excursion Beyond Window Plane
Zodiac AHPC - Pre-Broken Side Laminate

- Impact Position 1: NO TEST
- Impact Position 2: NO TEST
- Impact Position 3: 16 kmph/6 sec
- Impact Position 4: 20 kmph/1.5 sec, 24 kmph/1.5 sec
Ejection Mitigation
Rear Side Window Impact Locations
<table>
<thead>
<tr>
<th></th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>16 Kmph</td>
<td>20 Kmph</td>
<td>24 Kmph</td>
<td>16 Kmph</td>
<td>20 Kmph</td>
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<tr>
<td></td>
<td>6 sec</td>
<td>1.5 sec</td>
<td>1.5 sec</td>
<td>6 sec</td>
<td>1.5 sec</td>
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<td>Volvo XC90</td>
<td>189</td>
<td>183</td>
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<tr>
<td>Air Curtain</td>
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<tr>
<td>Volvo XC90</td>
<td>63</td>
<td>94</td>
<td>91</td>
<td>93</td>
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<tr>
<td>Air Curtain &amp;</td>
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<tr>
<td>Broken Glazing</td>
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<td></td>
</tr>
<tr>
<td>Lincoln Navigator</td>
<td>136</td>
<td>318*</td>
<td>318*</td>
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<td></td>
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<tr>
<td>(Open Window)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Zodiac AHPC</td>
<td>73</td>
<td>72</td>
<td>96</td>
<td>96</td>
<td>117</td>
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<td></td>
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</tr>
</tbody>
</table>

* Impactor reached physical stops
Ejection Mitigation
Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Lincoln Navigator - Open Window

- R1
- R2
- R3
- R4
- R5

Displacement (mm)

Impact Position

- 16 kmph/6 sec
- 20 kmph/1.6 sec
- 24 kmph/1.6 sec
Ejection Mitigation
Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Open Window

Displacement (mm)

Impact Position

R1 R2 R3 R4 R5

16 kmph/6 sec
20 kmph/1.6 sec
24 kmph/1.6 sec
Ejection Mitigation
Impactor Results – Rear Window

Maximum Excursion Beyond Window Plane
Volvo XC90 - Pre-Broken Side Laminate

Displacement (mm)

Impact Position

R1  R2  R3  R4  R5

16 kmph/6 sec
20 kmph/1.6 sec
24 kmph/1.6 sec
Ejection Mitigation
Ongoing Research

- Continue to Evaluate Current Production Systems
  - Those that offer protection in rollovers
- Develop or Adopt Method to Pre-Break Glazing
- Evaluate Possible Excursion Limit
- Develop Rollover Sensor Performance Test
THE END