The Injury Risk from Objects Impacted Before and During Rollovers

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Requirements for a Crash Severity Metric

- Measurable from post-crash data
- Related to crash energy
- Injury rate relating to metric
Initial Data Sources

- NASS/CDS
- Years: 1995 – 2004
- Vehicle Classes (all available model years)
  - Passenger Cars
  - SUVs
  - Minivans
  - Pickups
  - Belted Front Seat Occupants
  - Age 12+ Years Old
Definition of Vehicle Inversion

• Frequency that the vehicle roof faces the ground (May or may not actually impact)

• Vehicle Inversions to quarter turns
  - 0 vehicle inversions = 1 quarter turn
  - 1 vehicle inversion = 2, 3, 4, or 5 quarter turns
  - 2 vehicle inversions = 6, 7, 8, or 9 quarter turns
  - 3+ vehicle inversions = 10+ quarter turns
For Belted, Not-Ejected Front Seat Occupants

Examine

Single Vehicle Rollovers
(with no Planar Impacts prior to Rollover)
Belted – Non Ejected Single Vehicle
Front Seat Occupants 12+ and MAIS 3+ Injuries by Nr Quarter Turns - Cumulative Percentage based on Weighted Data

Exposure

MAIS 3+F

2nd vehicle inversion increases injury rate
Belted - Not Ejected Occupants Single Vehicle based on Weighted Data

48% MAIS 3+F in rollovers with more than 1 vehicle inversion

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

The number of vehicle inversions is a good severity metric for grouping quarter-turns

Applicable to belted occupants in single vehicle rollovers without planar impacts
The Challenges of Multi-impact Rollovers

• How do you group multi-impact rollovers?
  o Multi-vehicle crashes; impacts with fixed objects

• Which multi-impacts have higher risks?
  o Not all planar impacts contribute to the injuries
NASS/ CDS Classification by Planar Crash Severity & Roll Type

- Planar crash severity – extent of damage & delta-v
  - Minor
  - Moderate
  - Severe

- Classification of rollover type by:
  - Rollover only
  - Rollover followed by impact
  - Non-fixed object impact prior to rollover
  - Fixed object impact prior to rollover
Research Question

How to combine

- 3 categories of damage,
- 4 categories of impact types

With

- 3 categories of vehicle inversions

Result:

- Combine fixed & non-fixed object impacts
- Combine all other single vehicle rollovers
- Combine moderate and severe damage
Research Approach

• Look at:
  o Distribution of MAIS 3+F injured
  o Rate of MAIS 3+ injured per 100 exposed to the same crash type and severity
  o Examine belted front seat adults
## Injuries by Rollover Type and Damage Extent

<table>
<thead>
<tr>
<th>Planar Damage Extent</th>
<th>Distribution of MAIS 3+ (%)</th>
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<tr>
<td></td>
<td>Roll 1st</td>
<td>Obj 1st</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Minor &amp; Moderate</td>
<td>28.2%</td>
<td>38.7%</td>
<td>66.8%</td>
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<tr>
<td>Severe</td>
<td>10.9%</td>
<td>22.3%</td>
<td>33.2%</td>
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<tr>
<td>Total</td>
<td>39.1%</td>
<td>60.9%</td>
<td>100.0%</td>
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<table>
<thead>
<tr>
<th>Planar Damage Extent</th>
<th>Injury Rate per 100 Exposed</th>
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<tbody>
<tr>
<td></td>
<td>Roll 1st</td>
<td>Obj 1st</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Minor &amp; Moderate</td>
<td>2.34</td>
<td>2.88</td>
<td>2.63</td>
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<tr>
<td>Severe</td>
<td>3.39</td>
<td>10.26</td>
<td>6.16</td>
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<tr>
<td>Total</td>
<td>2.56</td>
<td>3.91</td>
<td>3.24</td>
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</tbody>
</table>

**Obj 1st**—Impact with fixed or non-fixed object prior to roll

\[13\]

*Higher Injury Rate*
Observations

• Crashes with severe planar damage have much higher injury rates than all other rollovers (22.3%).
• These crashes should be separated from the others when considering the injury risk associated with the rollover.
Statistical Significance of Metrics

For the remaining rollovers (77.7%) the relationship between the number of vehicle inversions and the presence of MAIS 3+ injuries produced a p value of .022.

Injury rate related to vehicle inversions
Conclusions
Disaggregation of Rollovers for Severity

(1) Rollovers preceded by impacts with fixed and non-fixed objects and with severe vehicle damage (22.3% of MAIS 3+);
(2) All other rollovers, separated by 0, 1, and 2+ vehicle inversions (77.7% of MAIS 3+)
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The End