Opportunities for Reducing Casualties in Far-side Crashes

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Participants in Far-side Research

- Australian Research Board
- Ford
- GM Holden
- Autoliv
- Australian Ministry of Transport
- Monash University
- GW University
- Va Tech
- Wake Forest
- Medical College of Wisc
- Miami School of Medicine
- Wayne State U
- Consultants & Students

US, Australia, Sweden
Data Sources

NASS/CDS 1993-2002

Front seat occupants, Age 12 and older

Restricted by:

- Far-side, Belted, Not Ejected, No Rollover
Crash Mode Definitions

Nearside

Farside
Crash Mode Definitions

Farside

Nearside
Summary of Accident Data Far-side Belted Front Seat Occupants

The following data is for belted occupants in far-side crashes, based on NASS/CDS 1993-2002

Data Set

NASS/CDS 1993-2002
All Model Years
Passenger Cars or LTVs Only
GAD = Left or Right Side
No Rollovers
Occupant on Opposite Side of Impact
3-Point Belt Restrained Occupants
## Far Side Cases:

### NASS 1992-2002

<table>
<thead>
<tr>
<th></th>
<th>Weighted</th>
<th>Unweighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupants</td>
<td>2,386,633</td>
<td>4,518</td>
</tr>
<tr>
<td>MAIS 3+ Occupants</td>
<td>21,982</td>
<td>281</td>
</tr>
<tr>
<td>Fatalities</td>
<td>5,175</td>
<td>80</td>
</tr>
<tr>
<td>Harm</td>
<td>20,492</td>
<td></td>
</tr>
<tr>
<td>(fatality normalized)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Near vs. Far Side
3 Pt Belted Occupants Only
NASS/CDS 1997-2002 (MY1997+)

Near Side: 52% Side Struck Occupants, 61% AIS 3+ Injured Persons, 68% Harm
Far Side: 48% Side Struck Occupants, 39% AIS 3+ Injured Persons, 32% Harm
Far-side Injuries & HARM by Body Region

- **Trunk**
- **Head**
- **UX**
- **LX**
- **Spine**
- **Other**

**Percent of Injuries or HARM**

Graph showing the percentage of injuries or harm by body region, with body regions including Trunk, Head, UX, LX, Spine, and Other.
Far-Side Injuries by Occupant Seating Location

- Driver:
  - Exposed Occupants: 74%
  - MAIS3+ Occupants: 73%
  - Harm: 76%

- RF Passenger:
  - Exposed Occupants: 19%
  - MAIS3+ Occupants: 25%
  - Harm: 20%

- Rear Passenger:
  - Exposed Occupants: 7%
  - MAIS3+ Occupants: 2%
  - Harm: 3%
Far-Side Injuries by Occupant Seating Location

- Head: 30% (AIS3+ - Driver), 21% (AIS3+ - RF Pass)
- Chest: 29% (AIS3+ - Driver), 46% (AIS3+ - RF Pass)
- Lo.Extr.: 15% (AIS3+ - Driver), 6% (AIS3+ - RF Pass)
- Up.Extr.: 15% (AIS3+ - Driver), 8% (AIS3+ - RF Pass)
- Face: 5% (AIS3+ - Driver), 1% (AIS3+ - RF Pass)
- Abdomen: 15% (AIS3+ - Driver), 3% (AIS3+ - RF Pass)
- Spine: 3% (AIS3+ - Driver, 2% (AIS3+ - RF Pass)
- Other: 0% (AIS3+ - Driver), 0% (AIS3+ - RF Pass)

AIS3+ - Driver (blue), AIS3+ - RF Pass (yellow)
Far-Side Injuries by Collision Partner

- Exposed Occupants
- MAIS3+ Occupants
- Fatalities
- Harm

<table>
<thead>
<tr>
<th>Collision Partner</th>
<th>Exposed Occupants</th>
<th>MAIS3+ Occupants</th>
<th>Fatalities</th>
<th>Harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>53%</td>
<td>40%</td>
<td>37%</td>
<td>31%</td>
</tr>
<tr>
<td>LTV</td>
<td>40%</td>
<td>35%</td>
<td>35%</td>
<td>27%</td>
</tr>
<tr>
<td>Fixed Obj</td>
<td>16%</td>
<td>17%</td>
<td>19%</td>
<td>18%</td>
</tr>
<tr>
<td>Other Veh</td>
<td>14%</td>
<td>3%</td>
<td>9%</td>
<td>1%</td>
</tr>
<tr>
<td>Other Obj</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

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Far-Side Injuries by Collision Partner

- **Head**: 12.9% (AIS3+ - Car), 9.6% (AIS3+ - LTV), 12.9% (AIS3+ - Fixed Obj)
- **Chest**: 10.1% (AIS3+ - Car), 10.1% (AIS3+ - LTV), 6.4% (AIS3+ - Fixed Obj)
- **Upper Extremity**: 6.4% (AIS3+ - Car), 3.0% (AIS3+ - LTV), 6.4% (AIS3+ - Fixed Obj)
- **Abdomen**: 4.8% (AIS3+ - Car), 1.6% (AIS3+ - LTV), 4.8% (AIS3+ - Fixed Obj)
- **Lower Extremity**: 4.4% (AIS3+ - Car), 3.4% (AIS3+ - LTV), 4.4% (AIS3+ - Fixed Obj)
- **Spine**: 1.3% (AIS3+ - Car), 1.3% (AIS3+ - LTV), 1.3% (AIS3+ - Fixed Obj)
- **Face**: 1.1% (AIS3+ - Car), 0.9% (AIS3+ - LTV), 1.1% (AIS3+ - Fixed Obj)
- **Other**: 0.0% (AIS3+ - Car), 0.0% (AIS3+ - LTV), 0.0% (AIS3+ - Fixed Obj)
Far-Side Injuries by Crash Direction (PDOF)

Number of Occupants
MAIS3+ Occupants
Harm

PDOF (Degrees)

7% 10% 16% 42% 60% 45% 24% 24% 29% 4% 6% 6% 3% 1% 1% 1% 0% 0%
0 30 60 90 120 150 180
Side Crash Damage Locations
Far-Side Injuries by Location of Impact (SHL)

<table>
<thead>
<tr>
<th>Location of Damage</th>
<th>Number of Occupants</th>
<th>MAIS3+ Occupants</th>
<th>Harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front 2/3 (Y)</td>
<td>28%</td>
<td>42%</td>
<td>39%</td>
</tr>
<tr>
<td>Front 1/3 (F)</td>
<td>14%</td>
<td>12%</td>
<td>18%</td>
</tr>
<tr>
<td>Rear 2/3 (Z)</td>
<td>18%</td>
<td>21%</td>
<td>20%</td>
</tr>
<tr>
<td>Center 1/3 (P)</td>
<td>10%</td>
<td>12%</td>
<td>12%</td>
</tr>
<tr>
<td>Distributed (D)</td>
<td>10%</td>
<td>11%</td>
<td>16%</td>
</tr>
<tr>
<td>Rear 1/3 (B)</td>
<td>0%</td>
<td>2%</td>
<td>9%</td>
</tr>
</tbody>
</table>
Far-Side Injuries by Total Delta-V

- **MAIS3+ Occupants**
  - Median Delta-V = 32 km/hr

- **Harm**
  - Median Delta-V = 24 km/hr

- **Exposed Occ**
  - Median Delta-V = 15 km/hr
Far-Side Injuries by Lateral Delta-V

Delta-V (km/hr)

Cumulative Frequency (%)

Number Occupants
MAIS3+ Occupants
Harm

MAIS3+ Median Delta-V = 28 km/hr
Harm Median Delta-V = 22 km/hr
Exposed Occ Median Delta-V = 12 km/hr
Measuring Damage Extent
Far-Side Injuries by Collision Deformation

CDC Extent of Damage

CDC 3.6 ~50% MAIS 3
-66% Harm

Number of Occupants
MAIS3+ Occupants
Harm

CDC Extent of Damage
Summary of Crash Factors

Crash Direction:
- 60% of MAIS 3+ occupants at 60 degrees
- 24% of MAIS 3+ occupants at 90 degrees

Body Region Injured:
- 40% of MAIS 3+ HARM is to the Trunk
- 40% of MAIS 3+ HARM is to the Head

CCD Extent of Damage – 3.6
Delta-V - 28 kph
Most Frequent Conditions for Far-side MAIS 3+ Injured Occupants

Drivers (75%)
Vehicle-to-vehicle Crashes (70%)
60° Crash (50+%); 90° Crash (25%)
Y Damage (40%); Z Damage (20%)

Collision Partner:
- Pass car - 40%; LTV-28%; Fixed Obj- 10%

Median Delta-V - 32 kph; Mean CDC - 3.6
Median Lateral Delta-V - 28 kph
Pre-test Occupant Modeling

Validate MADYMO human model against cadaver test already conducted

Compare MADYMO human and hybrid III models in far-side crashes

Evaluate the geometry of the cadaver test set-up and the applied crash pulse
Cadaver vs. Human MADYMO

Cadaver
Cadaver vs. Human MADYMO

Cadaver

SAE 2006 Gov/Ind

81 cm (32 in)

135 ms
Observations

MADYMO human model does reasonable job of predicting cadaver motion.

Cadaver retains the shoulder belt better than the model
MADYMO Human Model with 3.6 CDC Intrusion Displayed
Hybrid III Dummy vs Human Model

Sid 2S, Eurosid S impact dummies were no better
Dummy Measurement Challenges: Possible Far-side Countermeasures

Contacts:
- Shoulder
- Rib
- Pelvic

- Air Curtain
- Inboard Shoulder Belt
- Outboard Shoulder Belt

Countermeasures:
- Far Side Crash Pulse
- 5
- 4
- 3
- 2
- 1
- 0
New Injury Measures Needed

Corotid artery injury
Neck skeletal injury in side impact
T-12 injury
Lumbar spinal injury
The usual side impact injury measures
Conclusions

Crash configuration for 50% far-side MAIS 3+F belted occupants in planar crashes
- Delta-V - 28 kph
- Extent of Damage – 3.6 CDC
- Crash direction 60° (60%)

IIHS barrier at higher delta-V is best available test device

MADYMO human facet model is good evaluation device

Improved dummy needed
Conclusions

Target MAIS 3+F population for far-side belted planar crashes - 2,244

Target MAIS 3+F population for all far-side crashes - 17,194

Target MAIS 3+F population for all near-side planar crashes - 14,625
Conclusion

Far-side occupant protection offers large opportunities for injury and fatality reduction
Acknowledgement

The funding is provided in part by the Australian National Research Counsel with cost sharing and support from the other participants. Additional funding for this research has been provided by private parties, who have selected Dr. Kennerly Digges [and the FHWA/NHTSA National Crash Analysis Center at the George Washington University] to be an independent solicitor of and funder for research in motor vehicle safety, and to be one of the peer reviewers for the research projects and reports. Neither of the private parties have determined the allocation of funds or had any influence on the content.
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Questions?