Injuries to Restrained Occupants in Far-side Crashes

K. Digges
The Automotive Safety Research Institute
USA

D. Dalmotas
Department of Transport
Canada
Research Approach

• Identify injury distributions with NASS/CDS 1988-98 data

• Conduct crash tests to evaluate occupant motion in a vehicle-to-vehicle far-side crash mode
## Harm Distribution Front Occupants in Side Crashes

<table>
<thead>
<tr>
<th>Position</th>
<th>Frequency</th>
<th>Harm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near</td>
<td>66%</td>
<td>71.5%</td>
</tr>
<tr>
<td>Far</td>
<td>34%</td>
<td>28.5%</td>
</tr>
<tr>
<td>Ratio</td>
<td>1.9</td>
<td>2.5</td>
</tr>
</tbody>
</table>

NASS/CDS 1988-1997
NASS/CDS Data

Combined Years
1988-1998
# AIS 3+ Injuring Contacts - Far-side Crashes, NASS/CDS

<table>
<thead>
<tr>
<th>Injuring Contact</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far Side Interior</td>
<td>245</td>
</tr>
<tr>
<td>Safety Belt</td>
<td>75</td>
</tr>
<tr>
<td>Roof</td>
<td>57</td>
</tr>
</tbody>
</table>
### AIS 3+ Injuring Contacts - Far-side Crashes, NASS/CDS

<table>
<thead>
<tr>
<th>Injuring Contact</th>
<th>No</th>
<th>Unwgt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far Side Interior</td>
<td>245</td>
<td>32%</td>
</tr>
<tr>
<td>Safety Belt</td>
<td>75</td>
<td>10%</td>
</tr>
<tr>
<td>Roof</td>
<td>57</td>
<td>7%</td>
</tr>
</tbody>
</table>
### AIS 3+ Injuring Contacts - Far-side Crashes, NASS/CDS

<table>
<thead>
<tr>
<th>Injuring Contact</th>
<th>No</th>
<th>Unwgt</th>
<th>Wgt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far Side Interior</td>
<td>245</td>
<td>32%</td>
<td>27%</td>
</tr>
<tr>
<td>Safety Belt</td>
<td>75</td>
<td>10%</td>
<td>21%</td>
</tr>
<tr>
<td>Roof</td>
<td>57</td>
<td>7%</td>
<td>12%</td>
</tr>
</tbody>
</table>
## AIS 3+ Injuring Contacts - Far-side Crashes, NASS/CDS

<table>
<thead>
<tr>
<th>Injuring Contact</th>
<th>No</th>
<th>Unwgt</th>
<th>Wgt</th>
<th>Ave Wgt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far Side Interior</td>
<td>245</td>
<td>32%</td>
<td>27%</td>
<td>70</td>
</tr>
<tr>
<td>Safety Belt</td>
<td>75</td>
<td>10%</td>
<td>21%</td>
<td>178</td>
</tr>
<tr>
<td>Roof</td>
<td>57</td>
<td>7%</td>
<td>12%</td>
<td>137</td>
</tr>
</tbody>
</table>
Major Injuring Contacts

- Far Side Interior
- Seatbelt
## Most Frequent AIS 3+ Injury Combinations – Far Side Crashes

<table>
<thead>
<tr>
<th>Body Region</th>
<th>Contact</th>
<th>Weighted Percent</th>
<th>Crash Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk</td>
<td>Safety Belt</td>
<td>21%</td>
<td>Low</td>
</tr>
<tr>
<td>Trunk</td>
<td>Far Side Interior</td>
<td>12%</td>
<td>High</td>
</tr>
<tr>
<td>Head</td>
<td>Far Side Interior</td>
<td>11%</td>
<td>High</td>
</tr>
<tr>
<td>Head/Spine</td>
<td>Roof</td>
<td>13%</td>
<td>Mod</td>
</tr>
</tbody>
</table>
The Research Question

- What is causing the injuries?
  - Head to Opposite Side at Hi Severity
  - Trunk to Seat Belt at Low Severity

- Examine NHTSA Crash Test Data
  - One far side test at 90 degrees
Crash Test - Far-Side Dummy

Delta - V
18 kph

PDOF
9 O’clock (90 degrees)
Observations

• Shoulder belt ineffective in 90 degree opposite-side crashes

• Lap belt loading may be through soft tissue
Research Questions for Crash Testing

• How effective is the shoulder belt in side crashes other than 90 degrees?

• Do different belt latch rings make a difference?
Crash Configuration

Camera Locations

80 KPH
Far-side Crash Tests

• Side Impact – Chevrolet Caprice Bullet
  Chevrolet Pickup Target

• 80 kph, 60° Impact by Caprice

• No Occupant Compartment Intrusion
Crash Pulse

Time, sec.

Acceleration, G's

Ax
Ay
Belt Configurations Tested

- 1- Fixed Latch Ring – Dual Retractor
- 2- Low-Friction Latch Ring
- 3- Moderate Friction Latch Ring
Tested Belt Systems

Fixed

Low Friction
Tested Belt Systems

Intermediate Friction
Crash Test, Real Time
Far Side Crash Test

Fixed Latch Ring - Dual Retractors
Far Side Crash Test

Moderate Friction Latch Ring
Far Side Crash Test

Low Friction Latch Ring
Head Excursion – Comparative Results

Fixed Ring

Low Friction Ring

Moderate Friction Ring
Belt Loads – Far Side Crash

Shoulder Belt Force, N

Lap Belt Force, N

Time, ms.

Low Load

High Load
Illustrative Case---
Far Side Occupant Rear Seat) Liver Injury - Belt Induced
Scene Diagram

- PDOF - 2 o’clock
- Delta-V - 18.5 Kph (est)
- Restraints: Lap & Shoulder Belt
- Left Rear Passenger
- 12 year old female

Case 98-025AL
Vehicle Damage

- Female Back Left Passenger; 12 YO; 6’ Tall; 156 Lbs
- Veh. - ‘97 Lexus LS 400
- POV- ‘87 Toyota Tercel
- 2 o’clock, 18.5 Kph
- 195 mm Crush
Vehicle Belt Configuration

• Trauma Criteria:
  No Indicators of Injury!

• Restraint:
  Lap & Shoulder Belt

Case 98-025AL
Liver and Injuries

- **Belt Induced Injuries:**
  - AIS 5 - Liver
  - AIS 4 - Lungs
  - AIS 3 - Heart

- **Other Injuries:**
  - none

Case 98-025AL
Observations Liver Injury Case

- Impact at occupant compartment; low delta-V
- No injury significant injury to near side rear seat occupant
- Undetected liver injury to far-side rear occupant
- Shoulder belt is ineffective in this crash mode; Increased lap belt loading
Conclusions -
Belted Occupants in Far Side Crashes

• The most harmful contacts are:
  – Opposite side interior - 26.9%
  – Seatbelt - 20.8%
  – Roof - 12.2%

• The shoulder belt is ineffective in the far-side crashes tested to date.

• Restraint achieved by abdominal loading by lap belt.

• Different latch ring designs influence the extent of head excursion.

• Other countermeasures may be required.
Thank you!!

QUESTIONS?
MAIS 3+ Injury Distribution by Delta-V

Weighted Data

Delta-V Km/hr

Percent

Total dV

Lateral dV
Severity - Side Impact

Delta-V, Mph

Percent

Near Side

Far Side Restrained