

An Update on Classification of Rollover Crashes

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Application of Rollover Crash Severity

Benefits analysis

-Injuries in real-world crashes vs. crash parameter

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 relating to metric

Initial Data Sources

- NASS/CDS
- Years: 1995 – 2001
- Vehicle Classes (all available model years)
 - Passenger Cars
 - SUVs
 - Minivans
- Sampled Occupants
 - 5,227 Front Seat Occupants Age 12+
 - 1,309 MAIS 3+ Fatal Injuries (MAIS 3+F)
 - Expanded to 125,768 MAIS 3+F Injuries

Belted Not Ejected

Examine Single Vehicle vs.
Multi-Vehicle Crashes



Exposure and Injuries of Belted Occupants

Single and Multiple Crash Events Resulting in Rollover

	Belted	Single	Multi
	Occupants Involved	81%	19%
	MAIS 3+ F	68%	32%
RISK	MAIS 3+F/100	2.8	5.8

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-Vehicle Crashes

(with Planar Impacts prior to Rollover)

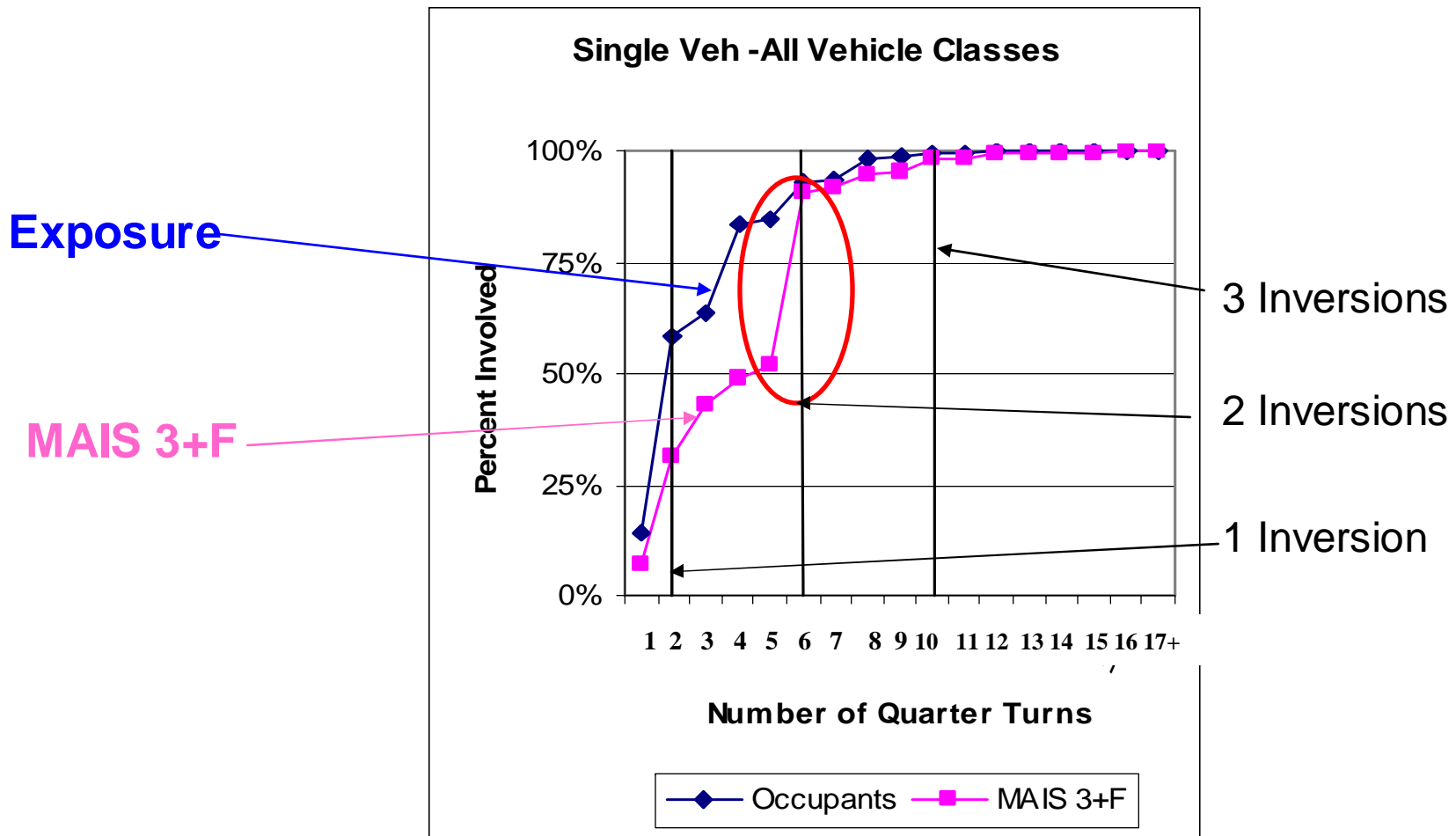


Definition of Vehicle Inversion

- 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

Belted – Non Ejected Single Vehicle

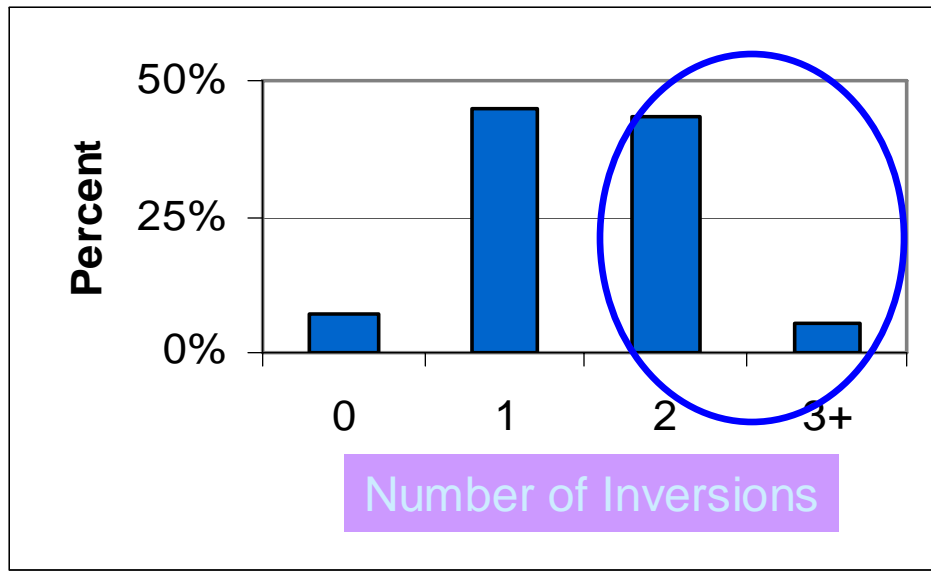
Front Seat Occupants 12+ and MAIS 3+ Injuries by Nr Quarter Turns – Cumulative Percentage based on Weighted Data



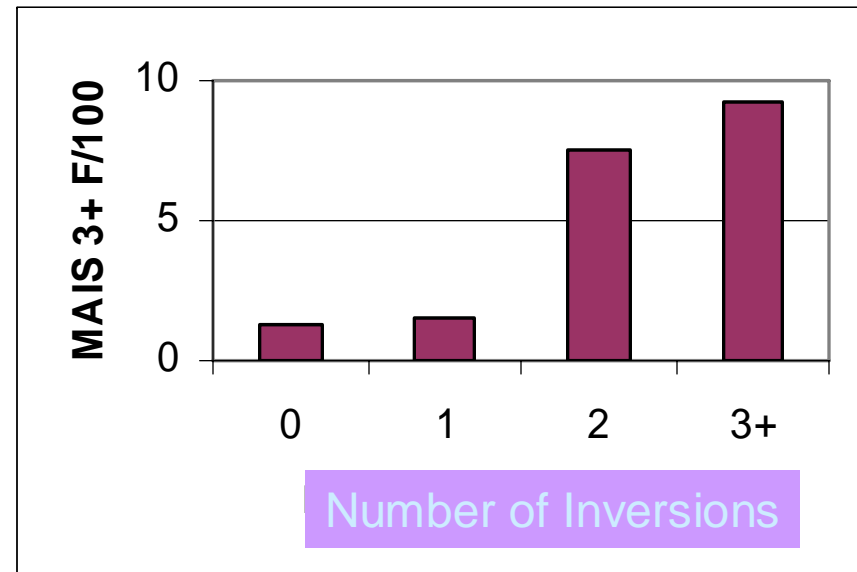
2nd vehicle inversion increases injury rate

Belted – Not Ejected Occupants Single Vehicle based on Weighted Data

MAIS 3+ F Injuries



Injury Risk



- 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 appears to be a good severity metric for grouping quarter-turns – applicable to belted occupants in single vehicle rollovers
- How do you group multi-impact rollovers?
 - Multi-vehicle; impacts with fixed objects
- Which multi-vehicle impacts have higher risks?
 - Not all planar impacts contribute to the injuries

Rollover Features in NASS/CDS Since 1995

- Number of quarter-turns up to 16
- Planar crash severity – extent of damage & delta-v
- Classification of rollover type by:
 - Rollover only
 - Rollover followed by impact
 - Fixed object impact prior to rollover
 - Non-fixed object impact prior to rollover

Analysis Approach

- Examine rollover type by planar crash severity
- Look at:
 - Distribution of MAIS 3+F injured
 - Rate of MAIS 3+ F injured per 100 exposed to the same crash type and severity
 - Examine belted and unbelted separately

Rollovers in Multi-impact (Multi-Event plus Multi-Vehicle 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 rollover crash type
 - MAIS 3+F Injuries
 - Injury Risk

Belted in Rollovers

Damage Severity	All Belted MAIS 3+F Injuries				
	Roll Only	R 1 st /Multiple	NF Object	Fixed Object	Total
MINOR	0.8%	0.1%	6.7%	2.8%	10.4%
MODERATE	21.6%	3.7%	7.4%	19.1%	51.9%
SEVERE	8.5%	1.6%	4.9%	15.8%	30.9%
OTHER/UNK	0.1%	0.1%	0.9%	5.8%	6.9%
Total	31.1%	5.5%	19.8%	43.7%	100.0%
Damage Severity	All Belted MAIS 3+F Injury Rate per 100 Exposed to Rollover				
	Roll Only	R 1 st /Multiple	NF Object	Fixed Object	Total
MINOR	0.17	0.16	2.68	1.16	1.01
MODERATE	4.67	2.92	3.83	3.41	3.85
SEVERE	3.17	5.50	12.37	9.74	6.16
OTHER/UNK	0.14	1.89	3.51	8.00	4.42
Average	2.44	2.66	3.92	4.19	3.30



Unbelted in Rollovers

Damage Severity	All Belted MAIS 3+F Injuries				
	Roll Only	R 1 st /Multiple	NF Object	Fixed Object	Total
MINOR	2.8%	0.1%	2.7%	5.1%	10.7%
MODERATE	13.9%	4.9%	6.2%	24.7%	49.7%
SEVERE	9.2%	5.6%	3.4%	14.6%	32.8%
OTHER/UNK	0.0%	0.0%	1.7%	5.0%	6.8%
Total	26.0%	10.7%	13.9%	49.4%	100.0%
Damage Severity	All Belted MAIS 3+F Injury Rate per 100 Exposed to Rollover				
	Roll Only	R 1 st /Multiple	NF Object	Fixed Object	Total
MINOR	6.75	0.74	9.41	9.13	7.44
MODERATE	13.01	27.49	13.58	16.56	15.56
SEVERE	37.24	41.70	44.91	32.56	36.23
OTHER/UNK	0.89	0.97	25.89	12.47	12.69
Average	14.65	20.66	15.79	17.03	16.46



Observations

- Crashes with severe planar damage have much higher injury risk than all other rollovers.
- These crashes should be separated from the others when considering the risk associated with the rollover
- Identify incidental versus serious crashes
- Examine population with minor, moderate and/or no planar damage for relationship between injury rate and vehicle inversions

Chi Tests for Vehicle Inversions

- The separation of severe damage crashes gives statistically significant results for the remaining rollover crashes
 - Injury rate related to vehicle inversions
 - Holds for both belted and unbelted
- Multi-impact rollovers with severe planar damage have a much higher injury rate and should be treated separately with regard to crash severity metrics

The End

Questions?

