

Sources of Injury Harm in Rollover Crashes

Kennerly Digges

The George Washington University

Presentation to SAE TOPTEC

April 23, 2001



*FHWA / NHTSA National Crash Analysis Center
The George Washington University Virginia Campus*

Overview

- Exposure of Light Vehicles to Rollover
- Belt Use Rates & Casualty Rates Cars & Light Trucks
- Injury Risks of Rollovers vs. Planar Crashes

Analysis Approach

- Data Source -NASS/CDS 1988 -1996
- - FARS 1975-1996
- Examine Ejections
- Examine Injury Sources and Injured Body Regions

Annual Exposure to Crashes

Vehicle Type	Nr. Crashes	% Rollovers
Pass Cars	3,438,670	8.7%
Lt. Trucks	961,330	25.7%
All	4,400,000	12.4%

Annual Exposure to Crashes

Vehicle Type	Nr. Crashes	% Rollovers	% in Roll Unbelted
Pass Cars	3,438,670	8.7%	46.6%
Lt. Trucks	961,330	25.7%	52.1%
All	4,400,000	12.4%	49.1%

Annual Casualties in Crashes (Seriously or Fatally Injured)

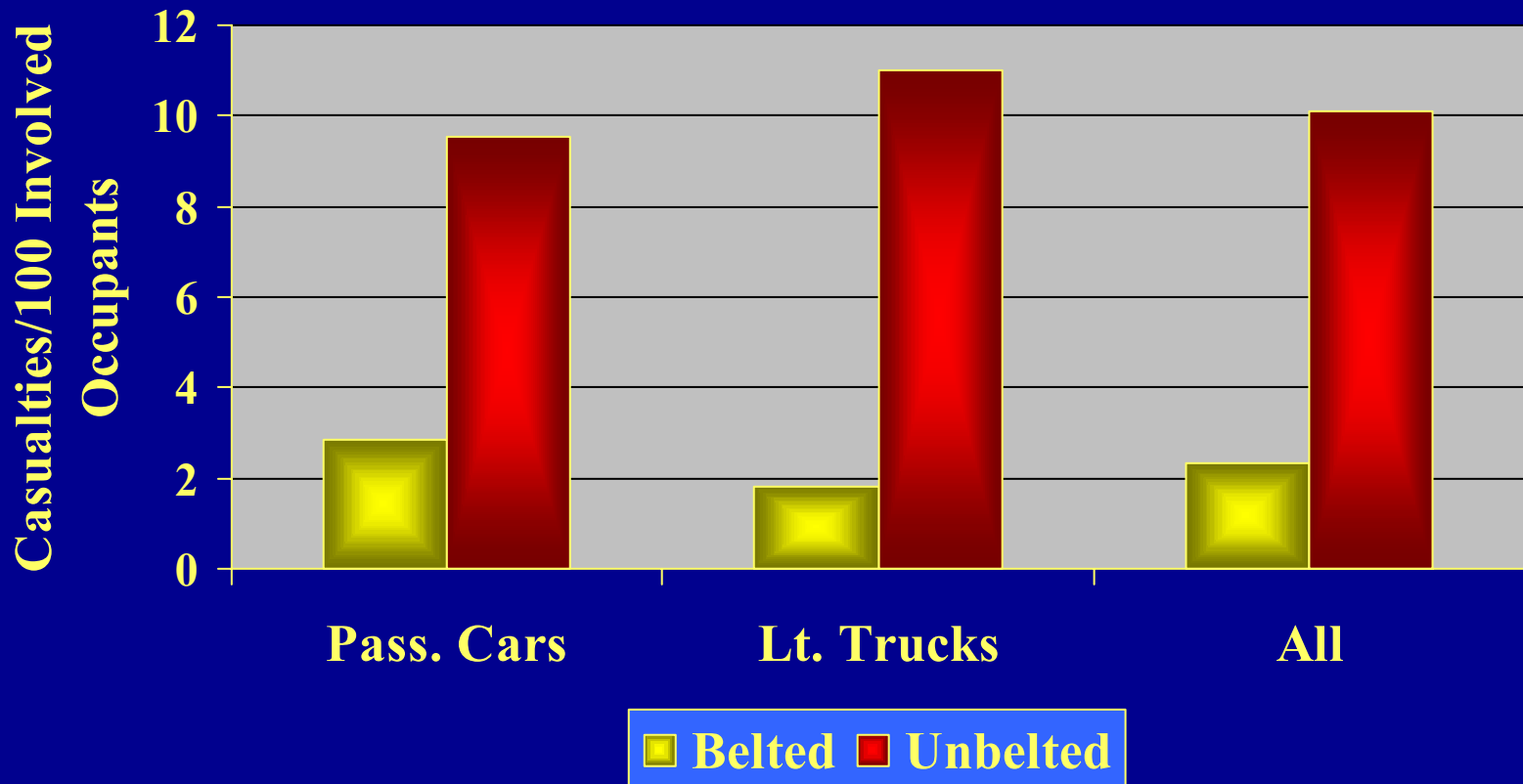
Vehicle Type	Nr. Casualties	% in Rollovers	% in Roll Unbelted
Pass Cars	129,550	18.7%	74.4%
Lt. Trucks	34,450	47.4%	86.9%
All	164,000	26.4%	80.4%

For Cars & Light Trucks

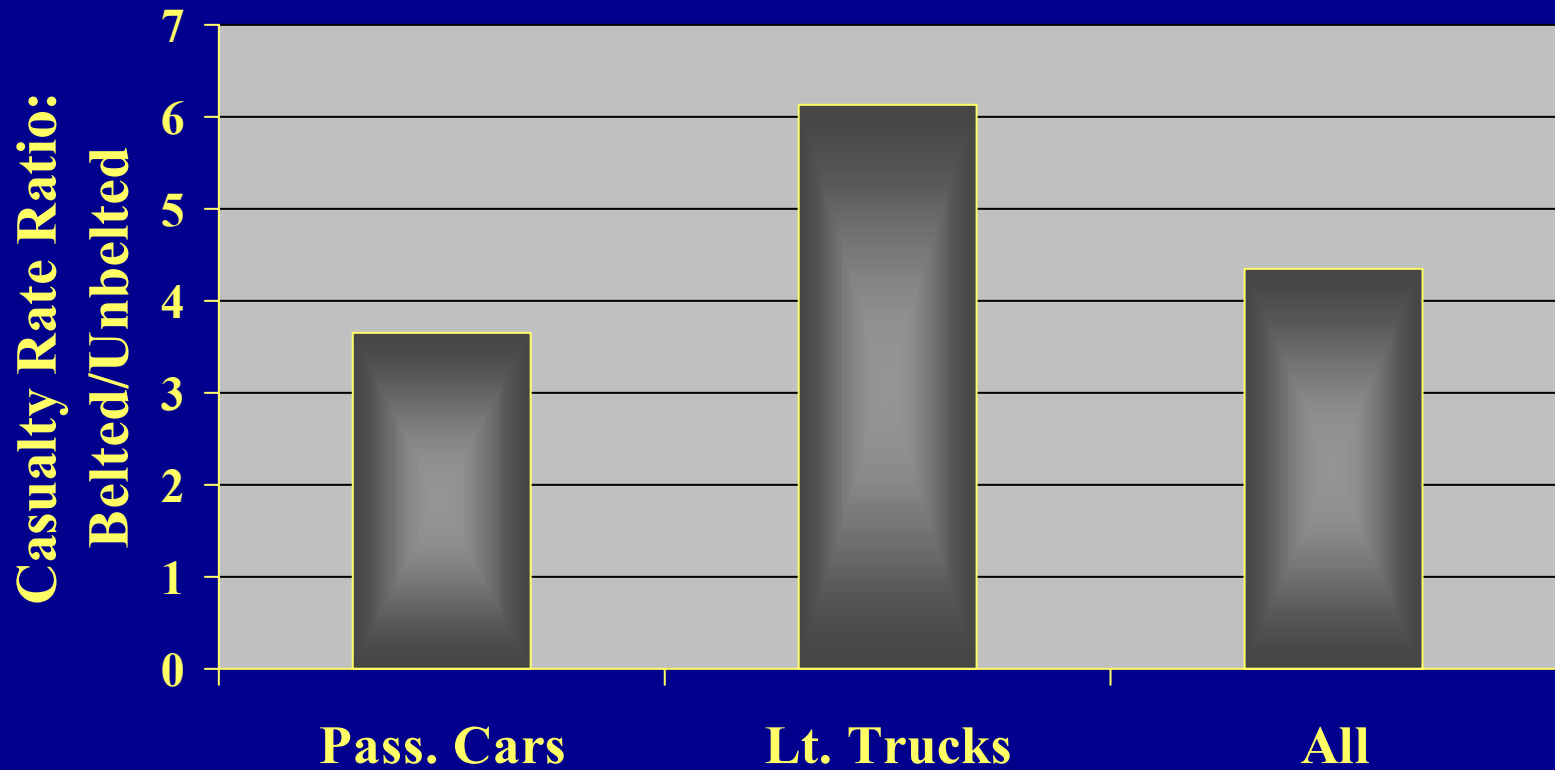
Compare Casualty Rates

- Belted vs. Unbelted in Rollovers
- Belted in Rollovers vs. Planar Crashes

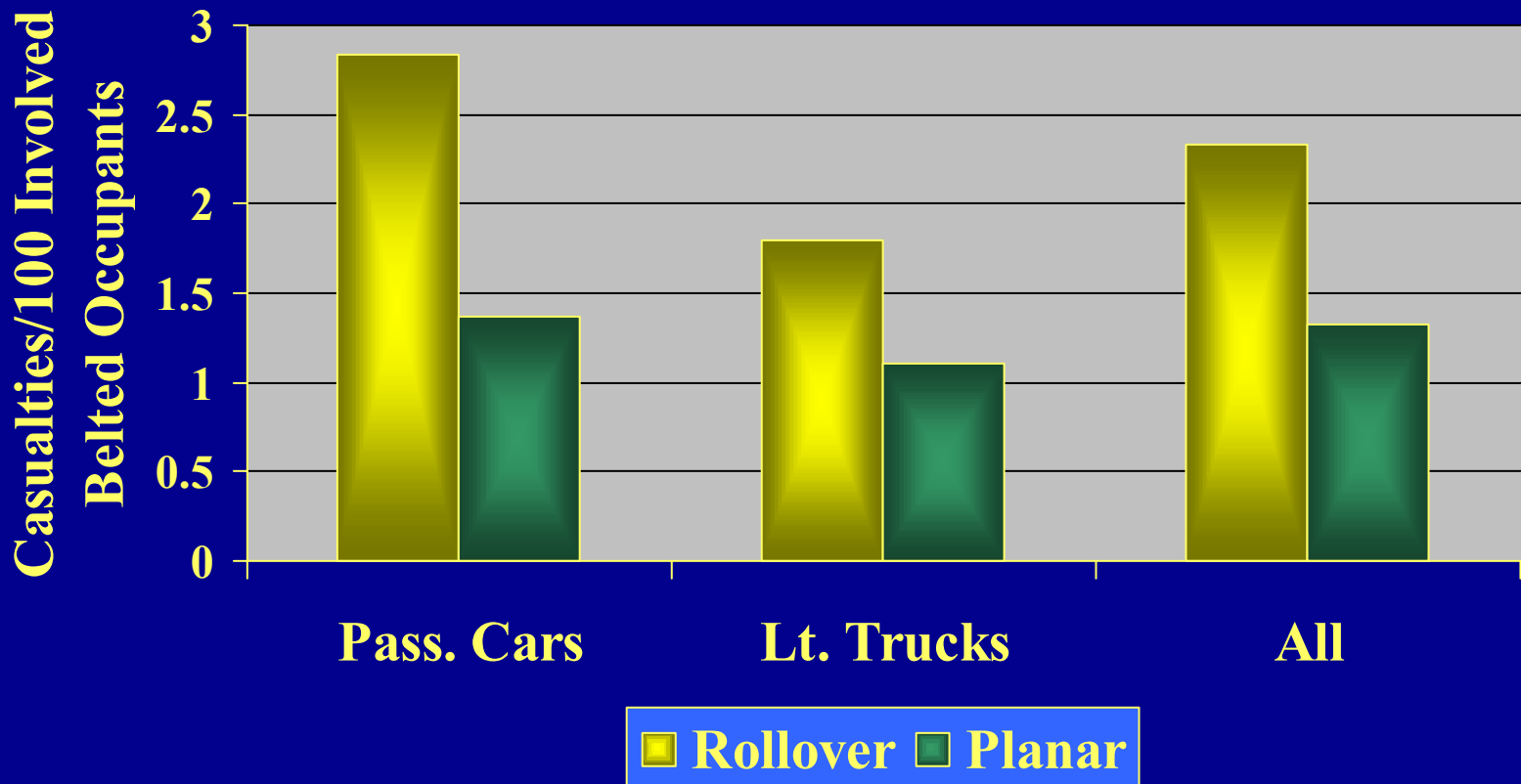
Rate of Casualties per 100 Occupants Involved in Rollovers Belted and Unbelted



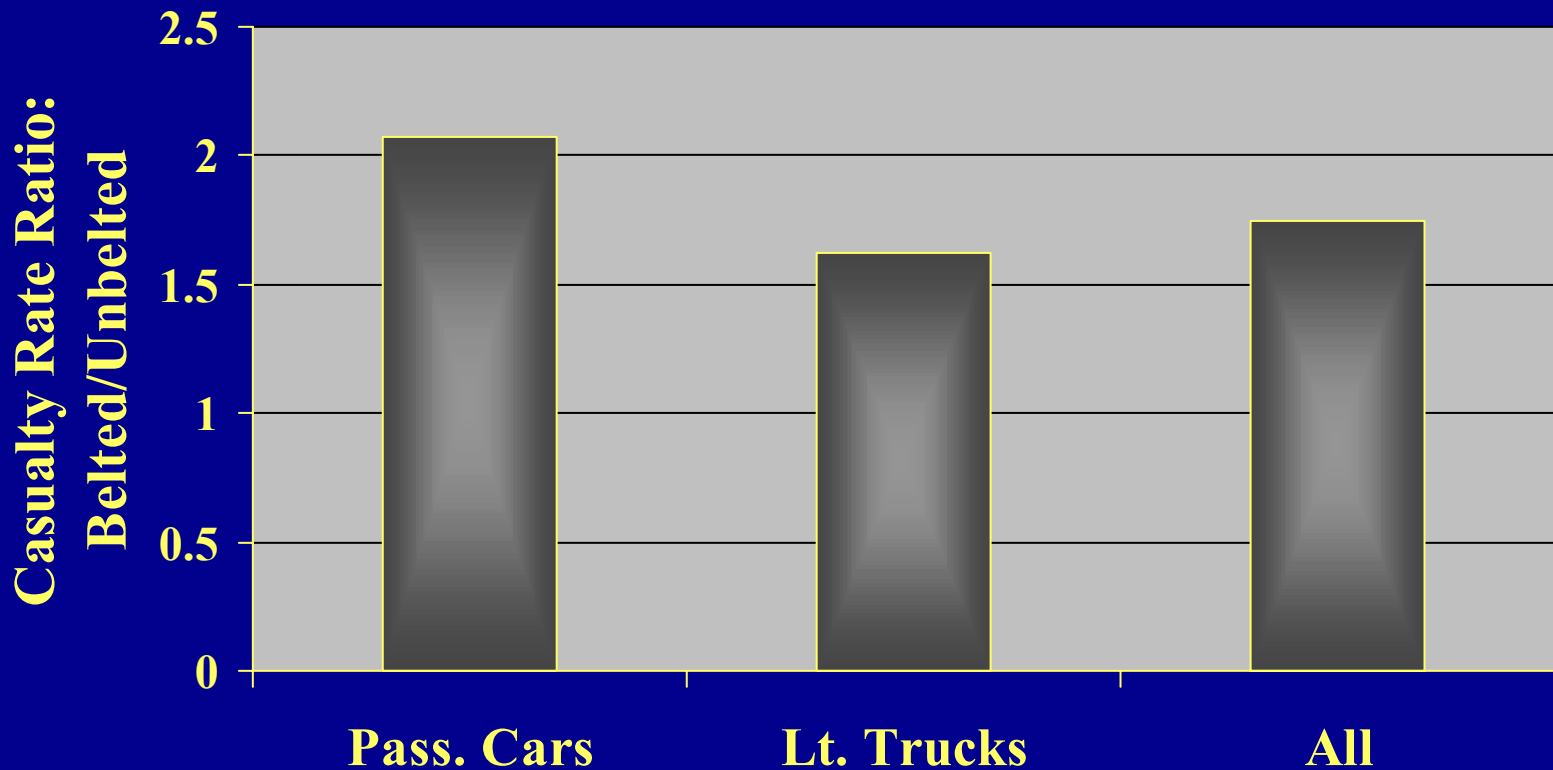
Rollover Casualty Rate Ratio: Belted/Unbelted



Casualties/100 (Belted) Occupants Involved in Rollover & Planar Crashes



Casualty Rate Ratio: Belted Occupants -Rollover/Planar



Observations

For Belted Occupants

- Rollover Injury Risk 1.75 Times Higher Than in Planar Crashes
- Rollover Injury Risk 4.3 Times Lower Than for Unrestrained

Opportunities for Injury Reduction

- Application of Harm Accounting for Injuries
- Ejection Paths in Rollovers
- Loss of Structural Integrity

Weighting Factors for Harm Scale

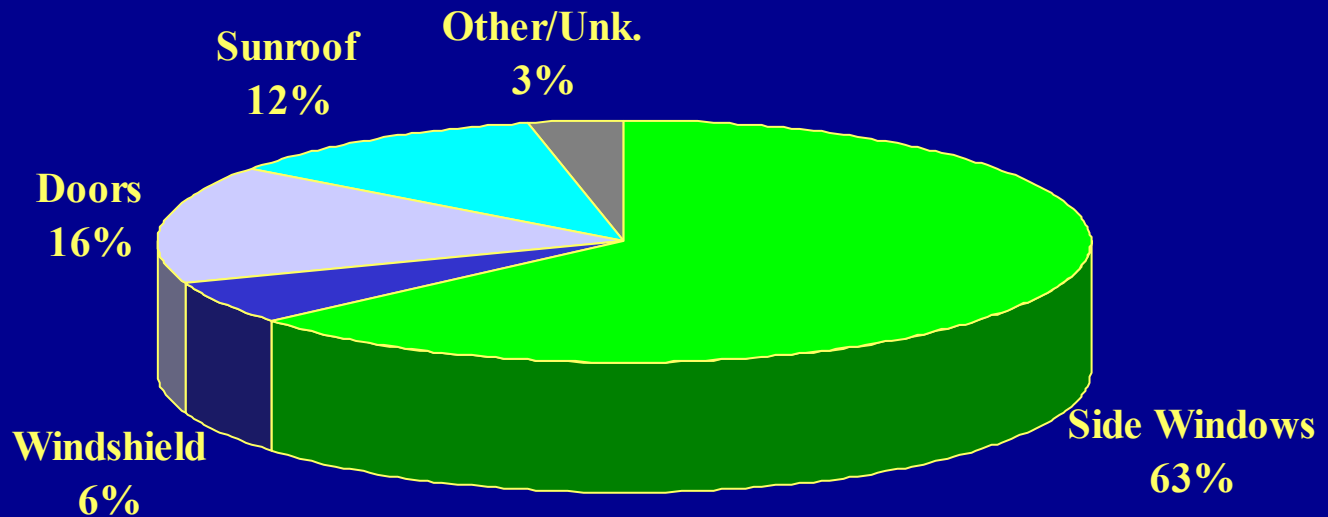
Injury	Factor
MAIS 1	0.006
MAIS 2	0.030
MAIS 3	0.121
MAIS 4	0.280
MAIS 5	0.564
Fatal	1.000

Distribution of Harm in Rollovers

- Unrestrained - 84%
- Restrained - 16%
- Ejection - 56%
- Restrained Ejection - 3%

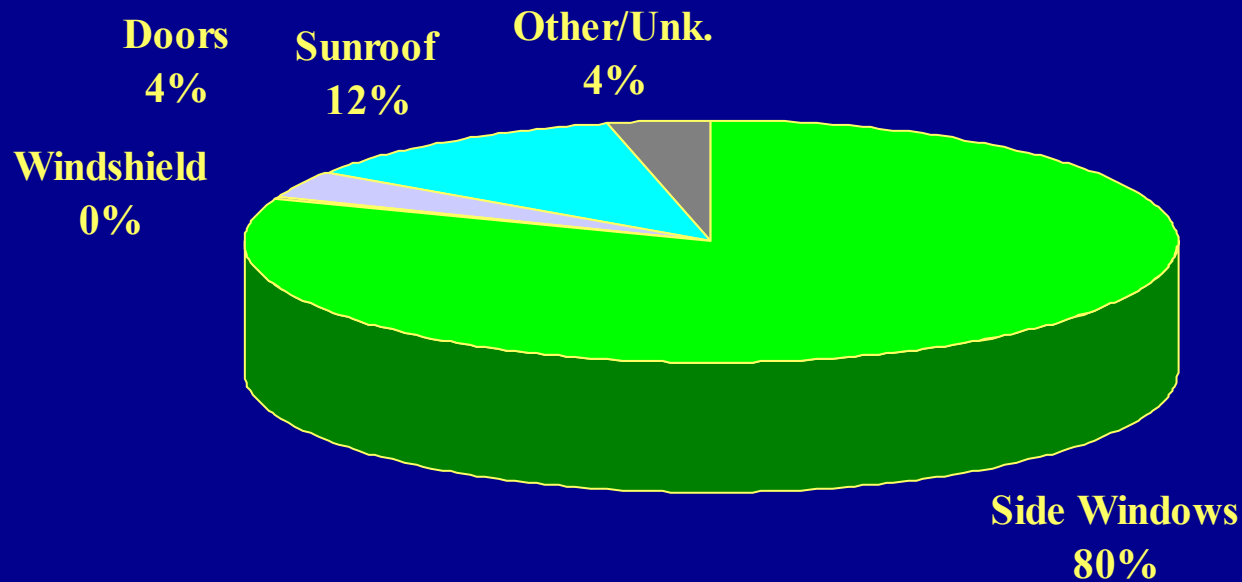
Examine Ejection Paths

Ejection Paths in Rollovers - Unrestrained Occupants



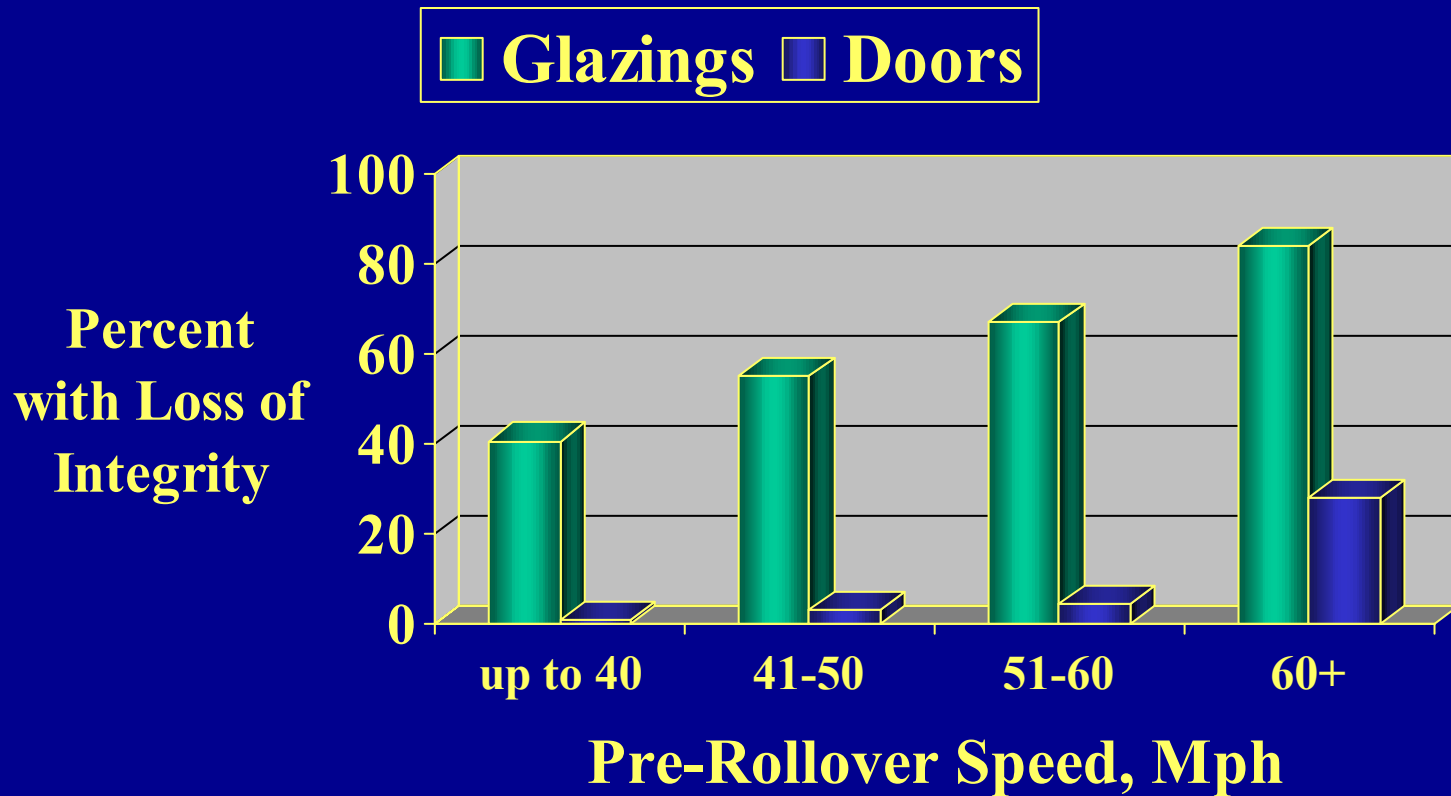
Harm Distribution

Ejection Paths in Rollovers - Restrained Occupants



Harm Distribution

Percent of Cars with Loss of Integrity - 4 Pre-roll Speed Ranges



Opportunities for Casualty Reduction

- Ejection Prevention
- Interior Contact Mitigation

Examine Interior Contacts

Harm in Rollovers, Restrained

Vehicle Region	Harm %
Roof	35.2
Front	8.4
Exterior	11.9
Side	8.9
Belts	2.2
All Other	33.4

Comprehensive Harm

Harm to Restrained Occupants in Rollovers - Partial List

Contact	Body Region	% Harm
Roof	Neck/Oth	12.2
Exterior	All	11.9
Lower Side	Chest/Abd	8.9
Int Objects	Brain	5.8
Roof	Brain	7.6
Rail/Header	Brain	6.0

Comprehensive Harm

Harm in Rollovers, Unrestrained

Vehicle Region	Harm %
Roof	29.3
Front	8.3
Exterior	34.2
Side	8.9
All Other	19.3

Comprehensive Harm

Harm to Unrestrained Occupants in Rollovers - Partial List

Contact	Body Region	% Harm
Exterior	All	34.2
Roof	Brain/Spine	11.8
A&B Pillars	Brain	7.5
Lower Side	Chest	3.9
Windshield	Brain	3.6
Rail/Header	Brain	3.8

Comprehensive Harm

Safety Standards Applicable to Rollover Protection

Crashworthiness Opportunities for Rollover Injury Reduction

Standard

Old 201

New 201/216

New 201+ Roll

New 214+

Seat Belt

Countermeasure

Dashboard Head Protection

Upper Interior Protection

Inflatable Head Protection

Dynamic Side Protection

Improved Belts & Use

Opportunities for Rollover Injury Reduction - Restrained Occupants

Countermeasure	% Harm
Old 201	6.3
New 201+ Roll	11.9
New 214	8.9
Roof Protection	35.2

Opportunities for Rollover Injury Reduction - Unrestrained Occupants

Countermeasure	% Harm
Old 201	4.4
New 201+ Roll	34.2
New 214	3.9
Roof Protection	29.3

Conclusions - Opportunities

- Unrestrained Suffer 84% of Rollover Harm
- Ejection Causes 56% of Rollover Harm
- Unrestrained Suffer 95% of Ejection Harm
- Safety Belts are Effective in Preventing Ejection
- Safety Belt Improvements May Further Reduce Injuries from Internal Contacts
- Strategies to Increase Belt Use Should be a High Priority in Rollover Injury Prevention

Conclusions

- Inflatable Head Protection Has a Large Potential Benefit in Rollover Protection
- Improved Seat Belt Technology Has a Large Potential Benefit
- Improved Roof Protection Offers Large Opportunities that Should be Researched
 - Opportunities – 35.2% for Restrained
 - 29.3% for Unrestrained

Thanks

The Author would like to express thanks to
The Santos Family Foundation
for sponsoring this research