# Recent MVFRI Research in Crash-Induced Vehicle Fire Safety

**Kennerly H. Digges**
**and**
**R. Rhoads Stephenson**
Motor Vehicle Fire Research Institute

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MVFRI

# Presentation Outline

- Fire Tests of a 5000 psi Hydrogen Fuel Tank
- Motor Vehicle Fire Statistics
  - FARS
  - NASS/CDS
- Fire Safety Technology on the Road
- Conclusions

# Fire Test of a Type 3 5000 psi $H_2$ Fuel Tank Under an SUV

- What is the response of a $H_2$ fuel tank to a car fire?
  - Internal pressure
  - Shell temperature
  - PRD sensing strategies
- How far away is safe for rescue and bystanders if the PRD valve does not release?

# Fire Test of a Type 3 5000 psi $H_2$ Fuel Tank Under an SUV

*No PRD in Test*

Distances from vehicle:

Small pieces – 350 ft.

Large pieces – 125 ft.

2 psi overpressure – 32 ft

0.3 psi overpressure- 150 ft

**Safe overpressure distance- 150 ft.**

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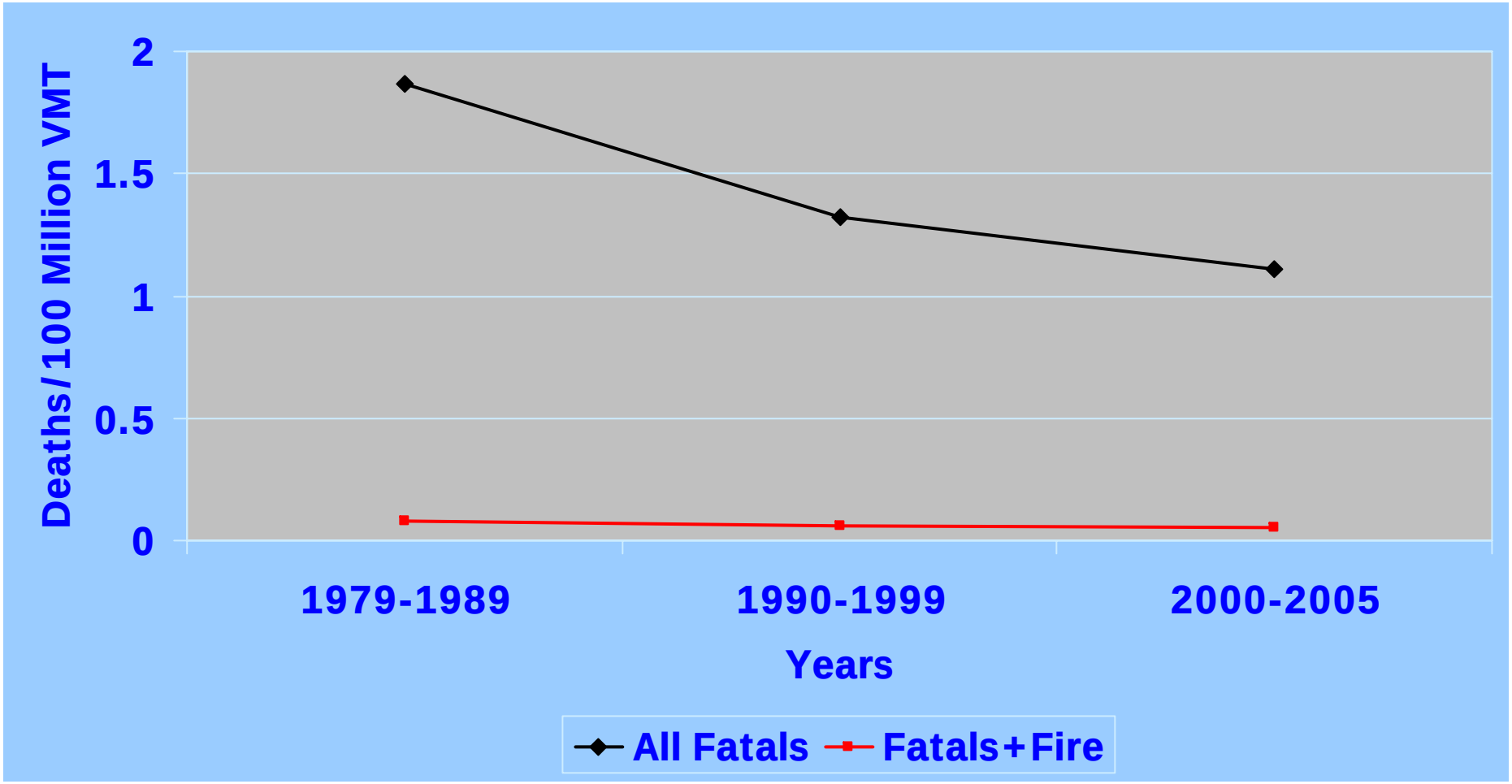
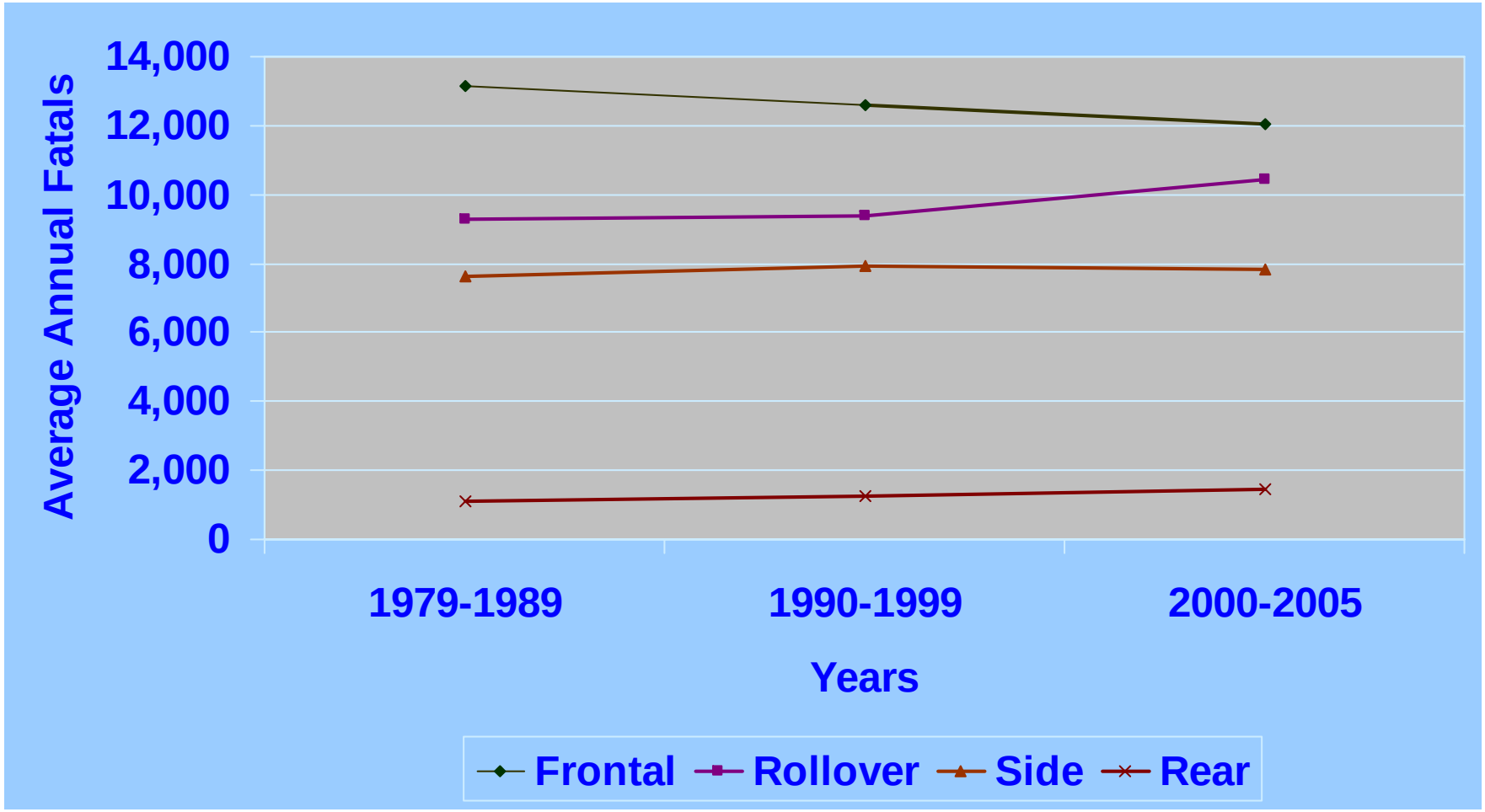
# US Highway Fatality Rate - VMT



# Average Annual US Fatalities



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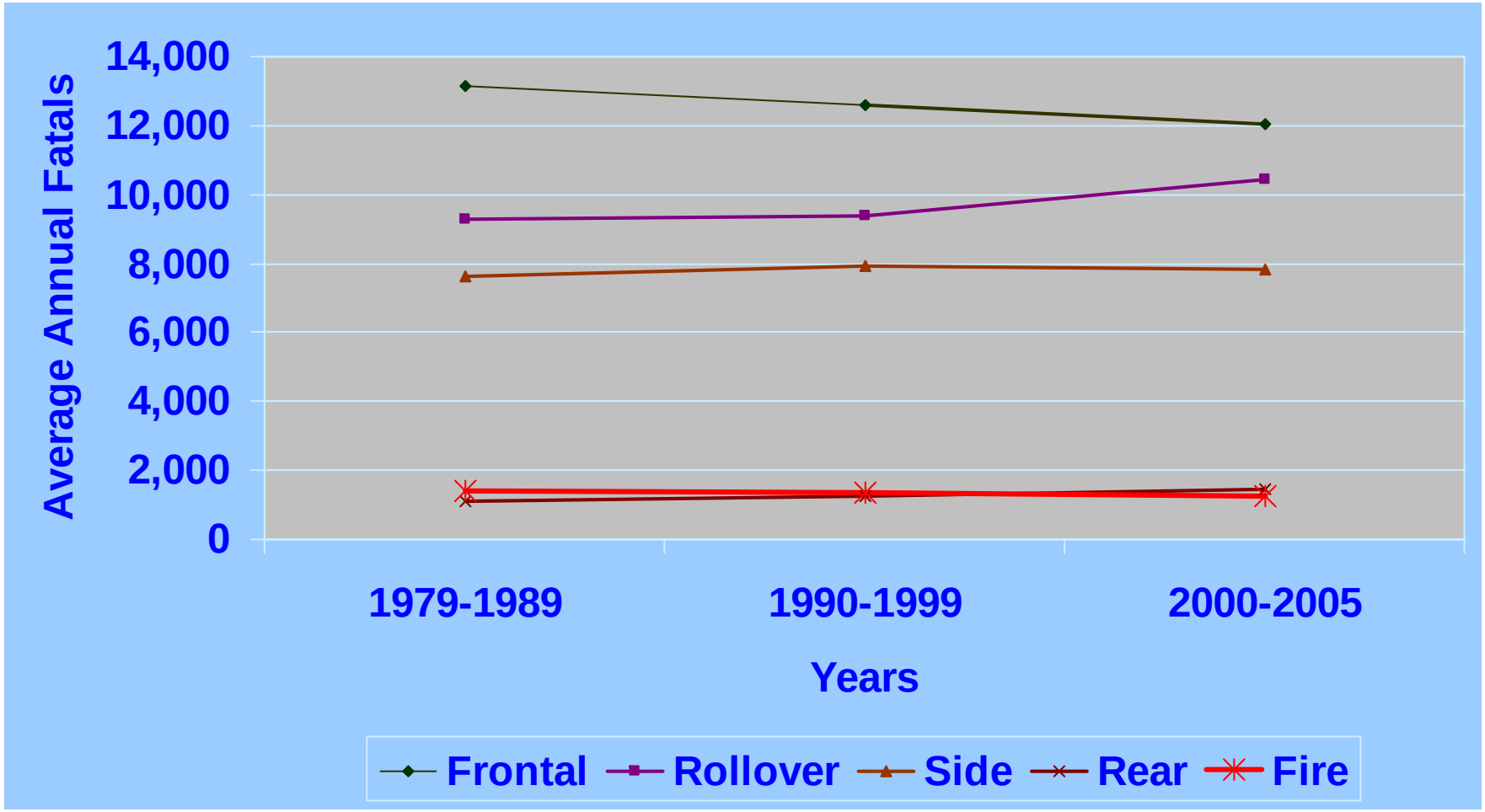
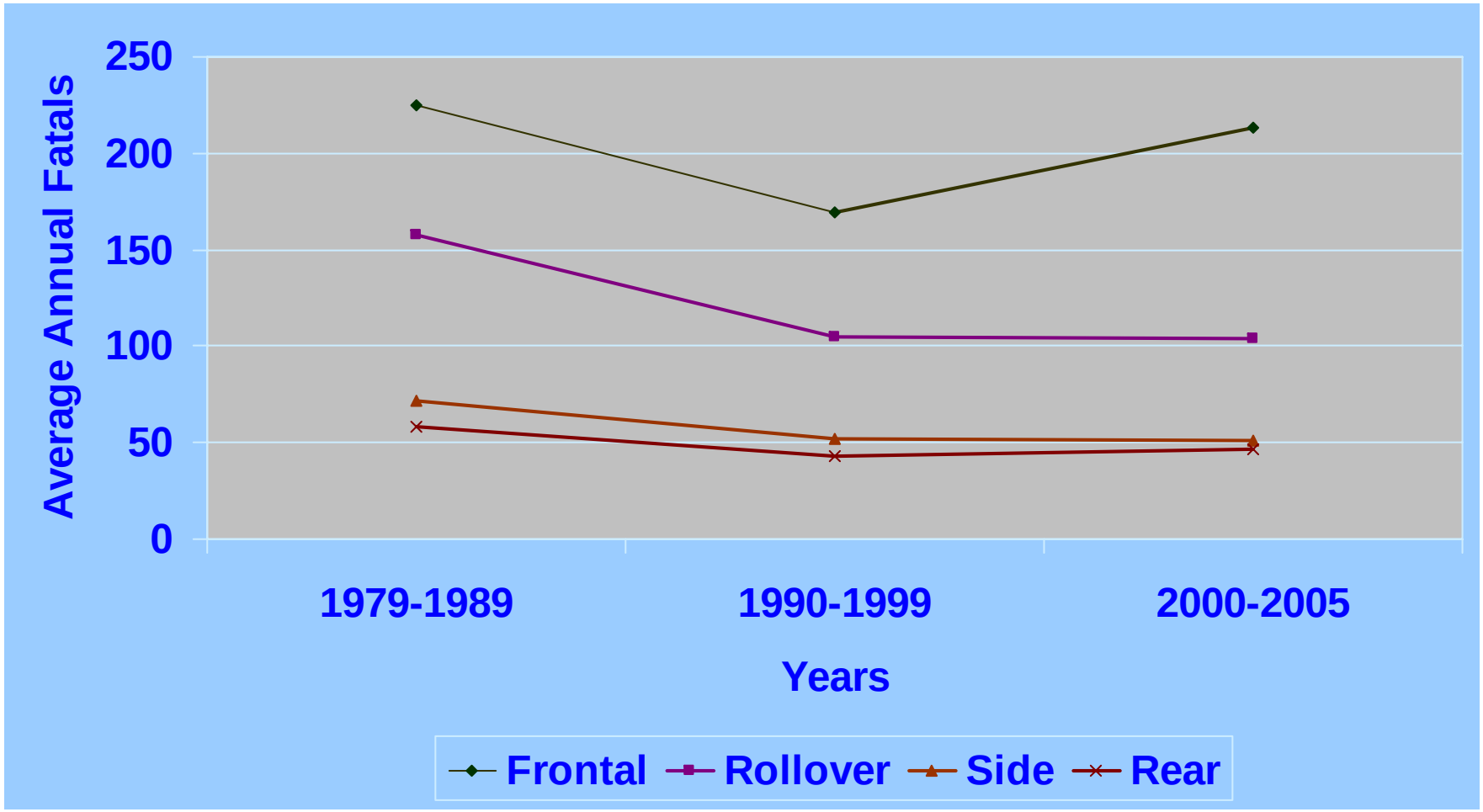


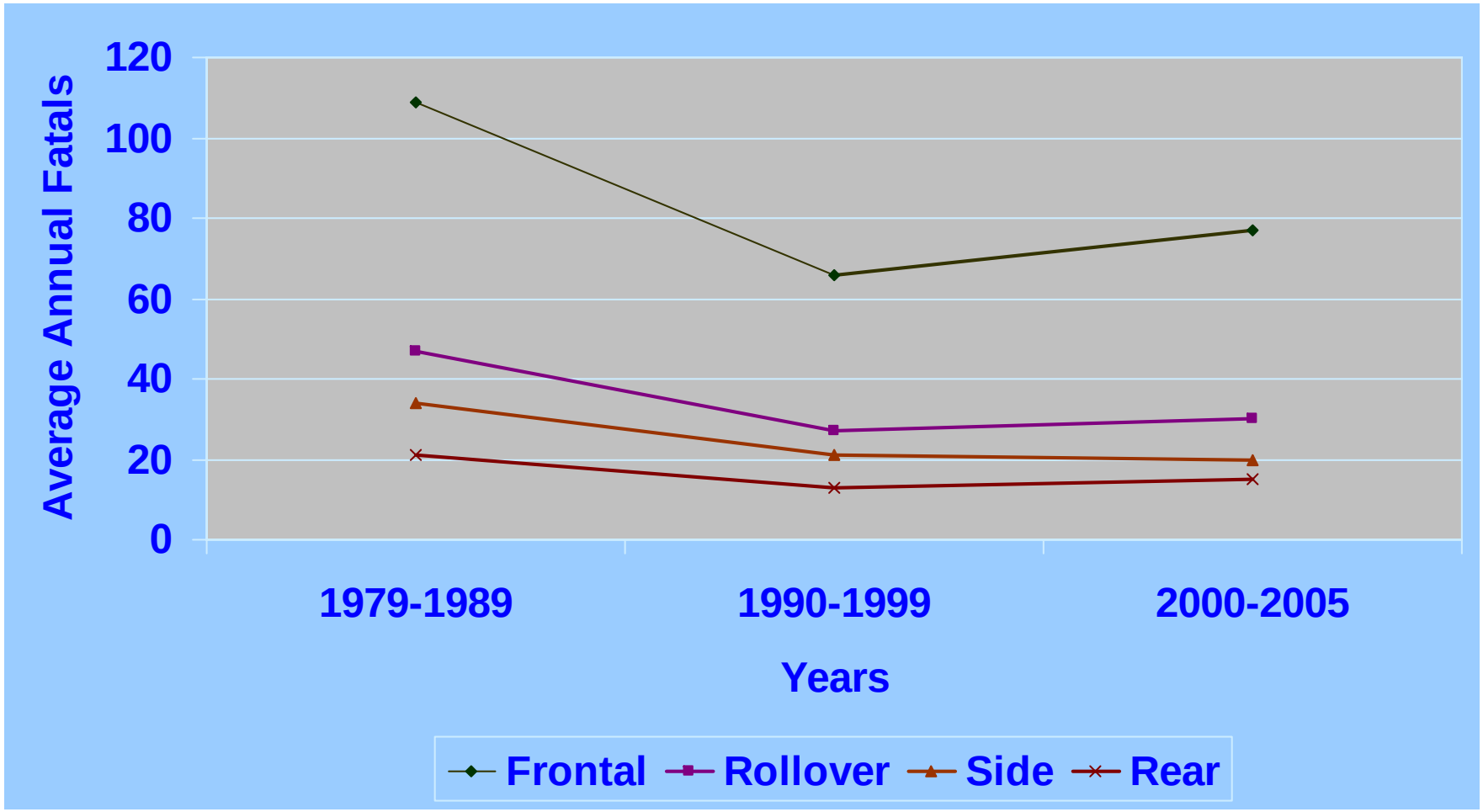
# Average Annual US Fatalities

## Fire as Most Harmful Event



# Average Annual US Fatalities

## Fire as MHE - Vehicles Less than 4 Years Old



# NASS Data on Fires – 1994-2005

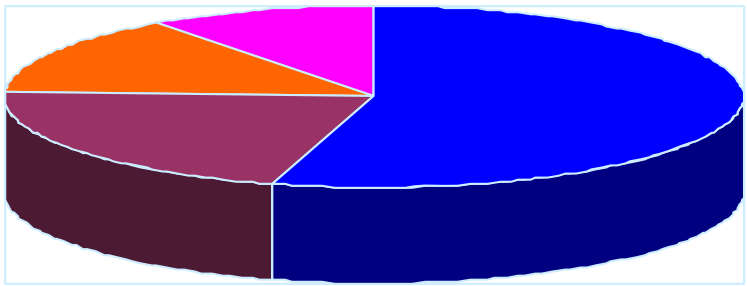
| | Fire Severity | | | |
|---|---|---|---|---|
| **Data Type** | Minor | Major | Unk. | All Fires |
| Unweighted | 290 | 335 | 6 | 631 |
| Weighted | 40,994 | 38,173 | 187 | 79,354 |

Minor fire does not spread to occupant compartment

# Comparison of Fires in FARS and NASS – Known Crash Modes

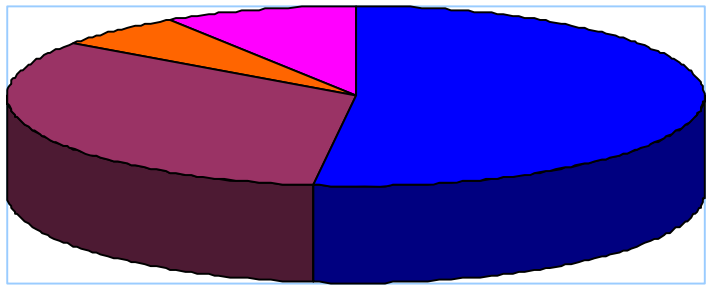
**FARS-Fire as MHV**

2000-05 FARS
Vehicles L.T. 4 YO



**NASS - Major Fires**

Weighted Data



**Frontal** **Rollover**
**Side** **Rear**

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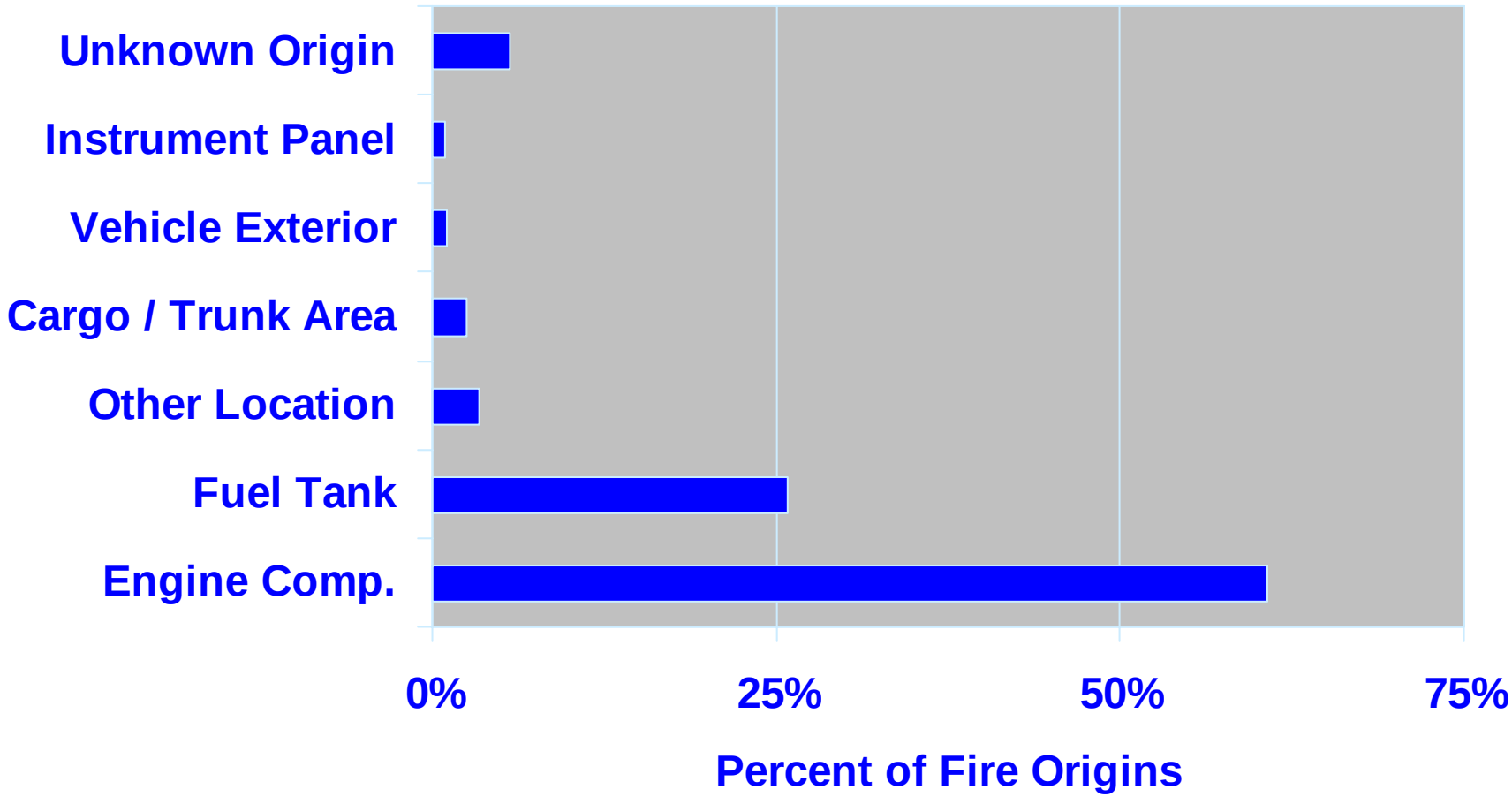
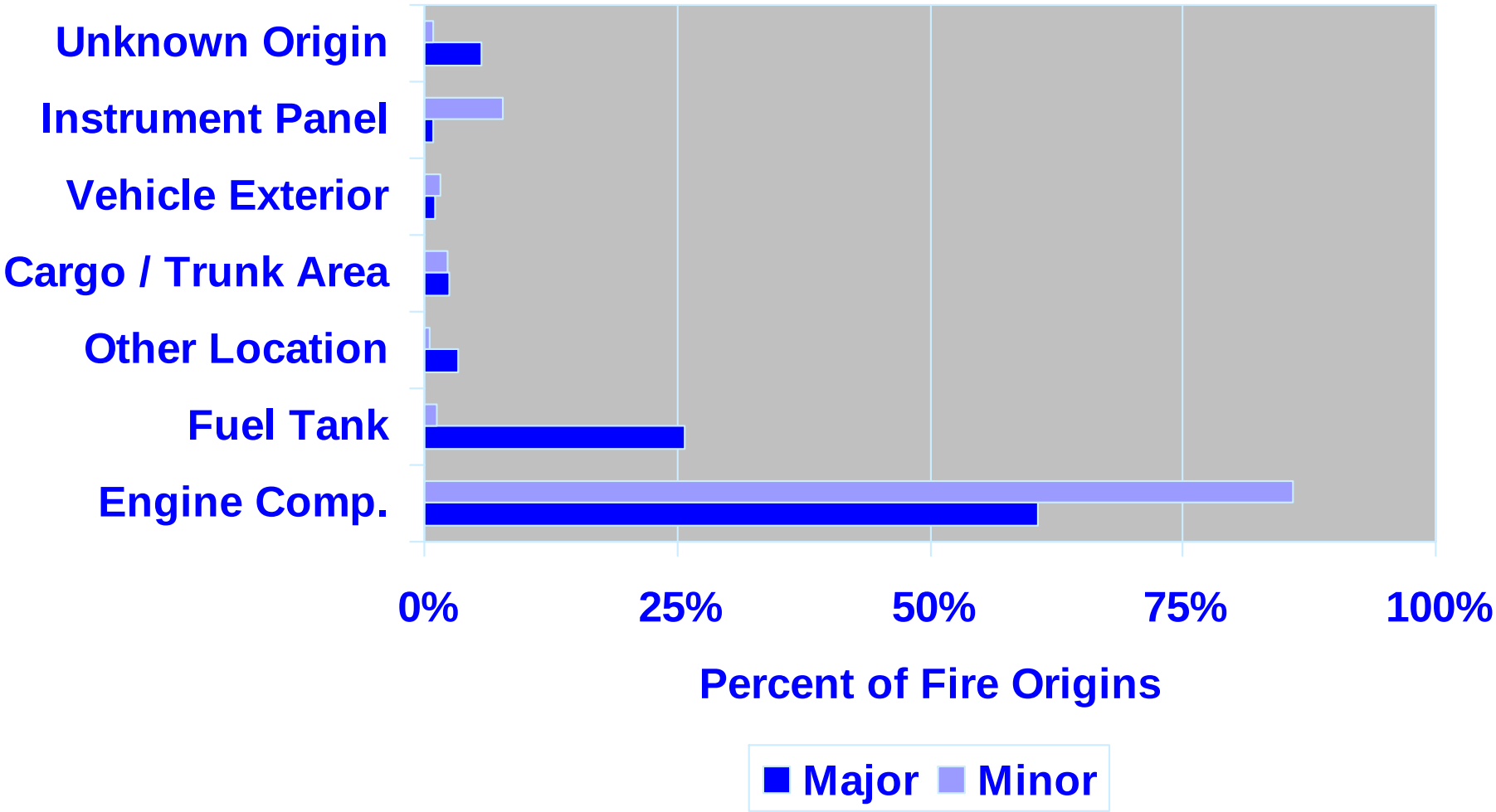
**Side** **Rear**

# Origin of NASS Major Fires
## Weighted Data



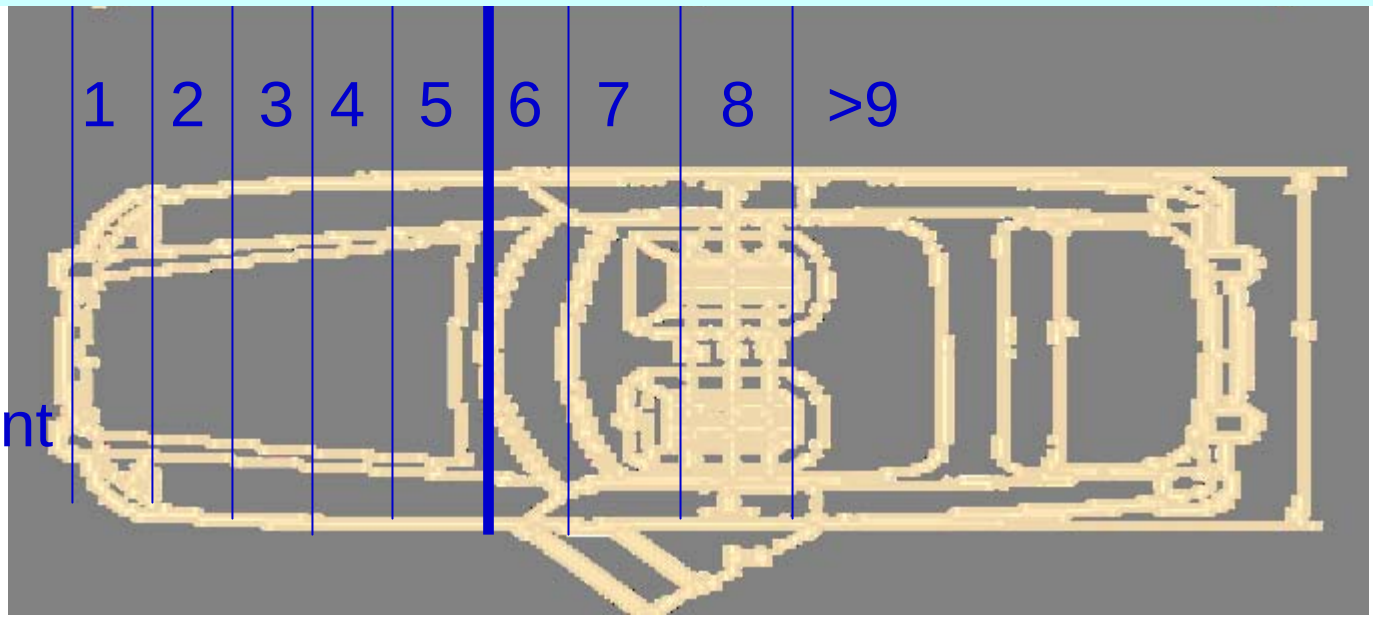
# Origin of NASS Major & Minor Fires
## Weighted Data



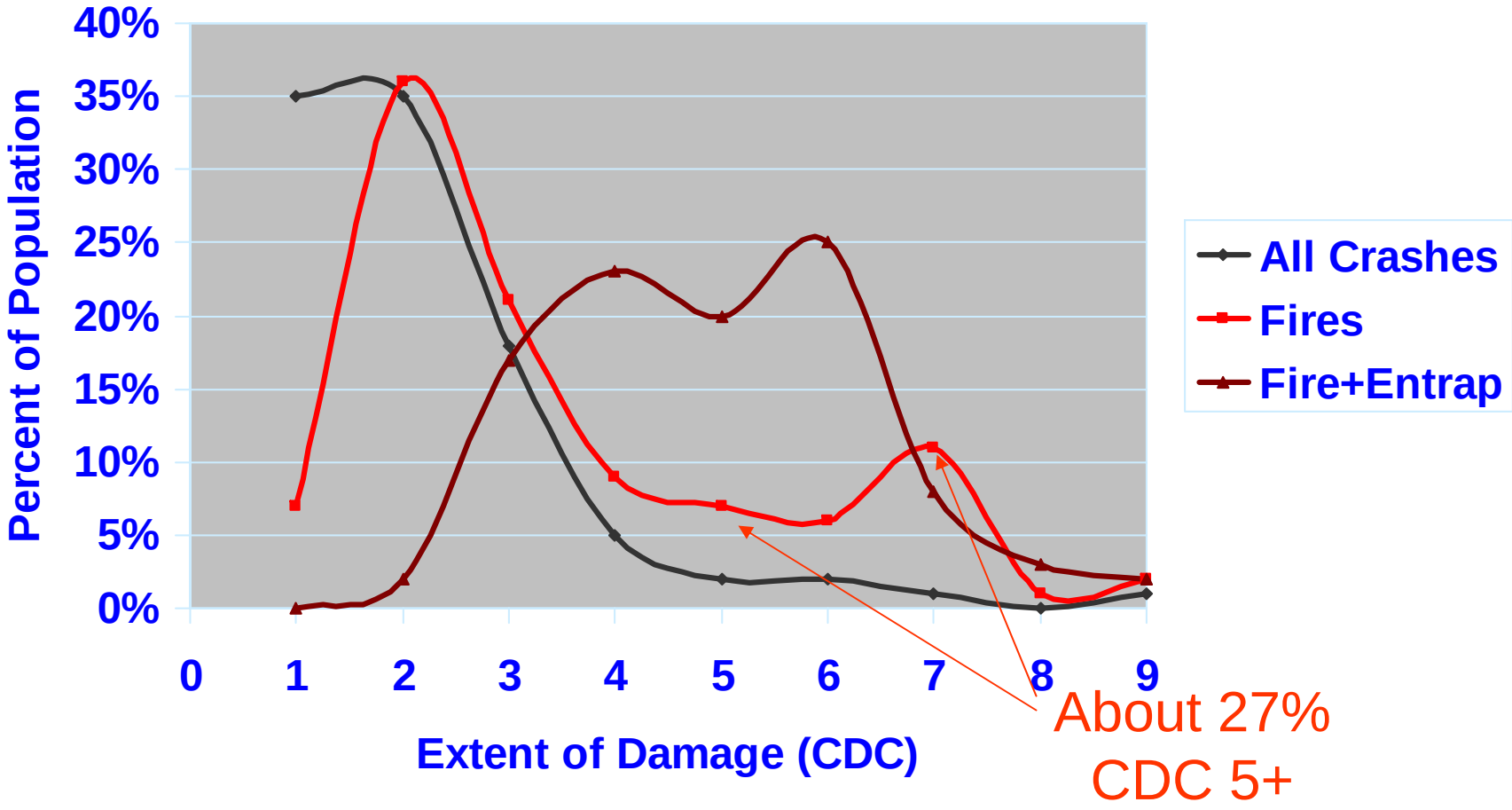
# Collision Deformation Classification

Extent of Damage - Frontal Crash Direction
Range 1 to 9
1 to 5 - Equally Divided to Firewall
6 – Front to Rear of Windshield
7 & 8 – Equally Spaced; Rear of Windshield to B-Pillar
9 – Beyond B-Pillar

Definition
Of CDC
Damage Extent

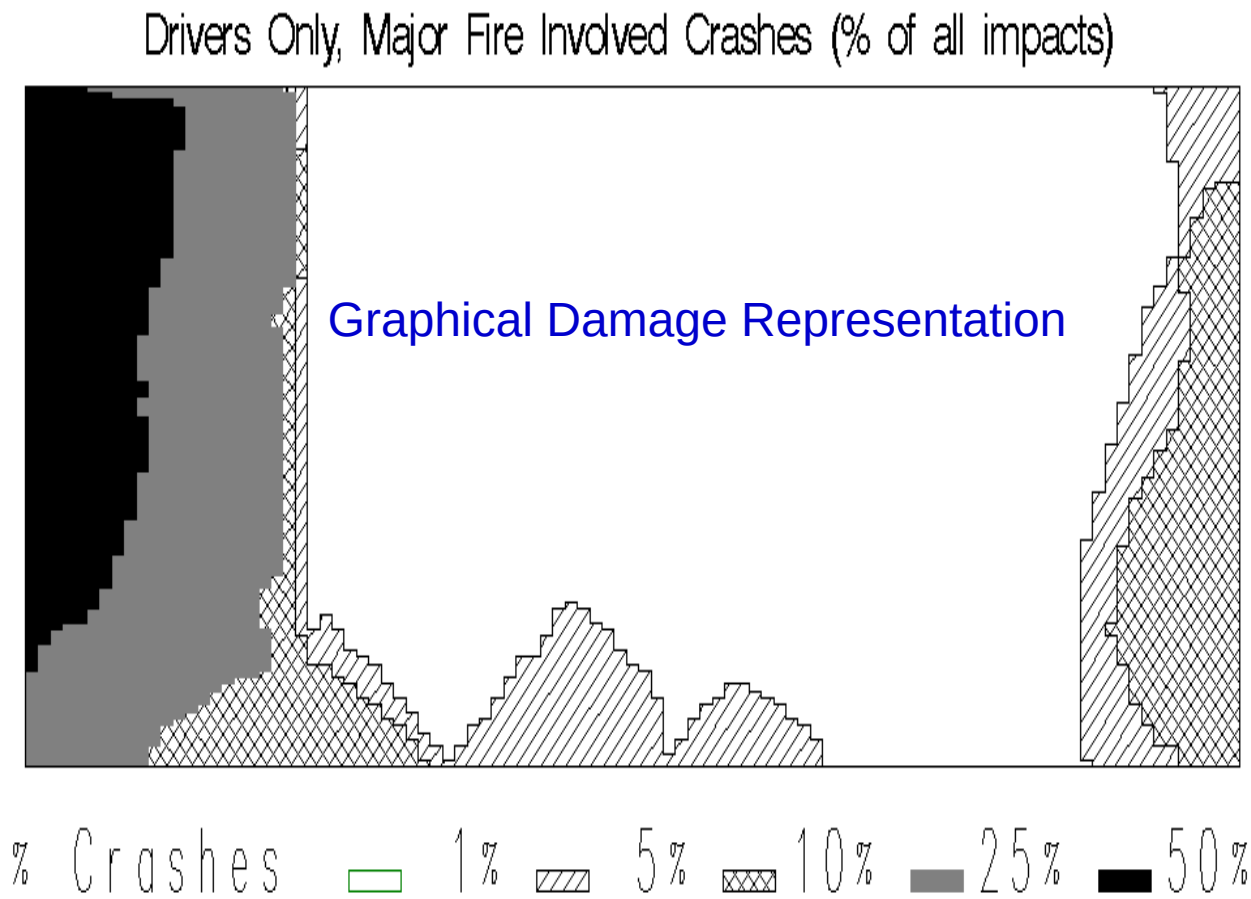


# Distribution of NASS Major Fires by Extent of Damage (CDC)



# Distribution of Fires In NASS
## by Extent of Damage

Front



# Frequency of Entrapment

| Extent Entrapped | No Fire | Fire Severity NASS & FARS | | |
|---|---|---|---|---|
| | | Minor | Major | FARS Fire |
| Not Entrapped | 93% | 92% | 82% | 77% |
| Entrapped | 2% | 6% | 13% | 23% |

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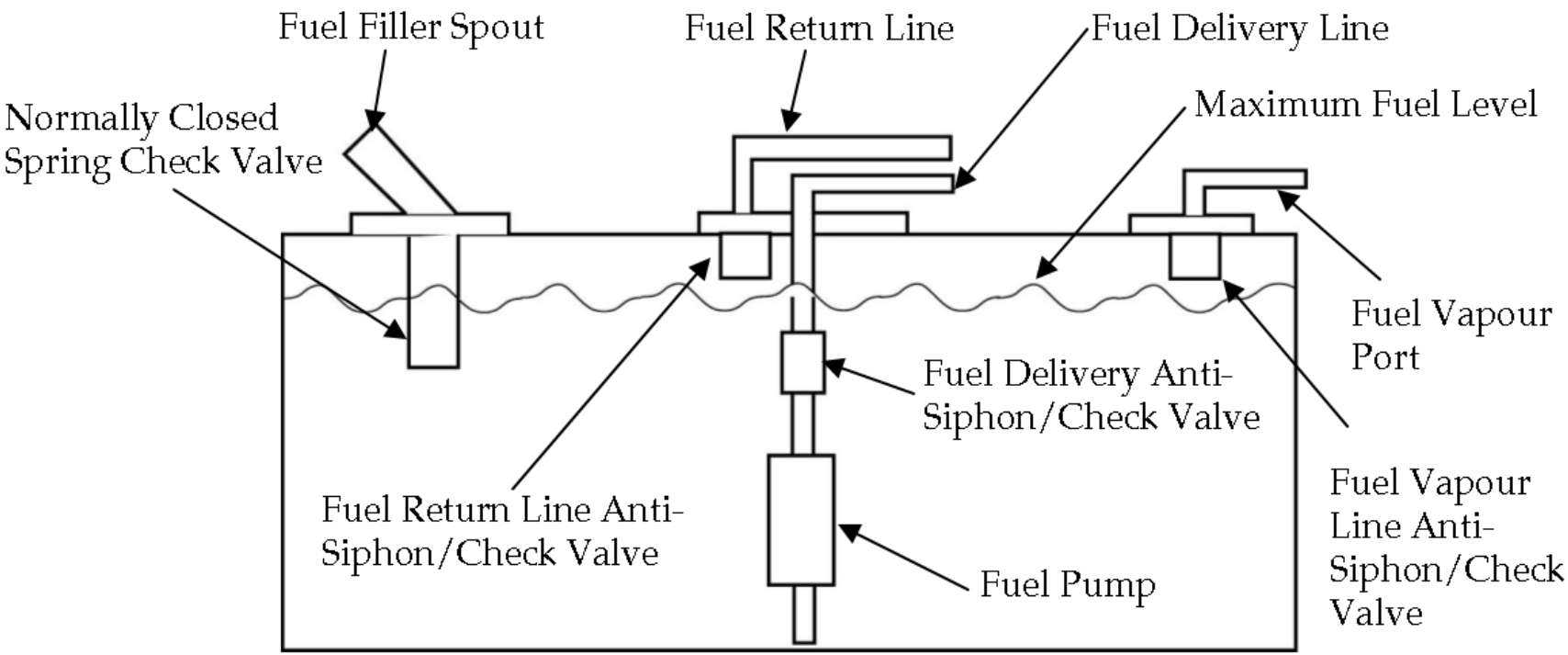
# Fuel Leakage in Rollover Tests of MY 2003 Vehicles

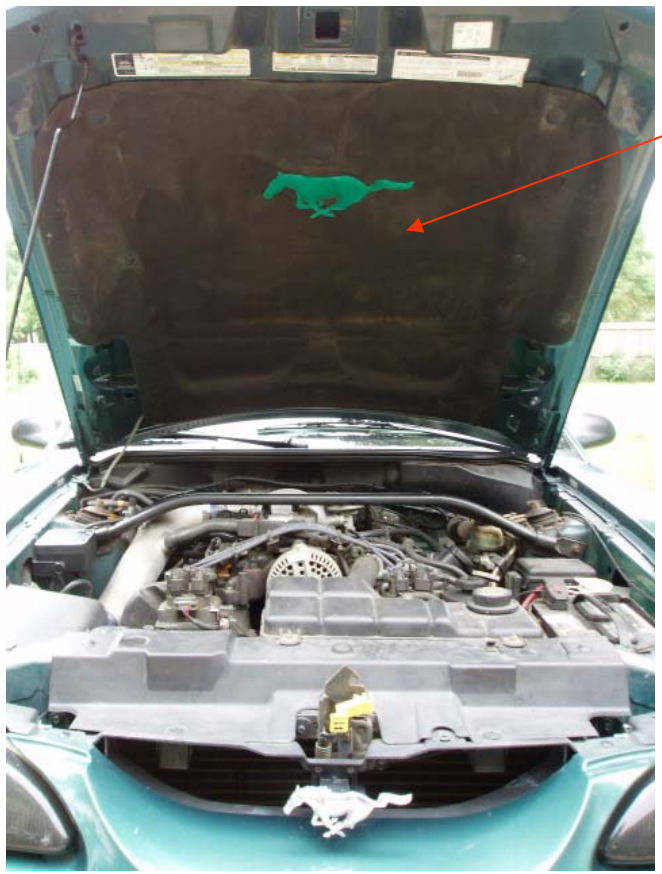
In rollover tests of 20 fuel systems, the following tanks had no leakage when each of the lines to the tank was severed:

- Chrysler Cirrus
- Dodge Neon
- Ford Mustang
- Kia Spectra

# Technology to Prevent Fuel Leakage with Lines Severed



# Fire Properties of Underhood Insulation



2 orders of magnitude difference in flammability

Of 20 tests, vehicles with the best fire resistance properties:

- Dodge Neon
- Ford F-150
- Nissan Frontier
- Mercedes C230*

*with foil surface present

# Results of GM Crash & Burn Fire Tests
## Reported in Earlier SAE Papers

- Underhood fires penetrated the occupant compartment in 10 to 24 minutes
- Principal areas of fire entry
  - Windshield – when hood was damaged
  - Firewall
- Vehicle design may influence penetration time

# Firewalls on Different Vehicles

Large Firewall Openings

Small Firewall Openings

# Vehicles with Different Cowl Designs

Plastic Cowl Burned Away

Metal Cowl with Openings

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# Conclusions - $H_2$ Fuel Tank Fire Tests

- The exclusion radius for no overpressure damage was 150 ft based on fire tests of a type 3 $H_2$ tank without PRD
- Earlier research showed that negligible pressure rise occurred inside a $H_2$ fuel tank exposed to fire
- Some tank designs (type 4) are excellent heat insulators; when exposed to fire, the tank surface temperature rise is not uniform
- The Pressure Relief Device (PRD) needs to work when a $H_2$ fuel tank is exposed to fire – smart sensing may be needed.

# Conclusions – Fire Data Analysis

Frontal crashes produce most fires in both NASS and FARS – about 50%

Rollovers are second with about 25%

There has been an upward trend in FARS frontal fires during 2000-2005

The engine compartment is the origin for 72% of the fires in NASS –

- 93% in frontal
- 66% in rollover

# Conclusions – Fire Data Analysis

Escape time is an important factor in engine compartment fires

Entrapment occurs in about 13% of NASS major fires and 23% of FARS (MHE) fires

About 27% of the crashes with major fires have a CDC 5 or greater extent of damage compared with 6% for all crashes

# Observations

- A lot of fire prevention technology is already on the road
- This technology should be more widely used
- Underhood fire prevention and control should be a significant consideration in vehicle safety designs and materials specifications

# The End

**All research reports referenced in the paper are on our website:**
**mvfri.org**