Severity Measurements for Rollover Crashes

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(2) The National Highway Traffic Safety Administration
Application of Rollover Crash Severity

Needed for benefits analysis –
  – Injuries in real-world crashes vs. test condition

Test may depend on countermeasure
  – Ejection prevention
  – Intrusion control (Roof strength)
  – Safety belt design
Requirements for a Crash Severity Metric

• Measurable from post-crash data
• Related to crash energy
• Injury rate increases with metric
Data Sources

• NASS/CDS 1995 -2001
• 5,227 Front Seat Occupants Age 12+
• 1,309 MAIS 3+ F Injuries
• Expanded to 125,768 MAIS 3+F Injuries
### Rollover Injuries by Belt Use and Ejection

<table>
<thead>
<tr>
<th>MAIS 3+F</th>
<th>No-Eject</th>
<th>Total Eject</th>
<th>Part-Eject</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belted</td>
<td>35.0%</td>
<td>0.4%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Unbelted</td>
<td>22.8%</td>
<td>32.1%</td>
<td>4.9%</td>
</tr>
</tbody>
</table>
Three Populations with Most MAIS 3+F Injuries

- Belted – Not Ejected – 35.3%
- Unbelted – Ejected – 32.5%
- Unbelted – Not Ejected – 22.8%

- Investigate Each Population Separately
Belted Not Ejected

Examine Single Vehicle vs. Multi-Vehicle Crashes
Exposure and Injuries of Belted Occupants
Single and Multiple Crash Events

<table>
<thead>
<tr>
<th>Belted</th>
<th>Single</th>
<th>Multi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>81%</td>
<td>19%</td>
</tr>
<tr>
<td>MAIS 3+ F</td>
<td>68%</td>
<td>32%</td>
</tr>
<tr>
<td>MAIS 3+F/100</td>
<td>2.8</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Multi-vehicle Crashes Involve Higher Risks
DELTA-V needs to be included in the crash severity metric
Belted Not Ejected

Examine Separately:
(1) Single Vehicle
(2) Multi-Impact Crashes
(Planar Impacts prior to Rollover)
Belted – Non Ejected Single Vehicle Front Seat Occupants 12+ and MAIS 3+ Injuries by Nr Quarter Turns

Exposure

Injury Rate

2nd roof impact increases injury rate
Belted – Not Ejected Occupants
Single Vehicle
Weighted Data NASS 1995-2001

Number of roof impacts is a good severity measure for belted occupants
(Not-ejected in Single-vehicle Crashes)

- 48% MAIS 3+F in rollovers with more than 1 roof impact
Belted Not Ejected Occupants

Examine Separately:
(1) Single Vehicle
(2) Multi-Impact Crashes
(Planar Impacts prior to Rollover)
Rollovers in Multi-impact Crashes—Belted Occupants

- NASS records estimated delta-V for planar crashes
- Combine measured and estimated delta-V
- Measured and estimated delta-V combination:
  - Low - <24 Kph
  - Med - >24 and <55 Kph
  - Hi - >55 Kph
- Compare delta-V levels by number of roof impacts
  - MAIS 3+F Injuries
  - Injury Risk
Crash Severity of Multi-impact Rollovers – Belted Occupants

Exposure %

Nr. Roof Impacts

Exposed %

Damage Extent

Low
Mid
Hi

Nr. Roof Impacts

0%
5%
10%
15%
20%
25%
30%

2+
1
0
MAIS 3+F in Multi-impact Rollovers – Belted Occupants
Injury Rates in Multi-impact Rollovers – Belted Occupants

General increase in risk with damage extent and roof impacts
Unbelted with and without Ejection

Examine Separately:
(1) Single Vehicle
(2) Multi-Impact Crashes
(Planar Impacts prior to Rollover)
## Exposure and Injuries of Unbelted Occupants Single and Multiple Crash Events

<table>
<thead>
<tr>
<th>Unbelted</th>
<th>Single</th>
<th>Multi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposed</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>MAIS 3+ F</td>
<td>78%</td>
<td>22%</td>
</tr>
<tr>
<td>MAIS 3+F/100</td>
<td>15.1</td>
<td>18.5</td>
</tr>
</tbody>
</table>

Multi-vehicle Crashes Involve Slightly Higher Risks
DELTA-V may be included in the crash severity metric (primarily for High Severity Planar Crashes)
Unbelted Occupants with Ejection

Single Vehicle Rollovers
Unbelted – Ejected Single Vehicle

- 44% of Ejected Occupants involve 2+ roof contacts
- Number of roof impacts is a good severity measure.
Conclusions - Unbelted Ejected Occupants

- Unbelted ejections account for 32.5% of all MAIS 3+F Injuries in rollovers.
- Nr. of Roof Contacts is a good severity measure for Unbelted-ejected occupants.
- The relationship between number of roof contacts and injury risk was found to be statistically significant.
- The relationship between the number of wheel contacts and injury risk was not found to be statistically significant.
Conclusions- Belted-not ejected Occupants

• Belted not-ejected occupants account for 35.3% of MAIS 3+F injuries in rollovers.
• For belted occupants, 68% of the MAIS 3+F injuries are in single vehicle rollovers and 7.3% involve partial ejections.
• For not-ejected belted occupants in single vehicle collisions, the number of roof impacts is a good severity measure.
Conclusions- Belted-not ejected Occupants in Multi-impact Rollovers

• For pre-roll multi-vehicle collisions the injury severity metric needs to combine pre-rollover extent of damage + rollover severity measure (Nr of roof contacts)

• For pre-roll fixed object collisions the injury severity metric needs to combine pre-rollover extent of damage + rollover severity measure (Nr of roof contacts)
The End

Questions?