Fire Occurrence in Rollover Crashes Based on NASS/CDS

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Research Questions

- What rollover crash factors influence the fire rate?
  - Vehicle class
  - Crash severity (Number of quarter-turns)
  - Final rest position
- What are the most common fire origins?
- How often is there fuel leakage?
- What are sources of fuel leakage?
- How often is pre-roll crash damage involved?

Outline

- Methods, Data Sources and Definitions
- The Size of the Rollover Fire Problem
- NASS Data on Rollover Fires
- Case Analysis
- Conclusions

Methodology

- Conduct an analysis of NASS rollovers with fires to determine distributions of:
  - Fire Origin
  - Fuel Leakage Location
  - Rollover Severity and Final Rest Position
- Examine 24 cases of rollover crashes with major fires in recent model vehicles for:
  - 1st Impact Location & Rollover Type
  - Fire Origin
  - Fuel Leakage Location

Data Sources

NASS/CDS 1997-2004

- 52,422 cases with crash exposed vehicles
- 9,700 front occupants injured at MAIS 3+ level
- 431 crashes with fires
- 103 cases with fire and rollover

Definition – Data Weighting

NASS is a sample of tow away crashes in US

The sample is stratified by crash severity

The sample rate for minor crashes is much lower than for severe crashes.

An inflation factor is assigned to each case to expand the sample to the entire population

When the data is processed using the inflation factors it is "weighted"

The actual number in the sample is "unweighted"

Definition of Fire Severity

- Minor fire –
  - an external fire that does not spread to the occupant compartment
  - an occupant compartment fire that does not spread
- Major Fire
  - an external fire that does spread to the occupant compartment
  - an occupant compartment fire that spreads

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The Size of the Rollover Fire Problem

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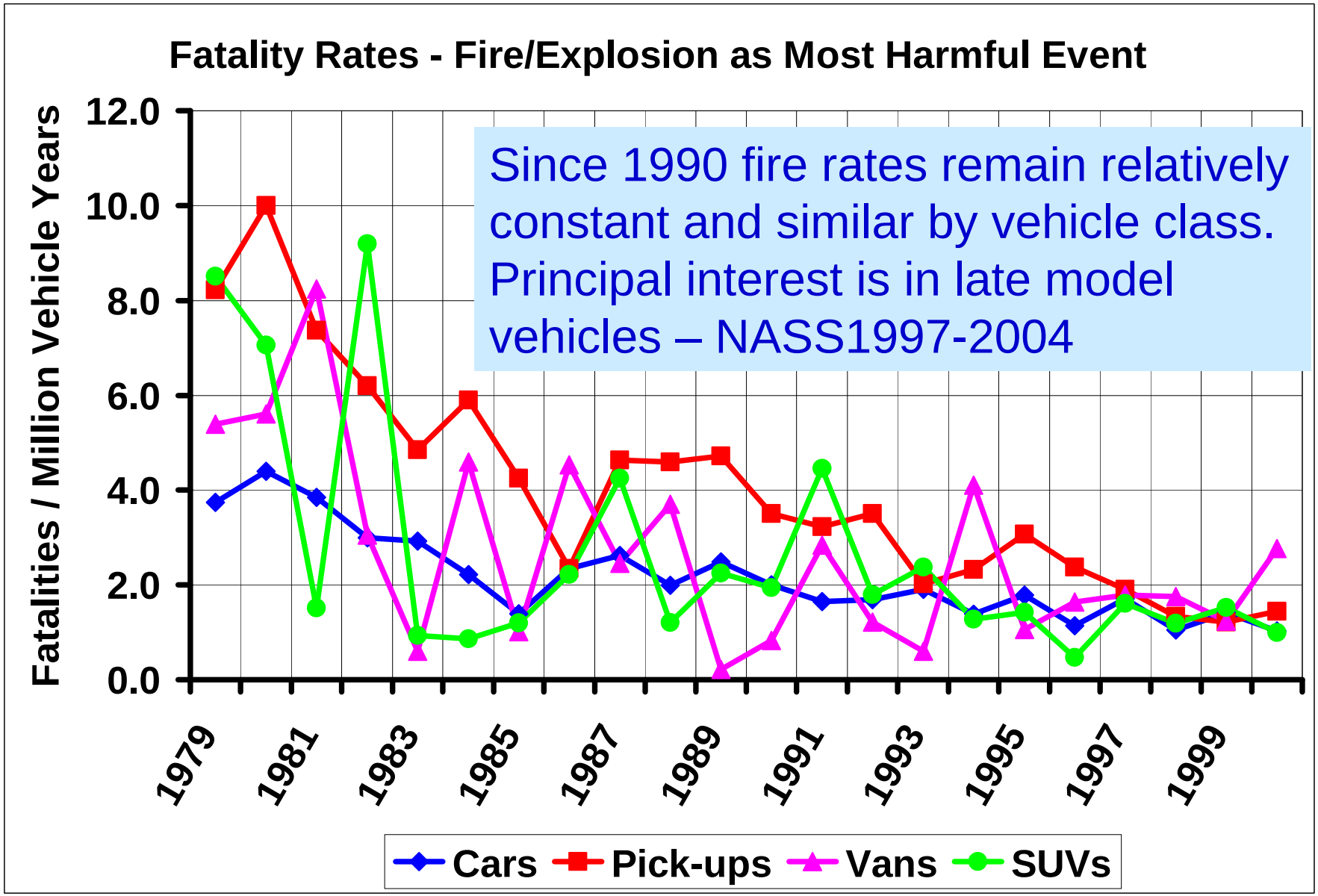

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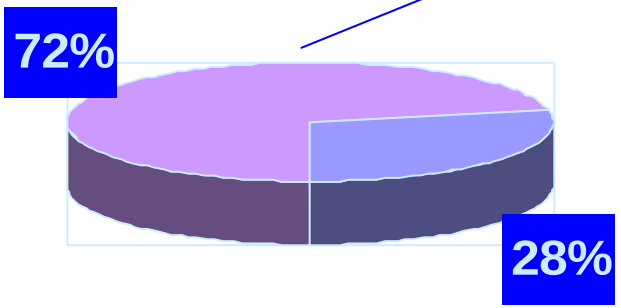
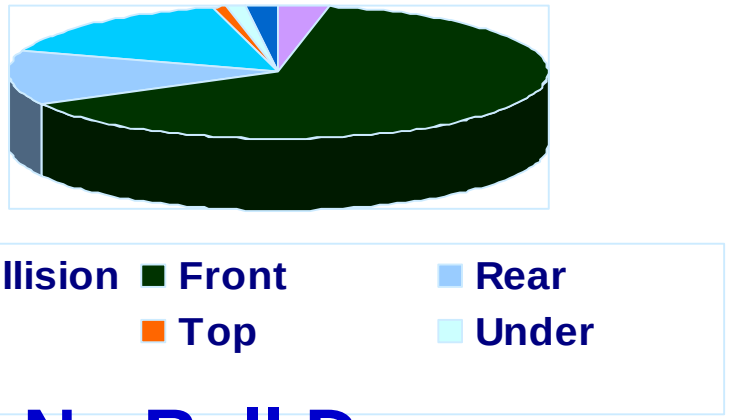
Data from ESV Paper 422, 2003 by Digges ;

Comparison of FARS Rollovers and Non-Rollovers by Damage Area

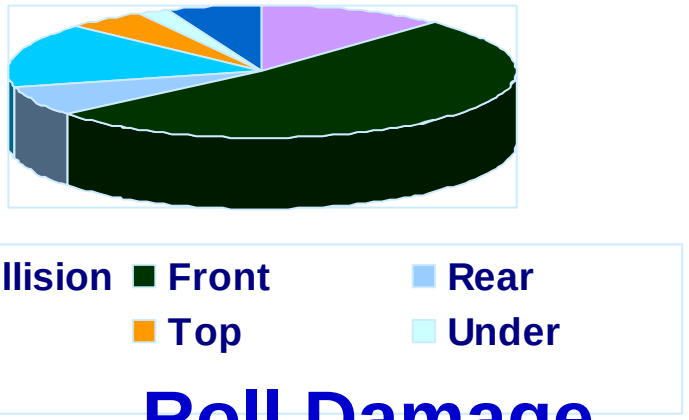
Fatal Crashes with Fire as Most Harmful Event

FARS 2000-2005



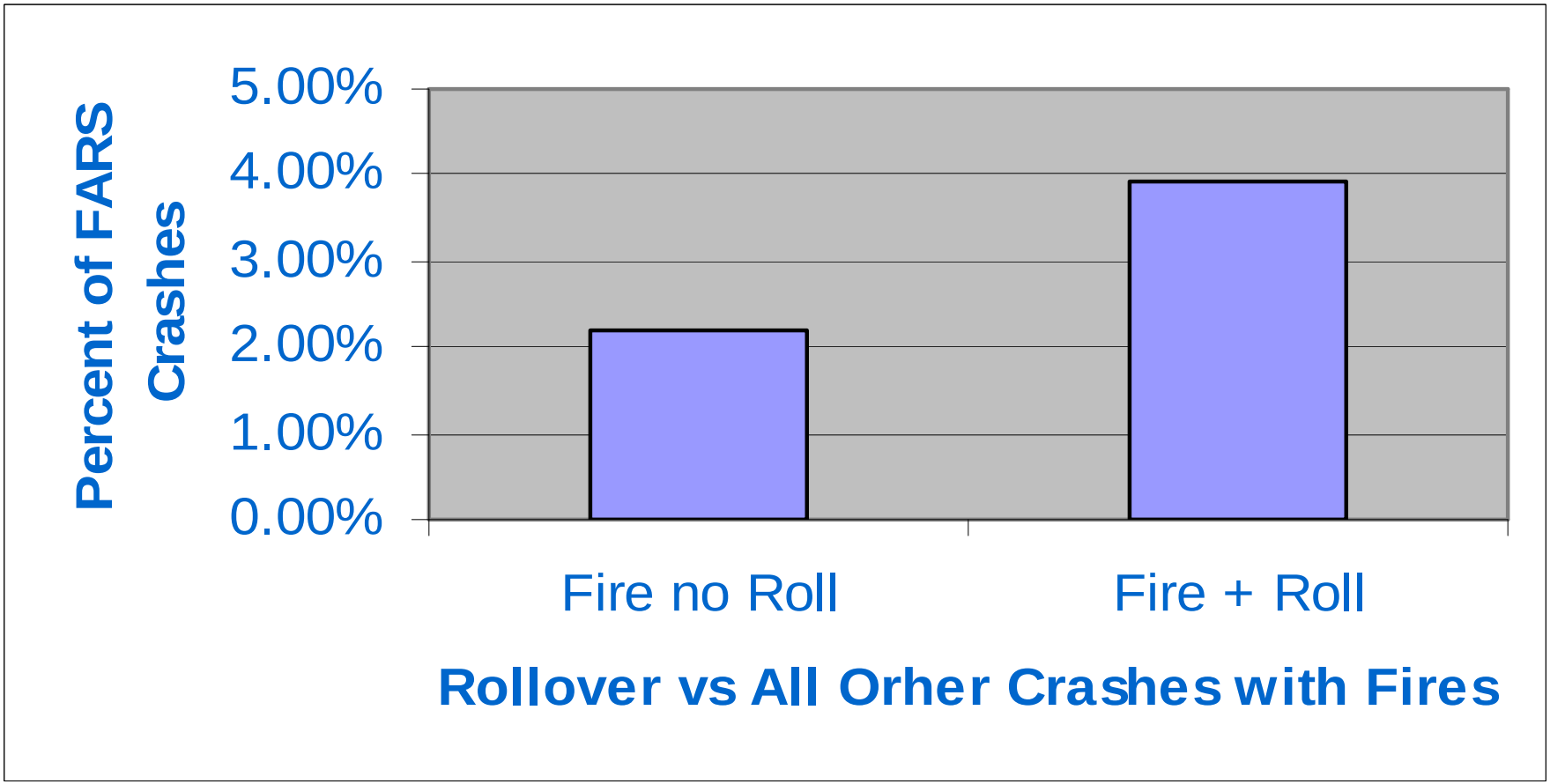


No Roll Damage



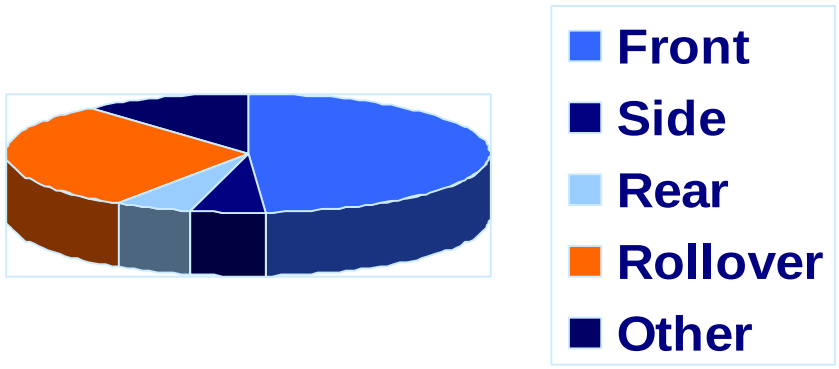
Roll Damage

Fire Rates in FARS Crashes with Fire as Most Harmful Event

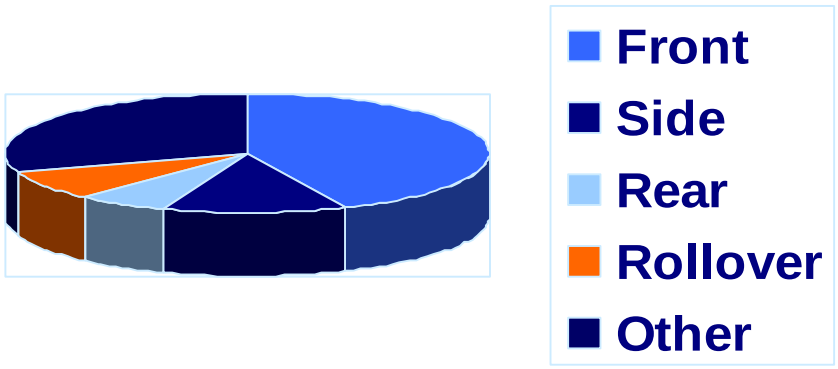


Fire and No-fire Distribution by Crash Direction – Weighted

NASS/CDS 1997-2004



All Fires



All Crashes No Fires

Magnitude of the Rollover Fire

FARS with Fire as MHE – Rollovers are 28%

NASS/CDS Major Fires – Rollovers are 30%

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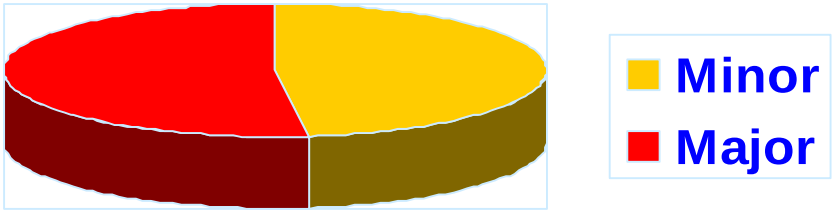
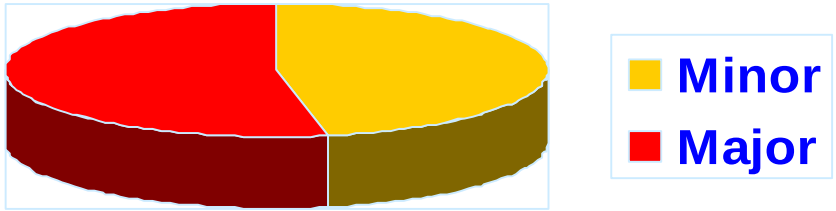
Fire Severity Distribution – Weighted and Unweighted Data



Weighted Data



Unweighted Data

Distribution in Rollovers by Fire Severity – Unweighted and Weighted

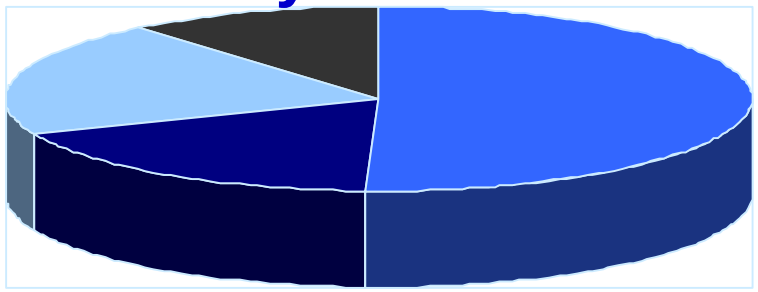
Data Type	Minor	Major	Unk.	All Roll Fires
Unweighted	49	53	1	103
Weighted	6,523	9,432	1	15,956

102 Cases with known fire severity

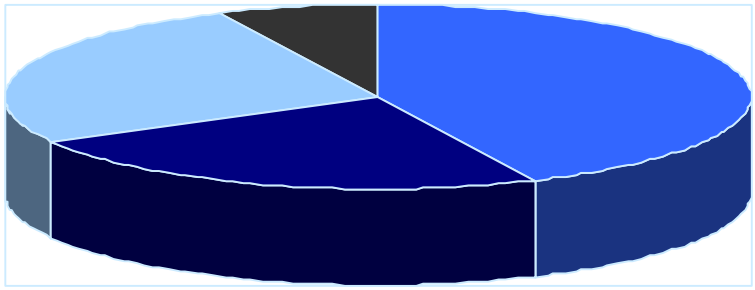
NASS/CDS 1997-2004

Fire and No-fire Distribution in Rollovers by Vehicle Type - Unweighted

102 Rollover Cases with known fire severity



All Rollover Fires



All Rollovers No Fires

Car Pickup SUV Van

Car Pickup SUV Van

Distribution in Rollovers by Fire Severity and **Fire Origin**

102 Fires Unweighted Data

Fire Origin	Minor	Major	All
Unknown Origin	3%	6%	9%
Exhaust System	1%	0%	1%
Fuel Tank	3%	17%	20%
Engine Compartment	36%	27%	63%
Cargo / Trunk Area	1%	0%	1%
Instrument Panel	1%	2%	3%
Other Location	3%	0%	3%
Total	48%	52%	100%

Distribution in Rollovers by Fire Severity and **Leak Location**

102 Fires Unweighted Data

Fuel Leak Location	Minor	Major	All
Unknown	2%	16%	18%
No Fuel Leakage	42%	22%	64%
Tank	1%	4%	5%
Filler Neck	2%	6%	8%
Cap	1%	2%	3%
Line/Pump/Filter	0%	2%	2%
Other	0%	1%	1%
Total	48%	52%	100%

Distribution in Rollovers by Fire Severity and Roll Severity

102 Cases - Unweighted Data

Number of Revolutions	Fire Severity		Fire Rate per 100	
	Minor	Major	All	Major
1 or less	36%	35%	1.32	0.66
1+ less than 2	4%	10%	1.06	0.76
more than 2	5%	6%	3.96	2.15
End over End	3%	1%	4.28	1.19
Total	48%	52%	1.42	0.74

Fire rate increases for more than 2 revolutions

Distribution in Rollovers by Fire Severity and Final Rest Position

102 Cases - Unweighted Data

Final Rest Position	Fire Severity		Fire Rate per 100	
	Minor	Major	All	Major
Side	21%	12%	1.48	0.56
Roof	14%	24%	1.31	0.81
Wheels	13%	16%	1.50	0.81
All	48%	52%	1.42	0.70

Not much difference in the fire rate

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Distribution of 24 Rollover Cases with Major Fires by Fire Location

Fire Location	Number	Percentage
Fuel Tank	5	21%
Instrument Panel	2	8%
Engine Compartment	17	71%
Total	24	100%

MY 1990 and later vehicles

Cases with Fuel Tank Origin

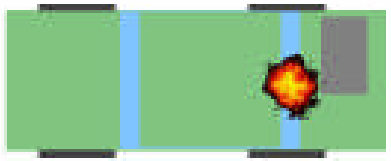
Origin	Leakage	Roll Type	Qtr-Turns	Impact Loc.
Fuel tank	Filler neck	BOUNCE-OV	1 to 4	Front/Side
Fuel tank	Tank	BOUNCE-OV	1 to 4	Front/Rear
Fuel tank	Filler neck	BOUNCE-OV	1 to 4	Front/Undercar.
Fuel tank	Unknown	CLIMB-OV	1 to 4	Front/Undercar.
Fuel tank	Unknown	2 VEHIC	1 to 4	Rear

All cases had major vehicle crash damage prior to the rollover

Case
2002 2-81

4 quarter-turns

Fuel Tank fire origin
Unknown leakage



PSU 02 CASE 081E

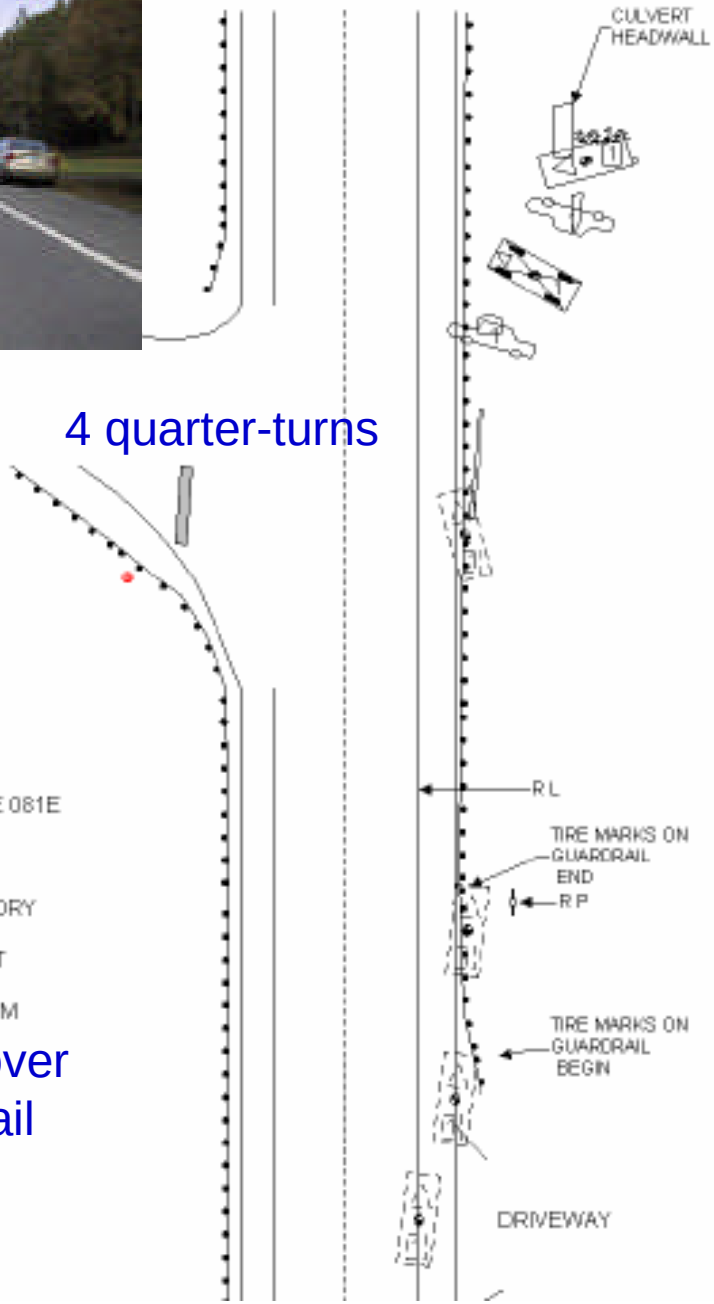
80 KPH

+3.3% / BIT / DRY

STRAIGHT

1 CM = 2.7 M

Climb-over
Guardrail

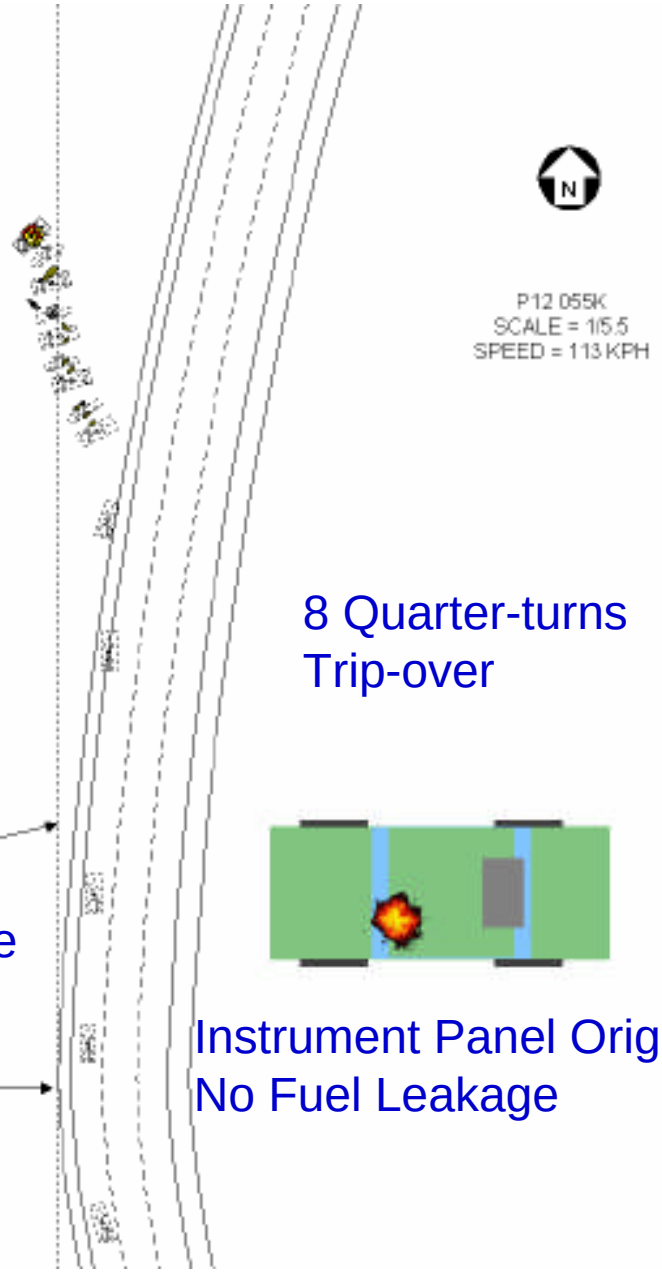


Cases with Instrument Panel Fires

Origin	Leakage	Roll Type	Qtr-Turns	Impact Loc.
Inst Panl	None	TRIP-OVER	5 to 8	Wheels
Inst Panl	None	TRIP-OVER	1 to 4	Wheels

All cases had no major vehicle crash damage prior to the rollover.

Case 1999-12-55



8 Quarter-turns
Trip-over

1-way 3 lane
Highway

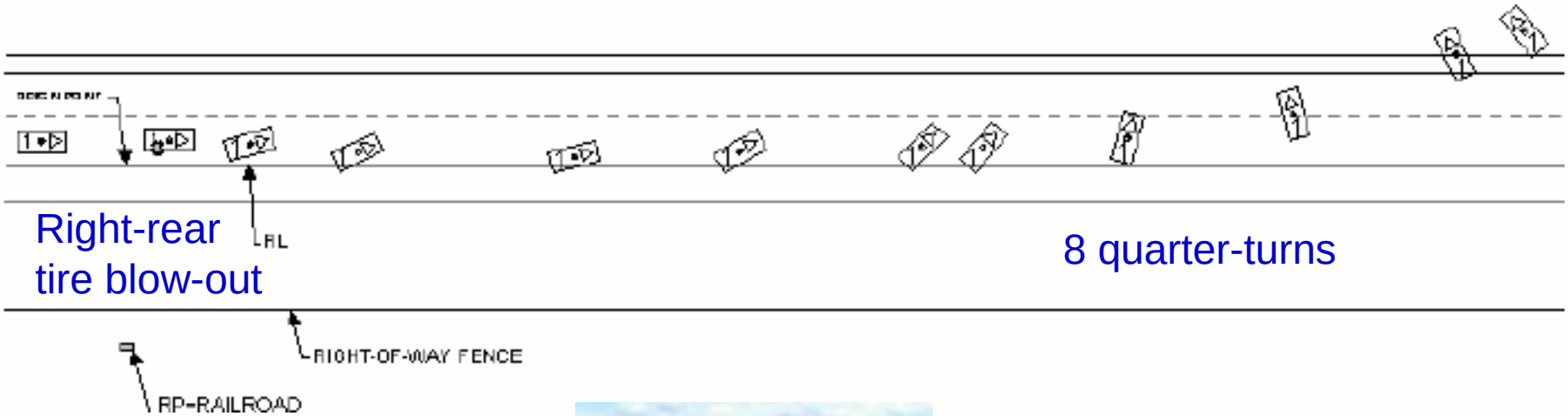
Instrument Panel Origin
No Fuel Leakage

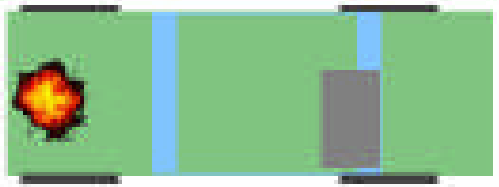
Cases with Underhood Fires

Origin	Leakage	Roll Type	Qtr-Turns	Impact Loc.
UndrHood	Unknown	BOUNCE-OVER	1 to 4	Front/Undercar.
UndrHood	None	BOUNCE-OVER	1 to 4	Rear
UndrHood	Filler cap	BOUNCE-OVER	5 to 8	Front/Undercar.
UndrHood	None	BOUNCE-OVER	1 to 4	Undercarriage
UndrHood	Unknown	TURN-OVER	1 to 4	Wheels/Overturn
UndrHood	None	FLIP-OVER	5 to 8	Front/Undercar.
UndrHood	Unknown	FLIP-OVER	1 to 4	Rear
UndrHood	None	FLIP-OVER	9+	Rear
UndrHood	None	TRIP-OVER	1 to 4	Wheels
UndrHood	None	TRIP-OVER	5 to 8	Wheels
UndrHood	None	TRIP-OVER	1 to 4	Wheels
UndrHood	None	TRIP-OVER	1 to 4	Front/Undercar.
UndrHood	None	TRIP-OVER	1 to 4	Wheels
UndrHood	Filler cap	TRIP-OVER	5 to 8	Wheels
UndrHood	None	TRIP-OVER	1 to 4	Wheels
UndrHood	Unknown	TRIP-OVER	9+	Wheels
UndrHood	Unknown	TRIP-OVER	1 to 4	Front/Wheels

8 of 17cases had no major vehicle crash damage prior to the rollover

Case 1997-78-135





Major Under-hood Fire
Filler Cap Fuel Leakage

2007-01-0875

Distribution of 17 Rollover Cases with Engine Compartment Fires by Contact Prior to Rollover

Contact Prior to Roll	Number	Percentage
Tripped Roll & Turnover	8	47%
Front & Undercarriage	6	35%
Rear, Side	3	18%
Total	17	100%

Damage before rollover may contribute to fire origin

Cause of these engine compartment fires unknown.

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- Rollovers are second to frontal crashes with regard to the frequency of fires – both NASS and FARS

- Rollovers carry the highest risk of fire
- Most NASS/CDS rollover fires originate in the engine compartment (63%)

- Fuel leakage was observed in 19% of rollover fires
- In major fires, the tank and filler neck were the most frequently observed sources of leakage (20%)

Conclusions

- Most of the fires occurred in rollovers of four quarter-turns or less (71%)
- End-over-end rollovers and rollovers with more than 2 revolutions had increased fire risk (Limited data)
- The final rest position did not appear to influence the risk of fire. (Limited data)

Conclusions

- Examination of 24 cases of late model vehicles with major fires in rollovers:
  - All 5 tank fire origins involved damage before roll
  - About half of the 17 underhood fires involved some damage prior to rollover
- Pre-roll damage appears to contribute to tank fire origins
- The causes of most major underhood fires without pre-roll damage remains uncertain - about ½ of the underhood fires.

The End