

Fire Occurrence in Frontal Crashes Based on NASS/CDS

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ABSTRACT

The basis for this analysis was FARS 1979 to 2005 and NASS/CDS 1997 to 2004. For these years, there were 12,493 cases in FARS where fire was coded as the most harmful event. In NASS there were 227 cases with major fires, 87 of which were in frontal crashes.

The paper shows the annual trends in FARS with regard to overall fatalities and fatalities with fire as the most harmful event by direction of principal vehicle damage. The NASS/CDS files are used to determine the location of fire origin. The FARS data show that crashes with frontal damage are the most frequent crash types where fire is the most harmful event. In general, the most harmful event fire rates have declined with the overall fatality rates in FARS. However, in recent years the trend in fires with frontal damage has been on the increase.

Cases in NASS were examined to identify patterns for major fires in frontal crashes. Engine compartment fires were by far the most frequent. The most frequent pattern in the NASS crashes with fires was pre-crash steering/braking followed by run-off-the-road and an impact with a large fixed object. Engine compartment fires with fatalities frequently involved severe frontal damage and occupant entrapment.

INTRODUCTION

The research reported in this paper is a follow-on to projects reported in earlier papers [Digges and Stephenson 2003, 2004, 2005, 2006 and 2007]. Some of the data is based on studies funded by MVFRI [Bahouth, 2006, Kildare, 2006]. This paper presents the results of a continuing analysis of two national data systems – the FARS and the NASS/CDS. An earlier paper attempted to examine the characteristics of rollover crashes in which fires occurred [Digges and Kildare, 2007]. This paper examines the crash factors that are associated with fires that occur after frontal crashes.

The Fatality Analysis Reporting System (FARS) is a database maintained by the US Department of Transportation. It contains records of all fatal crashes that occur on public roads in the United States. The FARS database has been used to document the variations in fatal injuries annually since 1975.

The FARS database documents all fatalities that occurred as a result of the crash including those where a fire resulted. In this paper, the term “FARS Fatalities” designates the fatalities in which a fire occurred in the vehicle, regardless of whether or not the fire caused the fatality. Since 1979, FARS also coded the “most harmful event” (MHE). If the fire event has been coded as the most harmful event, burn or inhalation injuries are the most likely cause of the fatality. In many crashes, it may be difficult to discern the cause of the fatality (biomechanical trauma vs. fire trauma). This distinction was not investigated and the coding was taken directly from FARS.

This paper uses the (NASS/CDS) National Automotive Sampling System/Crashworthiness Data System data to examine the crash factors that are associated with crash induced motor vehicle fires. NASS/CDS is a sample of tow away crashes that occur on US roads each year. The sample is stratified by the severity of the crash. The sample rate for minor crashes is much lower than for severe crashes. In order to expand the stratified sample to the entire population it represents, an inflation factor is assigned to each case in the NASS/CDS sample. When the data is processed using the actual number of cases investigated, the data is referred to as “unweighted” or “raw.” When the data is processed using the total of the inflation factors, the results should represent the total population of vehicles and the data is referred to as “weighted.”

NASS/CDS classifies fires as either Major or Minor. These fire severities are defined as the following:

A Minor Fire is a general term used to describe the degree of fire involvement and is used in the following situations:

- Engine compartment only fire
- Trunk compartment only fire
- Partial passenger compartment only fire
- Undercarriage only fire
- Tire(s) only fire

A Major Fire is defined as those situations where the vehicle experienced a greater fire involvement than defined under “minor” above, and is used in the following situations:

- Total passenger compartment fire (fire limited to the passenger compartment)
- Combined engine and passenger compartment fire

- Combined trunk and passenger compartment fire
- Combined undercarriage and passenger compartment
- Combined tire(s) and passenger compartment

FARS DATA ANALYSIS

An earlier analysis of FARS data examined changes in the rates of fatal crashes with fires over the time period 1979-2000 [Digges, 2003]. The figures presented in the earlier paper showed that the fire rates of vehicles generally decreased during the decade of the 1980's but have remained relatively constant since 1990. To examine these trends, the FARS years were averaged over a five year period. The figures to follow show the five year moving averages for the FARS years beginning in 1979 and ending in 2005. Figure 1 shows the FARS fire rate and FARS MHE fire rate using billions of annual vehicle miles traveled (VMT) as the denominator.

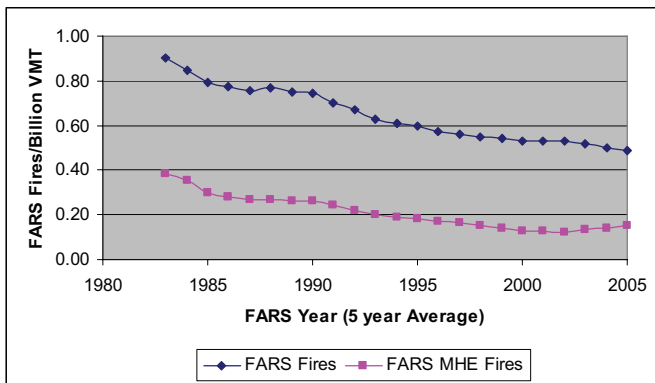


Figure 1. Fatalities in Vehicles with Fires and in Vehicles with Fire as the Most Harmful Event per Billion Vehicle Miles Traveled Annually - FARS

FARS does not record the direction of force in the crash. However, the location of principal damage is coded. In this coding, rollovers with damage from impacts with fixed objects or with other vehicles are coded according to the location of the damage. If the damage comes from ground contact, the crash is classified as a non-collision. Rollovers are classified according to the event during which it occurred (ie. non-rollover, rollover during 1st harmful event, or rollover during subsequent events). Most of the rollovers have damage to the front or sides of the vehicle. This damage may have been caused by impacts with fixed or non-fixed objects before or during the rollover. In some cases, these impacts may have been the cause of the fatality. In the analysis to follow, all rollovers are grouped together, regardless of the area of damage. No crashes with rollover are included in the groupings of front, side or rear damage areas.

The distributions of annual fatalities and fatalities where fire was the MHE are shown in Figures 2 and 3.

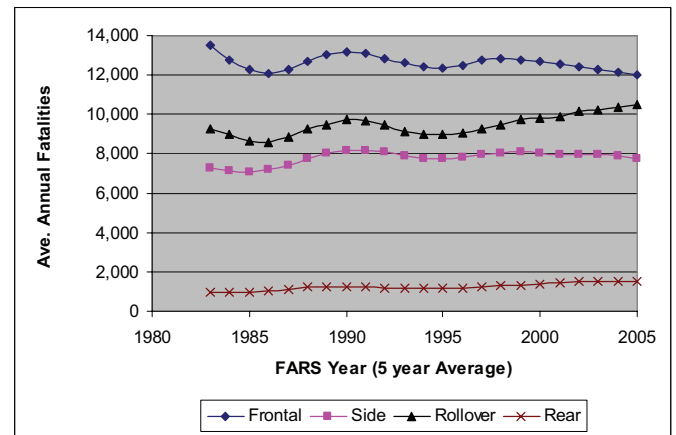


Figure 2. Average Annual Fatalities by Crash Damage Location - FARS 1979 to 2005

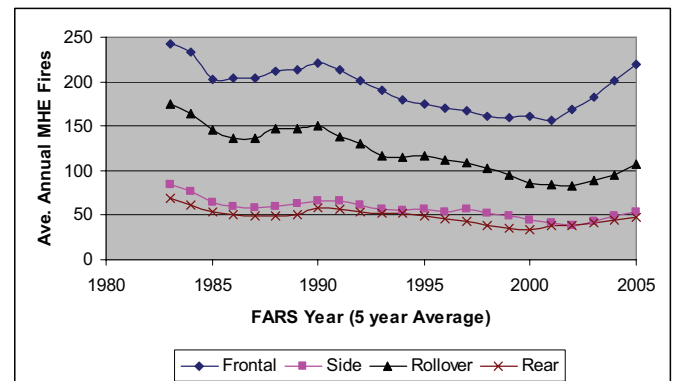


Figure 3. Average Annual Fatalities when Fire was Most Harmful Event by Crash Damage Location - FARS 1979 to 2005

The rate of fire occurrence in frontal crashes versus vehicle age is shown in Figure 4 [Fell 2007].

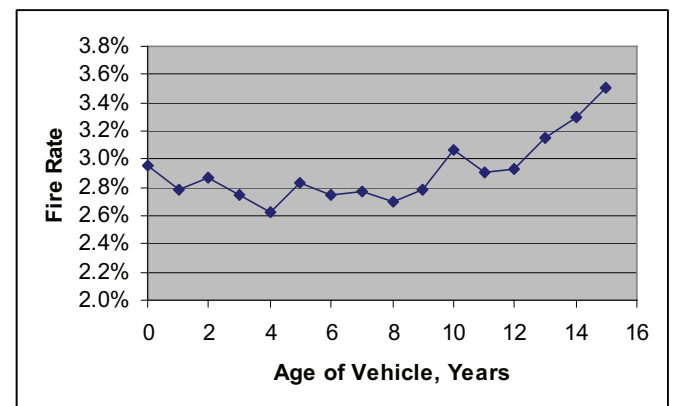


Figure 4. Fire Rate (Fires per Crash Involved Vehicle in FARS) vs. Age of Vehicle - FARS 2000 to 2002

Table 1 shows the damage distribution for the subset of cases with fire as the most harmful event. The data is separated into cases with and without rollovers. The damage in rollover may be caused by the rollover or by objects impacted before or during the rollover. Table 2 shows similar data for entrapment cases where fire was the most harmful event.

Table 1. Distribution of Average Annual Fatalities when Fire was Most Harmful Event by Crash Type and Damage Location – FARS 2000 to 2005

Damage Location	No Rollover	Rollover	Total
Non-Collision	2.1%	3.3%	5.4%
Front	45.8%	14.5%	60.3%
Right	5.8%	2.5%	8.3%
Rear	9.4%	2.0%	11.4%
Left	5.6%	2.1%	7.8%
Top	0.4%	1.4%	1.9%
Undercarriage	1.0%	0.6%	1.6%
Unknown	1.7%	1.7%	3.4%
Total	71.8%	28.2%	100.0%

Table 2. Entrapment Percentage for each Crash Type when Fire was Most Harmful Event by Damage Location and Rollover Presence– FARS 2000 to 2005

Damage Location	No Rollover	Rollover	Total
Non-Collision	18%	23%	21%
Front	23%	25%	23%
Right	21%	22%	21%
Rear	28%	28%	28%
Left	27%	20%	25%
Top	22%	19%	20%
Undercarriage	21%	18%	20%
Unknown	15%	15%	15%
Average of All	23%	23%	23%

NASS ANALYSIS OF FRONTAL CRASHES

Figure 5 provides a comparison of crash damage location for FARS cases with fire as MHE and NASS cases with major fires. The NASS data is weighted so that it represents the distribution that occurs in tow-away crashes on the US highways. It is not possible to determine the fire origin from the FARS data, but it is sometimes available from the NASS data. A study of the NASS cases with major fires provides insights into crashes that present fire injury risks to occupants.

Figure 6 displays a comparison of the distribution of all crashes in NASS/CDS and those with major fires, by crash direction. About 25% of the NASS weighted cases display complexities of the crash mode so that they do not fit into the categories of frontal, side, rear and rollover. These cases were excluded from the data in Figure 6. In view of the high frequency of fires in frontal crashes, that crash mode was selected for further analysis using NASS. In the analysis to follow, only frontal crashes without rollovers will be considered. Frontal crashes with rollovers and all rollovers with fires were analyzed in an earlier paper [Digges and Kildare, 2007].

Earlier studies have found that the rate of crash induced fires increases with vehicle age [Fell 2007]. The analysis by Fell indicates that fire rates in FARS crashes

increases with vehicles age past nine years, as shown in Figure 4. To reduce the influence of vehicle age, this paper analyzes cases of major fires in frontal crashes in vehicles that were less than 10 years old. The NASS years 1997 to 2005 were used. Consequently, the oldest vehicles in the frontal crash study would be 1988 models that crashed in the NASS year 1997.

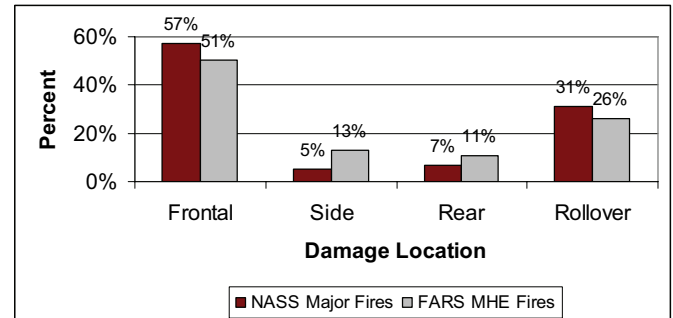


Figure 5. Distribution of Crashes with Fires by Damage Location for Major Fires in NASS/CDS 1997-2005 and MHE Fires in FARS 1997-2005

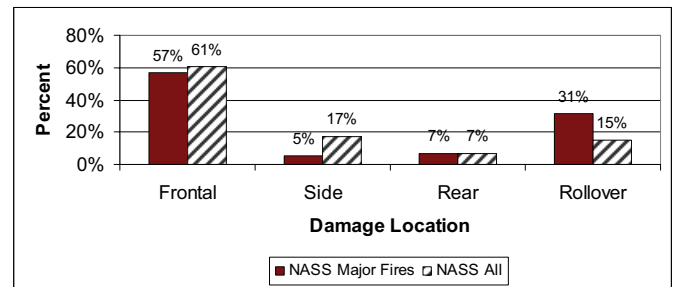


Figure 6. Distribution of Crashes and Crashes with Major Fires by Damage Location in NASS/CDS 1997-2005

Figures 7 through 12 present distributions of frontal crash data on fire origin, fuel leakage location, entrapment, object contacted, extent (depth) of vehicle damage and type (width) of vehicle damage. The data is based on NASS/CDS 1997 to 2005 and it contains 87 cases of major fires in vehicles less than 10 years old. When weighted, these cases expand to 10,337. The standard error for this size NASS population is about 2,300 or 23% [NHTSA 2001].

The data set contains 29 fatalities that expand to 1,386 when weighted. Fatalities are rare events that are difficult to capture in a limited sample such as NASS. A comparison of fatalities in frontal crashes with major fires in NASS and FARS for the time period 1997 to 2005 found that NASS predicted only 85% of the fatalities that were predicted by FARS. Figure 5, compares the frequency of major and harmful fires in the two data sources. Frontal crashes account for more than 50% of the fires in each database.

Figures 7 through 12 show the distributions of vehicles in frontal crashes with major fires and with major fires and fatalities, based on NASS.