Analysis of Fire Related Crash Fatalities and Crashed Vehicle Rescue Times

George Bahouth, D.Sc.

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Purpose:

The objective of this study is to provide real world data to characterize crash involved populations, rescue timing and crash characteristics for occupants to evaluate the benefit of increased fire protection following a crash event. During the analysis a number of FARS data queries were performed to evaluate the crash direction in all crashes with fires and crashes with fires as the most harmful event. The tables of data from the FARS queries for vehicle damage location are contained in the Appendix A. Appendix B contains data on occupant extraction and crash direction. Appendix C contains data on rollovers.

Summary of Findings:

The information presented here includes an analysis of the National Fire Incident Reporting System (NFIRS), the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System- General Estimates System (NASS/GES) databases. Due to the fact that no single database provided all data points required for this study, a selection of information from each database is provided when appropriate.

Below, a summary of each relevant population is presented here while more detailed breakdowns of each population are provided within the results section of this document. 2002 calendar year data from the NFIRS, FARS and GES data systems were the primary sources of data for this study. Key findings to date are:

1. **15,393,064** occupants were involved in police reported motor vehicle crashes
2. NFIRS reports **68,202** motor vehicle fires occurred (**329,500** for National Population)
3. NFIRS reports **7,343** crash involved motor vehicle fires (**34,894** for National Population)
4. GES reports **15,788** crash involved motor vehicle fires
5. NFIRS reports **40,637** occupants were extricated from vehicles- injured and uninjured (**196,667** for National Population)
6. NASS/CDS reports **106,676** occupants were extricated from vehicles (pinned and non-pinned, injured and uninjured)
7. From crash time to rescue time, 25% of the crash population in urban areas receive rescue care within **5 minutes,** 50% receive rescue care within **8 minutes** while 75% receive rescue care within **12 minutes** of a crash based on fatality information
8. From crash time to rescue time, 25% of the crash population in rural areas receive rescue care within **9 minutes,** 50% receive rescue care within **15 minutes** while

75% receive rescue care within **24 minutes** of a crash based on fatality information

9. The distribution of extrications (occupant entrapment) was investigated versus crash severity. For frontal crashes, nearly 50% of the entrapments occurred during crashes with a deltaV of **17 mph** or less. **16 mph** for nearside crashes, **20 mph** for farside crashes and **16 mph** for rear impacts.

Background:

According to the Federal Emergency Management Agency (FEMA), 329,500 fires occurred in motor vehicles in 2002. This information is based on a national survey of fire departments collected annually by the National Fire Protection Agency (NFPA). This data provides national estimates describing fire rescue service activities for fire and rescue events. On average, fires occurred during 4.4% of motor vehicle crashes where fatalities are involved and between 400 and 500 deaths are attributed to fire/smoke inhalation injuries.

Current Federal Motor Vehicle Safety Standards address the Integrity of Fuel Systems (FMVSS 301) and the Flammability of Interior Materials (FMVSS 302) to reduce the risk of fire ignition and limit flame propagation in the event of a motor vehicle crash. These standards are effective in limiting the likelihood of ignition and burning before occupants can exit a crash involved or non-crash involved vehicle; however, in many cases vehicles are severely deformed and entrapment may occur. Further, injured occupants may not be conscious or physically capable of exiting the vehicle under their own power following a crash.

Earlier research conducted under the GM/DoT C/K Pickup Settlement Agreement found that technology exists to delay the penetration of fire into the occupant compartment of vehicles; however, the value of providing additional time was not determined. The project summarized here explores this research area. In particular, the value of increased fire protection time and reduced egress time are evaluated in terms of the populations these changes would effect.

Data Sources:

A number of data systems exist that contain crash, occupant and vehicle information as well as fire and rescue related data. These databases include the National Fire Information Registry System (NFIRS), the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System- General Estimates System (NASS/GES).

NFIRS Database:

The National Fire Incident Reporting System (NFIRS) contains fire and rescue related information as reported by fire stations. This data is used to evaluate the magnitude and trends of the US fire problem and to characterize required rescue resources around the country. Recent data provided by the US Fire Administration (NFIRS 5.0) reports the

activities related to all aspects of a fire department including fire personnel activities as well as activities of EMS that may be part of the fire station. For this study, NFIRS data was used to establish the distribution of rescue times for both rural and urban areas and to describe crash and non-crash involved populations requiring extrication.

The information for each NFIRS case is reported by fire and rescue personnel from a subset of all fire stations around the country. Following case collection, each event type within NFIRS is assigned a weighting ratio which inflates case counts to national estimates. These inflation or weighting factors are based on case counts from the National Fire Protection Administration (NFPA) annual survey. Approximately 1/3 of all fire stations contribute case information to the NFIRS database. Because NFIRS is a registry of all types of fire related events (i.e. building fires, forest fires and motor vehicle fires) only a subset of reported cases are motor vehicle related.

Although the system is not a random sample, the NFIRS contains data on roughly 1 out of every 2.2 estimated residential structure fires in the U.S., 1 of every 2.7 deaths, and 1 of every 2.1 injuries. For motor vehicle fires, every 1 out 4.8 events are captured within the database. It is believed that the distribution of participating fire departments is reasonably representative of all fire departments in the U.S. The NFPA survey is based on a stratified random sample of fire departments in the U.S. The sample is stratified by the size of community protected by the department. The NFPA makes national projections by weighting sample results according to the proportion of total U.S. population accounted for by communities of each size.

Reporting of EMS activities has been a recent addition to the data system since NFIRS 5.0 (2000 and later). Because 60% of EMS crews within urban locations and 40% of EMS crews in rural areas are part of fire stations, not all EMS crews report to the NFIRS system. Since the NFPA survey only considers fire station activities, a complete survey of EMS activities does not exist. The NFIRS data and NFPA estimates procedures do not allow for national projection to be made of EMS activities. For this reason, EMS reporting from NFIRS is not considered representative of EMS at the national level; however trends and population characteristics are valid for those EMS crews who do report to NFIRS.

NFIRS Rescue Time Information

Recent evaluations have indicated that significant variation in reported versus actual rescue times may exist in some databases listed above. This variability may result from instructions which do not specify repeatable or well defined events for time recording. In order to extract rescue times, the following data points were used. This rescue timing is required for every case entered into the NFIRS system.

Arrival Date

If the date that the first fire department personnel arrived on-scene was the same as the Alarm Date, just check the box provided. Otherwise, enter the numeric designation for the month, day and year. Arrival date should be the same as Last Unit Cleared if cancelled on the way to a call. Do not check the box if the Alarm Time was before midnight and the Arrival Time was after midnight. Required for all incidents.

Arrival Time

Always enter the time of day that the first fire department personnel arrived on-scene. Use military time. Required for all incidents.

Controlled Date

(Leave blank except for fires) For fires, enter the date that the fire was determined by the incident commander to be under control. If the date that the fire was controlled was the same as the Alarm Date, just check the box provided. Do not check the box if the Controlled Date was after midnight and the Alarm Date was before Midnight. Required for wild land fires; optional for other fires; otherwise leave blank.

Controlled Time

(Leave blank except for fires) For fires, enter the time of day that the fire was determined by the incident commander to be under control. Use military time. Required for wild land fires; optional for other fires; otherwise leave blank.

Last Unit Cleared Date

If the date that the last fire department personnel left the scene was the same as the Alarm Date, just check the box provided. Do not check the box if the incident extended (from the Alarm Time to the Clear Time) across midnight. Required for all incidents.

Last Unit Cleared Time

Always enter the time of day that the last fire department personnel left the scene. Use military time. If cancelled en route, enter the time of cancellation in this space. Required for all incidents.

Often, rescue times are established based on accurate times recorded by dispatch services while other times are estimated by first providers. Each method involves some degree of uncertainty with respect to the accuracy of information recorded. If the information is collected as on-scene providers radio to dispatch that they have arrived on scene, some variability may result although a protocol exists concerning the moment this notification is made. The definition of the time where an incident has been controlled is also an area

of uncertainty. The exact time when a fire has been completely extinguished is somewhat subjective for both vehicle and structural fires. This trend exists for the point that an injured occupant is considered stable as well. Additionally, variation exists between rescue systems in terms of the time spent providing care to crash involved occupants on-scene. In order to quantify the distribution of crashes versus time to hospital care, the nature of this variation must be defined. Studies have shown that these estimates are often rounded but do not exhibit any particular biasing.

FARS Database

The Fatality Analysis Reporting System (FARS) is a census of all motor vehicle crashes where one or more occupants are fatally injured. FARS data is collected by NHTSA to evaluate trends in crash occurrences and effectiveness of safety programs. To be included in FARS, a crash must involve a motor vehicle traveling on a public road, and must result in the death of an occupant of a vehicle or a non-motorist within 30 days of the crash. Case data is based on information contained within police accident reports, rescue reports, coroner and medical examiner data as well as driver records (licenses, registration files, etc.). Within FARS, only basic information regarding crash configuration and accident severity are available as reported by police. No formal crash investigation is performed by FARS personnel. Because FARS is a census of all fatality involved crashes, case data is not weighted to project to national estimates.

For this study, FARS rescue data characterizing crash time, notification time and rescue arrival time was used. This data is based on police estimates of crash time and recorded EMS data regarding Notification and Arrival times. The population of fatal crashes where entrapment and fire has occurred was evaluated as well to help identify the population who may directly benefit from increased fire protection and/or decreased crash notification and rescue time.

For the FARS analysis, extrication refers to the use of equipment or other force to remove persons from the vehicles; i.e., more than just lifting or carrying person out of wreckage. This definition differs somewhat from entrapment as defined by NASS/CDS.

Results:

The following steps have been used to evaluate the distribution of rescue times from motor vehicle crash time to rescue arrival. Times have been further correlated with crash location (rural vs. urban), the occurrence of fire related and non-fire related injuries as well as overall injury severity.

1. Identify populations and key characteristics of crash occupants by:
    a. Urban vs. rural crash occurrence
    b. Fire vs. non-fire involved events
    c. Injury vs. Non-injury crashes
    d. Occupants requiring extrication vs. non-extricated individuals

2. Determine time duration between crash occurrence and arrival of first providers on-scene. Data points required are:
    a. Crash time to Notification Time
    b. Notification to Arrival Time
3. Identify the relative proportion of occupants who currently receive care during a series of time intervals
    a. Evaluate populations where decreased rescue time would improve occupant care.

Fire Involved Fatalities

From 2001 to 2003, over 1200 fatalities have been attributed to fire related injuries. Of these, nearly 28% required extrication. This corresponds to approximately 120 occupant deaths each year. Table 1 below shows occupant fatality counts per year where fire or explosions were considered the most harmful event for fatal crash cases for fatal crashes FARS. It can be seen that approximately 110 occupants die due to fire related injuries where extrication is required. These fatally injured occupants may benefit from extended fire suppression time.

Table 1
FARS Fire Crash Counts, Fire Related Fatalities, Fatal Crashes where Extrication is required.

	Occupant Fatality Counts			
FARS Year	Total Occupant Fatalities	Fire or Explosion Occurred	Fire/Explosion as Most Harmful Event	Fatal Occupant Required Extrication
1997	42,013	1,490	436	98
1998	41,501	1,612	352	67
1999	41,717	1,631	354	102
2000	41,945	1,707	411	114
2001	42,196	1,629	410	124
2002	42,815	1,688	473	127
2003	42,643	1,594	496	134
Total	294,830	11,351	2,932	766
Annual Count	**42,119**	**1,622**	**419**	****109**

****26.1% of fire related deaths**

Table 2
NFIRS Vehicle Fire/Crash Counts.

Incident Type	NFIRS 2002 Incident Count	NFPA Survey Count	National Estimate	GES Estimate
Passenger vehicle fire	68,084	329,500	329,500	
Vehicle accident with injuries	282,283		1,366,140	
Extrication of victim(s) from vehicle	25,357		122,718	
Passenger Vehicle Fires Due to Collision	7,343		34,894	15,788

Entrapment and Injury During Crashes

One primary goal of this study was to quantify the following populations:

- Occupants involved in crashes where no restriction to egress, no physical restriction to occupants exists
- Occupants involved in crashes where restriction to egress, no physical restriction to occupants exists
- Occupants involved in crashes where no restriction to egress, physical restriction to occupants exists
- Occupants involved in crashes where restriction to egress, physical restriction to occupants exists

Due to the fact that no single data source contains all of the above information for the complete crash population, a combination of data elements shown in Table 3 below. The total number of occupants involved in crashes who are not entrapped is based on NASS/GES data. Based on the KABCO scale, B (Non-Incapacitation evident injury), C (Non-Incapacitating) and O (uninjured) populations are considered uninjured, while K (killed), A (Incapacitating) make up the injured population. Because NASS/GES data does not indicate entrapment, NASS/CDS populations are listed for the entrapped group. For the injured population, MAIS2 and higher injuries are included. Regarding entrapment, the following definitions are considered entrapped:

Entrapped/pinned- mechanically restrained - is used when this occupant was physically restrained in the seat position by an intruding vehicle component. The occupant could not move from the post impact position without some part of the vehicle being cut away, bent or moved.

Could not exit vehicle due to jammed doors, fire, etc.- is used when this occupant could not exit the vehicle due to jammed door(s), roof collapse, etc. This occupant however could move about within the vehicle.

Table 3
Entrapment versus Injury (NASS/GES and CDS Data Combined).

	Not-Entrapped	Entrapped
Uninjured (B,C,O Injuries)	13,609,410	64,090
Injured (K,A Injuries or MAIS2+ Injured)	378,354	40,549

Figure 1 below shows the relationship between crash severity and entrapment. It should be noted that this graph shows the cumulative percent of entrapped occupants by deltaV for frontal, nearside, farside and rear impacts. 50% of the entrapped occupants are involved in crashes with deltaV's of 17, 16 20 and 16 mph for each crash mode respectively. This indicates that even moderate crashes (under 20 mph deltaV) experience a high percentage of entrapments. The deltaV indicates the amount of crash energy absorbed by the vehicle and should not be interpreted purely as impact speed.

As stated above, the definition of entrapment used here includes occupants who are pinned or in a collapsed portion of a vehicle, as well as occupants whose doors are jammed. Many of these occupants will not be injured and can easily exit from another door. Figure 2 shows the cumulative percent of MAIS3+ injured occupants versus deltaV. By 20 mph, 48%, 47%, 55% and 31% of the MAIS3+ injuries have occurred for frontal, nearside, farside and rear impacts.

Figure 1- NASS/CDS 2002 Crash Data- Cumulative percent occupant entrapment vs. DeltaV.

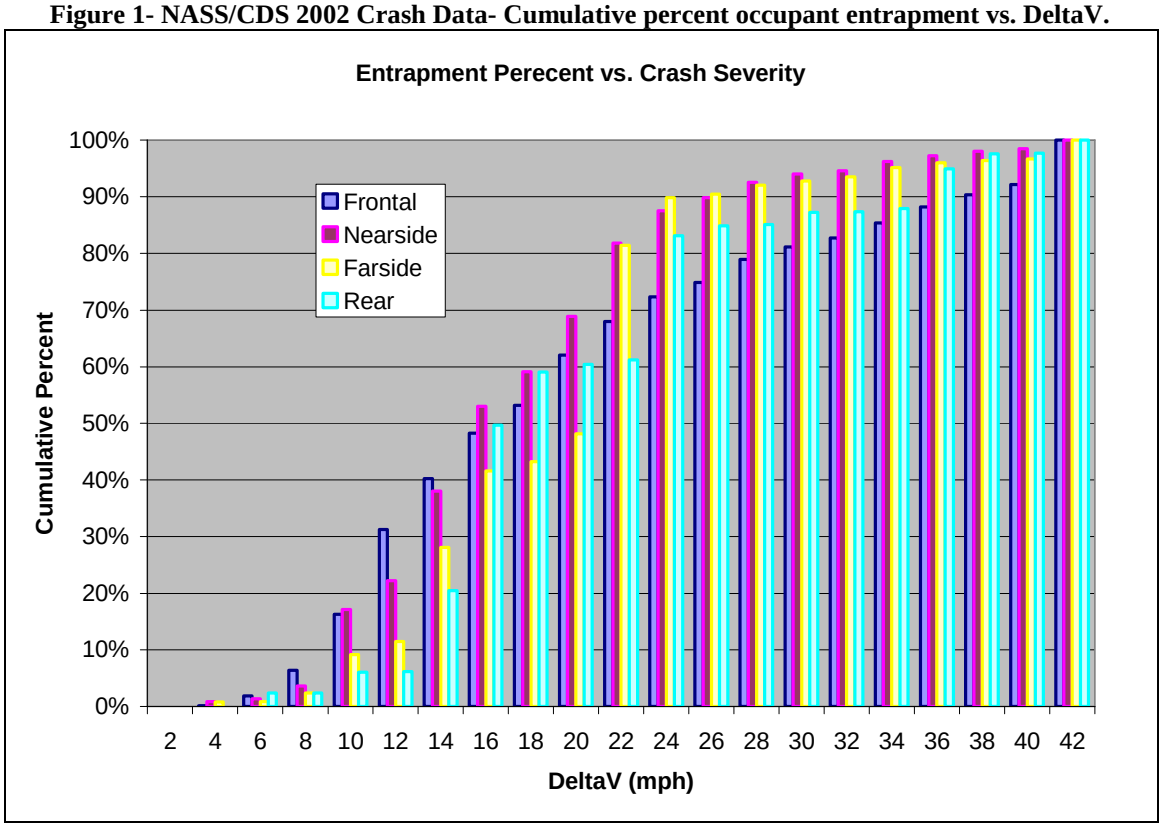
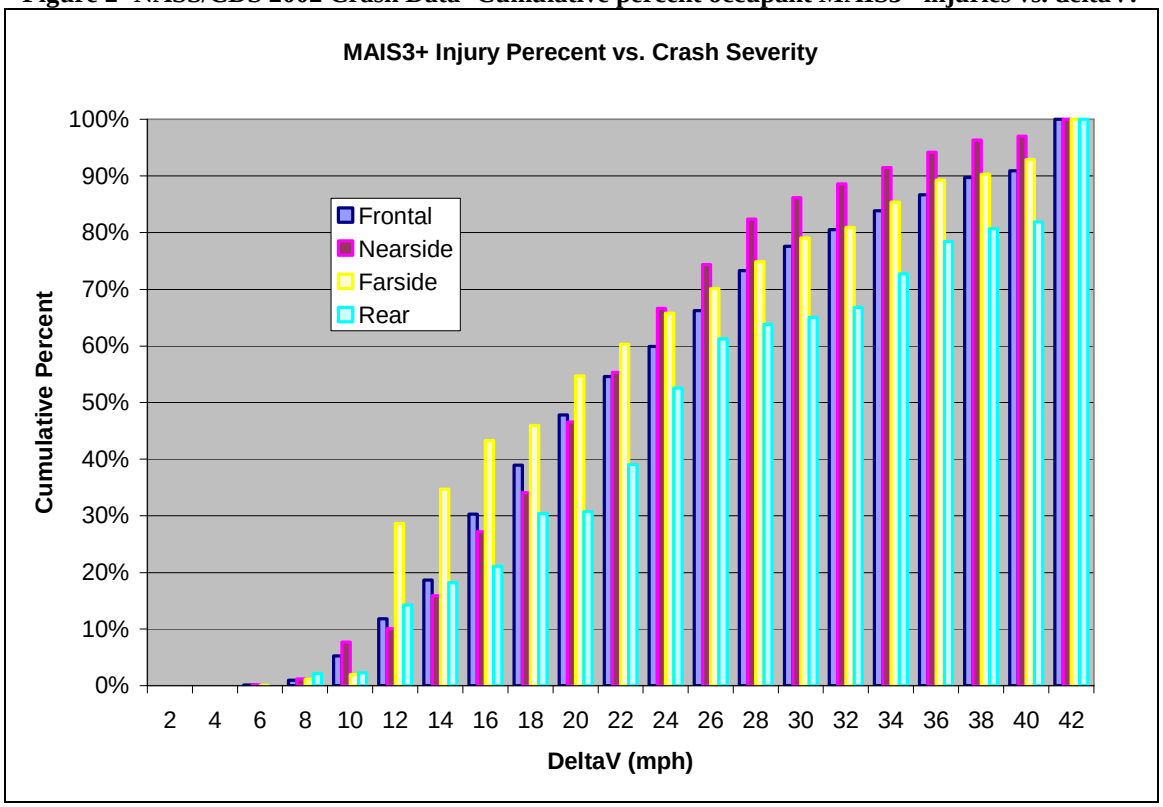


Figure 2- NASS/CDS 2002 Crash Data- Cumulative percent occupant MAIS3+ injuries vs. deltaV.



Determination of Time Intervals for Existing Rescue System

In order to evaluate the distribution of the time typically elapsed following a crash before rescue arrives, information regarding crash time, notification time and rescue arrival are necessary. Information describing actual crash time is not recorded because not reliable method exists to capture these times.

1. Occupants involved in crashes may not immediately contact first responders because the situation may not warrant urgent attention
2. Occupants may be incapacitated where use of cellular technology is not possible
3. Occupants may not have access to a telephone, cellular phone or Automatic Crash Notification Technology.
4. A number of data systems exist that document crash characteristics and even the progression of rescue from the point that the event occurs, however few provide an indication of the crash time.

Analysis of NFIRS case data was conducted to understand rescue time differences between rural and urban crash locations. Based on census tract information recorded for cases listed in the NFIRS database, each crash was assigned a Rural/Urban Commuting Area Code (RUCA). These codes have been developed and implemented by the US Department of Agriculture and the US Census to further distinguish urbanization changes at a higher resolution than classifications by zip code. Each RUCA code definition is shown below.

RUCA Codes:

1- Metropolitan-area core: primary flow within an urbanized area (UA)
2- Metropolitan-area high commuting: primary flow 30% or more to a UA
3- Metropolitan-area low commuting: primary flow 5% to 30% to a UA
4- Large town core: primary flow within a place of 10,000 to 49,999
5- Large town high commuting: primary flow 30% or more to a place of 10,000 to 49,999
6- Large town low commuting: primary flow 5% to 30% to a place of 10,000 to 49,999
7- Small town core: primary flow within a place of 2,500 to 9,999 7.0 No additional code
8- Small town high commuting: primary flow 30% or more to a place of 2,500 to 9,999
9- Small town low commuting: primary flow 5% to 30% to a place of 2,500 to 9,999
10- Rural areas: primary flow to a tract without a place of 2,500 or more

Table 4 below shows the average crash time to notification time for rural versus urban regions. As shown, NFIRS does not provide an estimate of crash or event time. Based on FARS data, the average time from crash to notification for fatal crashes is 11.4 minutes in urban areas and 17.4 minutes in rural areas. It should be stressed that these are average times, therefore the magnitude of the population at or above this time are significant. Further, the tail section of the population distribution shown in Figure 3 is quite long indicating that a significant number of occupant crash notifications do not occur for quite some time beyond the averages shown here.

When the Average Notification to Arrival Time for the NFIRS population is compared to the FARS populations, it can be seen that the average time for the urban and rural populations are similar from one dataset to another. In Table 5, a total crash to rescue arrival value is presented. In order to calculate this value for the NFIRS population, the average crash time to notification times were added to the notification to rescue arrival for the urban and rural populations. When the average crash to rescue arrival for urban populations is compared, the NFIRS and FARS times are similar. When the average crash to rescue arrival for rural populations is compared, the FARS times are somewhat longer in the rural areas. This suggests that rescue time may influence the likelihood of fatality for remote crash victims when compared to victims in less-remote urban areas.

During the calculation of these mean rescue times, time data was limited to notification within 12 hours of the event.

Table 4
Average Crash to Notification, Notification to Rescue Arrival Times per Geographic Region Type (NFIRS 2002, FARS 1997-2003).

Region/Datasource	Average Crash to Notification Time (min)	Lower 95% CLM	Upper 95% CLM	Average Notification Time to Arrival Time (min)	Lower 95% CLM	Upper 95% CLM
NFIRS Urban	Unk	Unk	Unk	5.7	5.6	5.8
NFIRS Rural	Unk	Unk	Unk	6.8	6.6	7.0
FARS Urban	11.4	11.2	11.7	6.3	6.2	6.3
FARS Rural	17.4	17.1	17.6	7.3	6.8	7.8

Table 5
Crash Time to Rescue Arrival Time (NFIRS estimate uses FARS Crash to Notification information to calculate total time from crash to rescue).

Region/Datasource	Crash to Arrival (min)	Lower 95% CLM	Upper 95% CLM
NFIRS Urban	17.2		
NFIRS Rural	24.2		
FARS Urban	18.3	18.0	18.6
FARS Rural	29.2	28.9	29.5

As shown in Table 6, the distribution of rescue times for rural populations from notification time to rescue arrival time indicate that 25% of the crash population receives rescue care within 4 minutes, 50% receive rescue care within 7 minutes while 75% receive rescue care within 10 minutes of notification time (6, 9 and 14 minutes respectively for the fatal population). The distribution of rescue times for urban populations from notification time to rescue arrival time indicate that 25% of the crash population receives rescue care within 3 minutes, 50% receive rescue care within 5 minutes while 75% receive rescue care within 8 minutes of notification time (same times for the fatal population). In Table 7, it should be noted that the time 25% of the population does not received rescue care within 12 minutes from crash time in urban areas and 24 minutes in rural areas. This distribution with time can be seen in Figure 4 as well for each geographic region type.

Table 6
Notification to Rescue Arrival Time: Minutes Passed before Rescue Arrival per Crash Population Segment.

Population Percent	NFIRS Urban Time (min)	NFIRS Rural Time (min)	FARS Urban Time (min)	FARS Rural Time (min)
10%	2	2	2	3
25% Q1	3	4	3	6
50% Median	5	7	5	9
75% Q3	8	10	8	14
90%	11	15	11	21

Table 7
Crash Occurrence to Rescue Arrival Time: Minutes Passed before Rescue Arrival Per Crash Population Segment

Population Percent	FARS Urban Time (min)	FARS Rural Time (min)
10%	3	6
25% Q1	5	9
50% Median	8	15
75% Q3	12	24
90%	21	38

Figure 3- FARS 1997-2003 Crash time to notification time

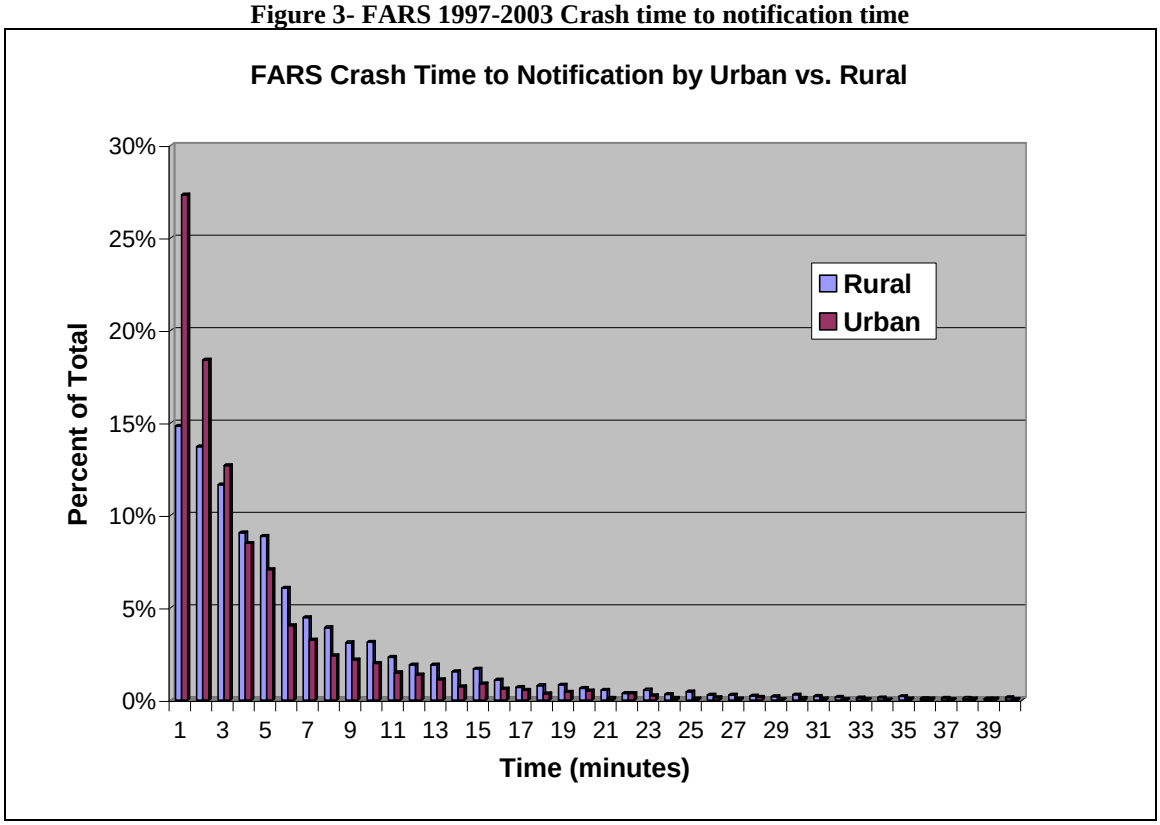


Figure 4- FARS 1997-2003 Crash Time to Rescue Arrival Time

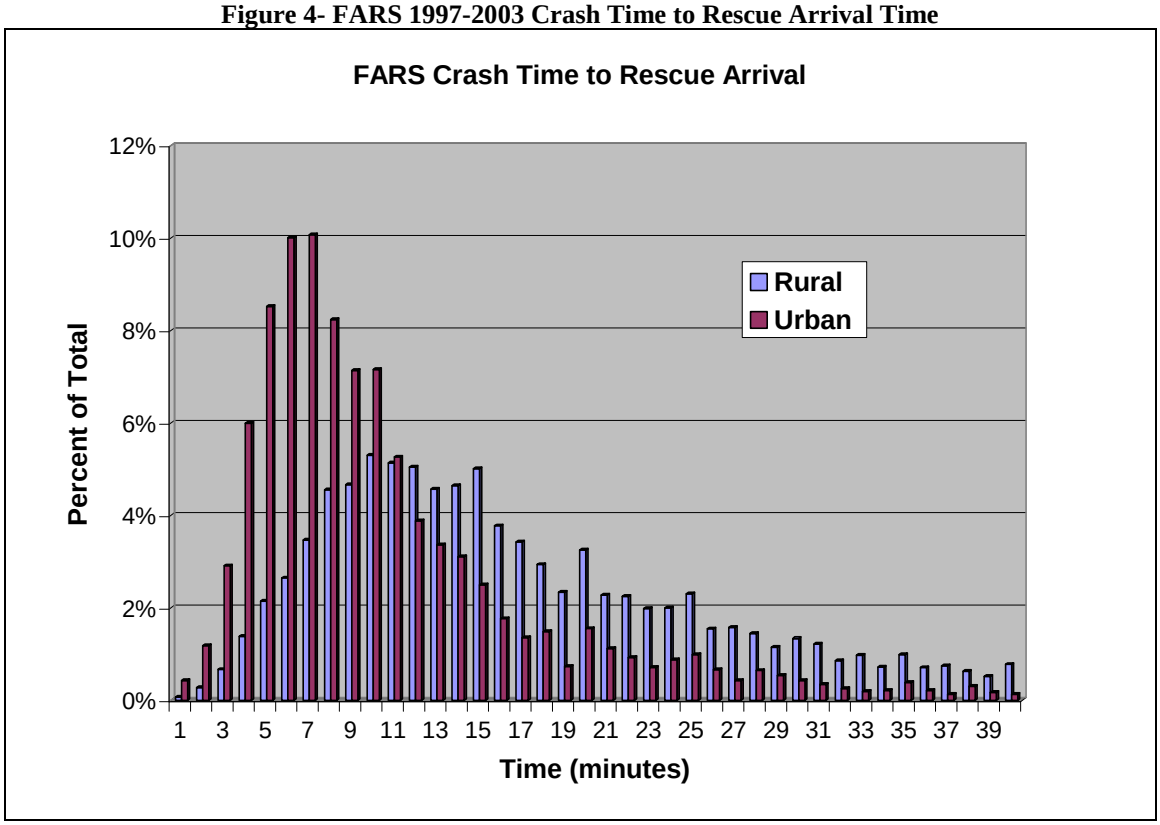
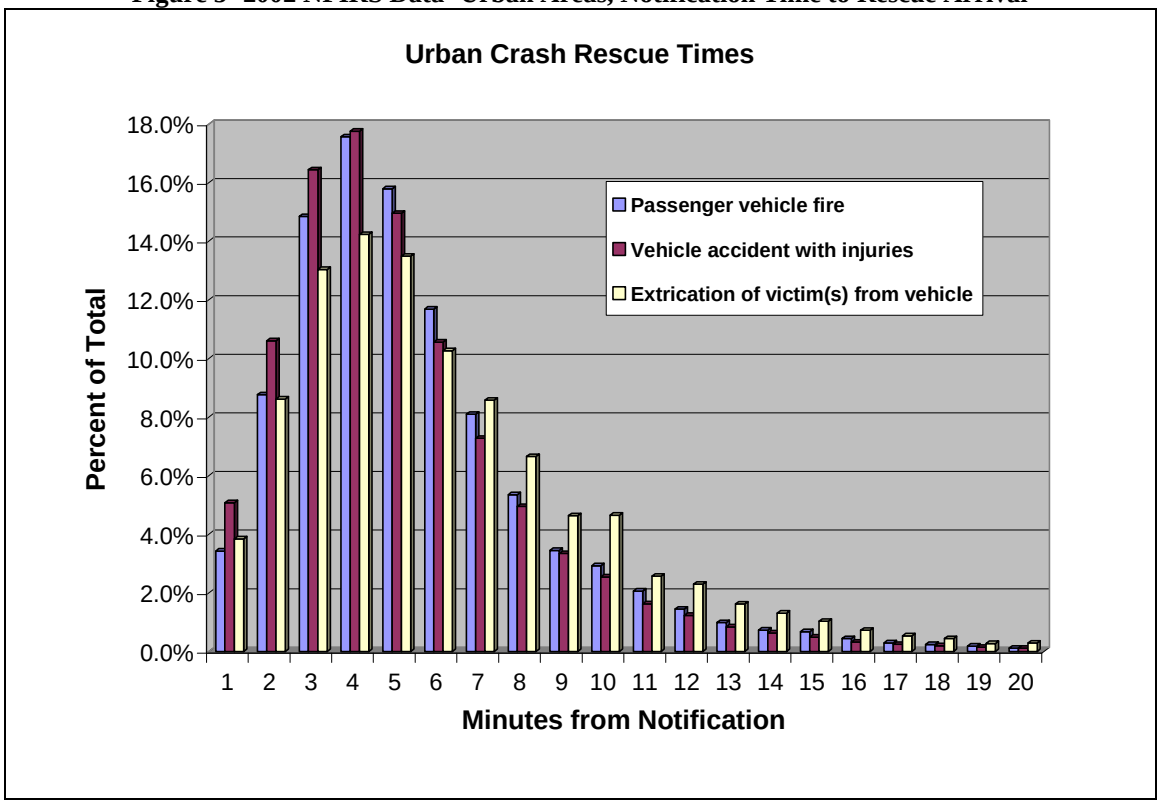


Figure 5- 2002 NFIRS Data- Urban Areas, Notification Time to Rescue Arrival



Figures 5, 6 and 7 identify the distribution of times from crash notification to rescue arrival for non-fatal crashes. The distribution show time intervals reported within NFIRS for passenger vehicle fire cases, vehicle accidents with injuries and crashes where extrication of occupants is required. It should be noted that the nature of the event does not significantly effect the time taken for rescue providers to reach a crash victim with the exception of vehicle extrications. The distribution of rescue time is somewhat longer for these cases.

Figure 6- 2002 NFIRS Data- Large Rural Areas, Notification Time to Rescue Arrival

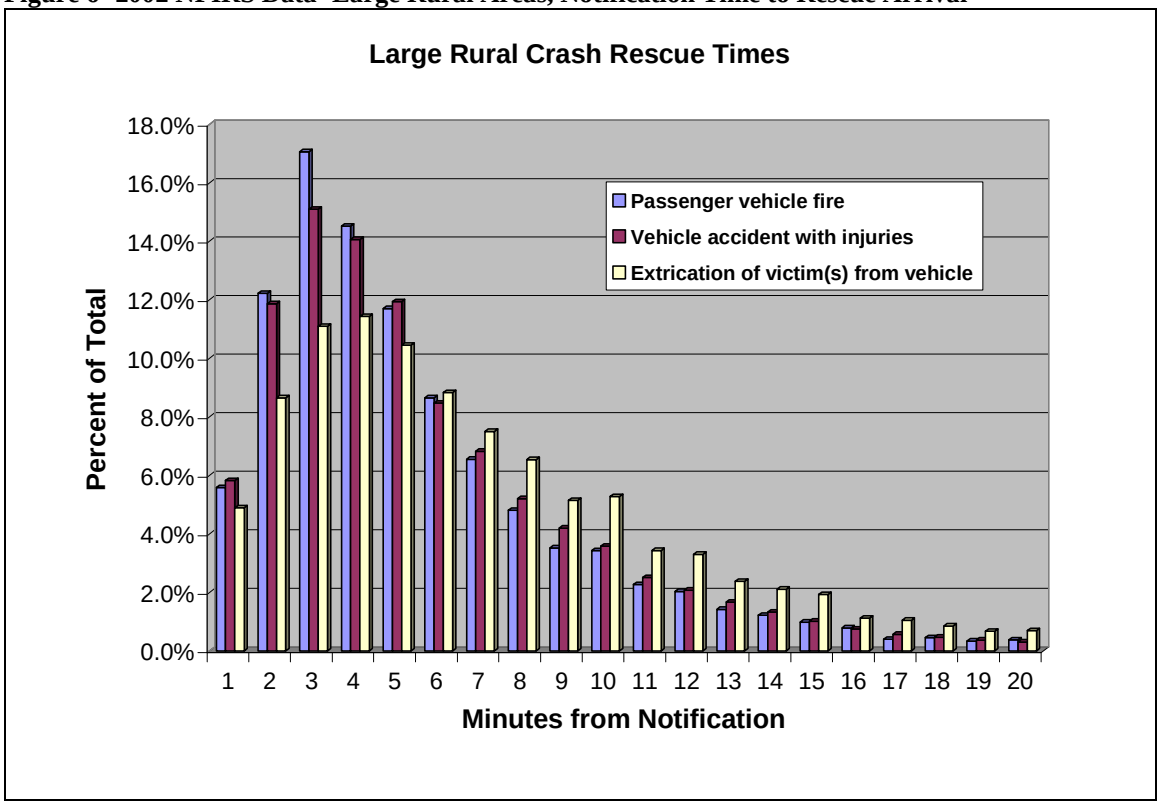
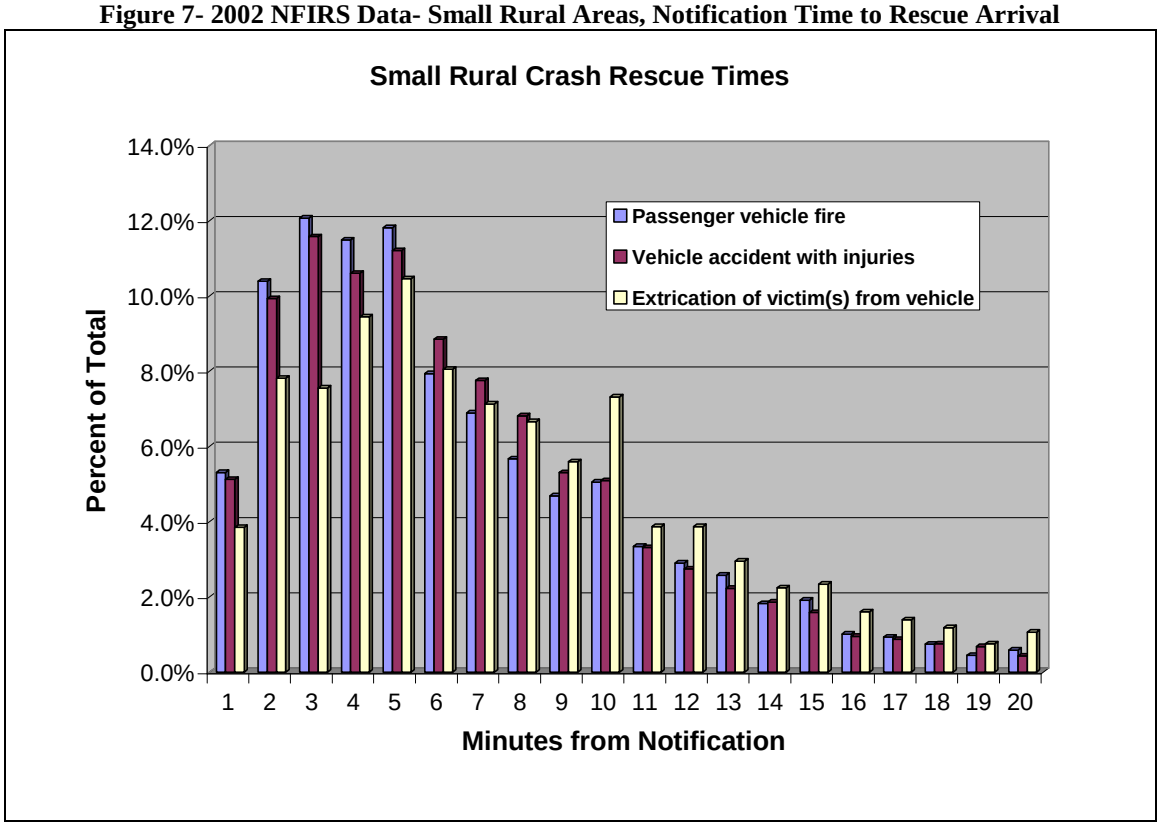


Figure 7- 2002 NFIRS Data- Small Rural Areas, Notification Time to Rescue Arrival



Conclusions:

Based on this evaluation of the NFIRS data system, the FARS crash case data and their usability to identify the current distribution of rescue times across various geographical areas, the following conclusions can be made:

1. Extrication is required for about 25% of fatal fire involved crashes corresponding to approximately 110 potential lives affected by level of fire protection offered by vehicles.
2. The average time from crash event to notification for urban areas is 18.3 minutes and for rural areas, it is 29.2 minutes based on FARS estimates.
3. The mean time from notification to rescue arrival is shown in Table 8 (repeated Table 4) below for the FARS and NFIRS datasets.

Table 8
Average Crash to Notification, Notification to Rescue Arrival Times per Geographic Region Type (NFIRS 2002, FARS 1997-2003).

Region/Datasource	Average Crash to Notification Time (min)	Lower 95% CLM	Upper 95% CLM	Average Notification Time to Arrival Time (min)	Lower 95% CLM	Upper 95% CLM
NFIRS Urban	Unk	Unk	Unk	5.7	5.6	5.8
NFIRS Rural	Unk	Unk	Unk	6.8	6.6	7.0
FARS Urban	11.4	11.2	11.7	6.3	6.2	6.3
FARS Rural	17.4	17.1	17.6	7.3	6.8	7.8

4. When NFIRS time from notification to rescue arrival is compared with FARS data, the urban data is very similar in distribution indicating that this data may be somewhat reliable. (Figures 8 and 9 below show the differences in NFIRS and FARS Notification to rescue times)

Figure 8- Urban crash notification to rescue arrival times, NFIRS vs. FARS data.

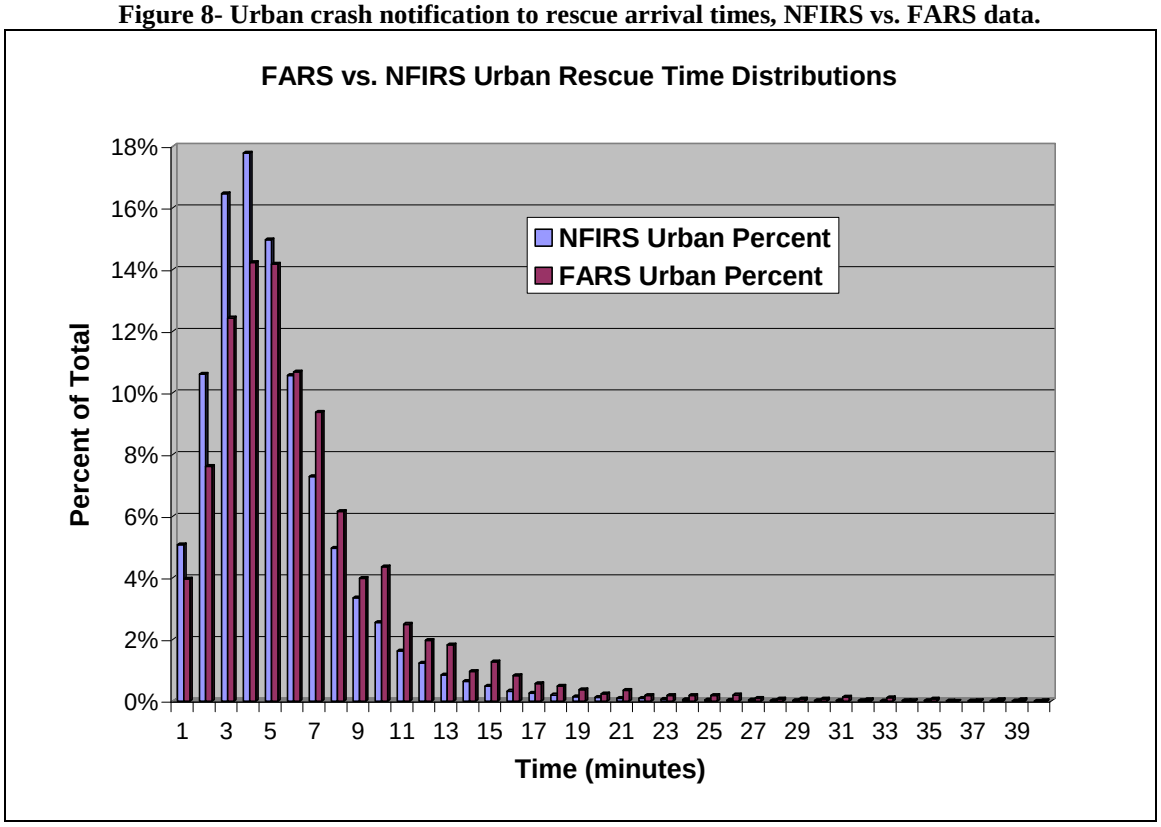
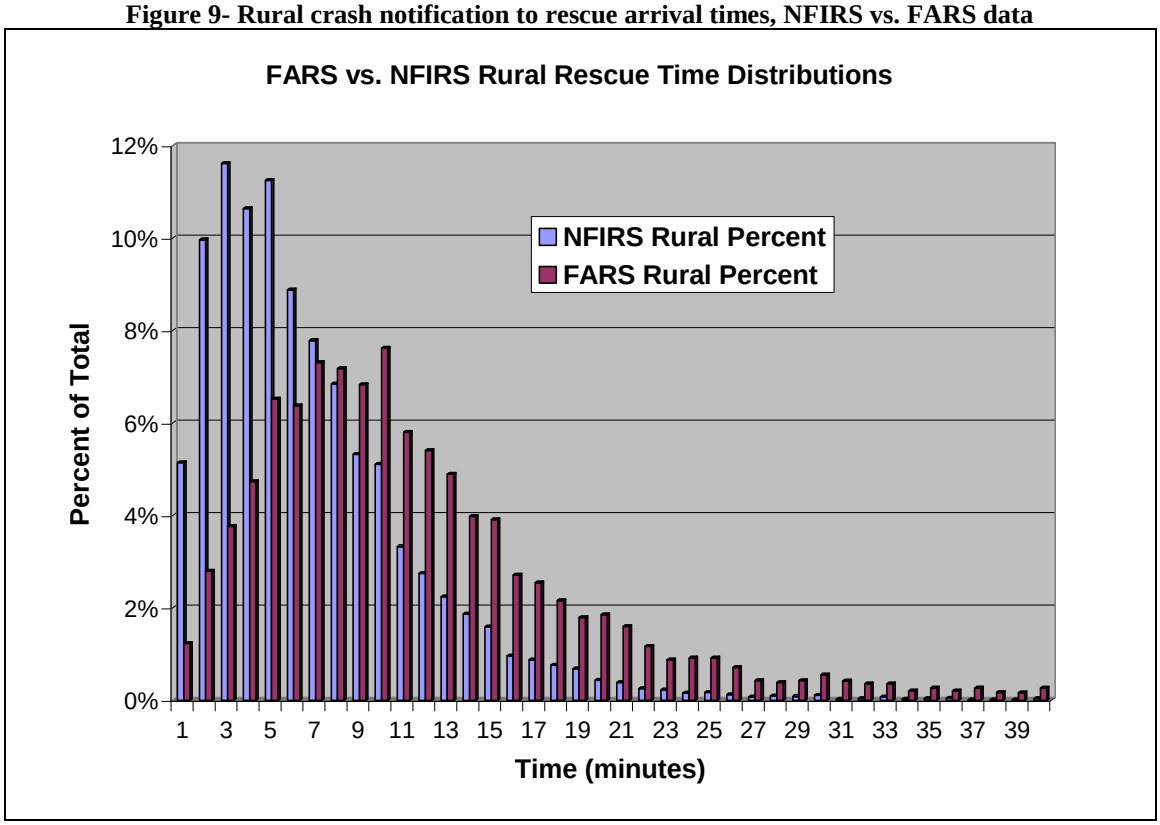


Figure 9- Rural crash notification to rescue arrival times, NFIRS vs. FARS data



5. When NFIRS time from notification to rescue arrival is compared with FARS data, the rural data indicates a significantly longer time for FARS data (see Fig 9). This result may be a function of three phenomena:
    a. Time to rescue may effect survivability of crashes where fatal crashes may have notably longer rescue times.
    b. Fire department time to arrival reporting may be skewed in favor of faster arrival.
    c. The RUCA classification systems may not have 1:1 correspondence between URBAN and RURAL regions when compared with FARS roadway classification.
6. The distribution of rescue time for vehicle extrication cases is somewhat longer than vehicle fire and vehicle crash with injury cases. It is possible that many of these cases are deemed non-urgent because typically occupants do not report injuries and no fire is immediately evident during crash notification. The development of vehicle fires at some time after a crash should be considered while assessing the benefit of increased fire suppression during these events.
7. Classification of fire ignition source and cause of fire is unclear based on findings to date. A review of ignition factors is required to understand which categories are associated with crash events. Additional clarification is required from NFPA personnel.

APPENDIX A – FARS FIRE DATA 1979 to 2005 BY DAMAGE AREA

FARS Fire Data - All Damage Areas				
Year	All Fatal	All	All Fire	MHE Fire
1979	35,017	35,017	1,575	640
1980	34,961	34,961	1,457	717
1981	33,755	33,755	1,512	659
1982	29,708	29,708	1,338	566
1983	29,201	29,201	1,225	457
1984	30,116	30,116	1,287	437
1985	29,901	29,901	1,216	360
1986	32,261	32,261	1,567	572
1987	33,190	33,190	1,455	539
1988	34,114	34,114	1,591	575
1989	33,614	33,614	1,411	463
1990	32,693	32,693	1,423	466
1991	30,776	30,776	1,418	466
1992	29,485	29,485	1,308	391
1993	30,077	30,077	1,333	404
1994	30,901	30,901	1,383	388
1995	31,991	31,991	1,428	440
1996	32,438	32,438	1,296	386
1997	32,448	32,448	1,337	381
1998	31,899	31,899	1,415	284
1999	32,127	32,127	1,433	296
2000	32,225	32,225	1,509	366
2001	32,043	32,043	1,454	356
2002	32,598	32,598	1,480	407
2003	31,904	31,904	1,378	419
2004	31,693	31,693	1,328	482

Note: MHE indicates the Most Harmful Event for the crashed vehicle as coded in the FARS file. One can not assume that the most harmful event for a vehicle was the cause of any death or injury for any specific individual within the vehicle.

FARS Fire Data - Rollovers					Fire &	MHE	MHE
Year	All Fatal	No Roll	Roll	All Fire	Rollover	All Fire	Rollover
1979	35,017	25,351	9,666	1,575	442	640	187
1980	34,961	24,721	10,240	1,457	412	717	205
1981	33,755	23,955	9,800	1,512	439	659	210
1982	29,708	21,410	8,298	1,338	363	566	155
1983	29,201	20,962	8,239	1,225	311	457	114
1984	30,116	21,619	8,497	1,287	351	437	133
1985	29,901	21,617	8,284	1,216	305	360	113
1986	32,261	22,787	9,474	1,567	440	572	167
1987	33,190	23,389	9,801	1,455	387	539	154
1988	34,114	23,976	10,138	1,591	423	575	173
1989	33,614	23,925	9,689	1,411	356	463	129
1990	32,693	23,074	9,619	1,423	362	466	125
1991	30,776	21,518	9,258	1,418	357	466	112
1992	29,485	20,849	8,636	1,308	341	391	113
1993	30,077	21,516	8,561	1,333	318	404	105
1994	30,901	21,920	8,981	1,383	345	388	118
1995	31,991	22,454	9,537	1,428	368	440	134
1996	32,438	22,814	9,624	1,296	338	386	87
1997	32,448	22,921	9,527	1,337	324	381	97
1998	31,899	22,126	9,773	1,415	358	284	77
1999	32,127	21,987	10,140	1,433	384	296	83
2000	32,225	22,266	9,959	1,509	379	366	85
2001	32,043	21,886	10,157	1,454	391	356	79
2002	32,598	21,932	10,666	1,480	384	407	92
2003	31,904	21,528	10,376	1,378	413	419	105
2004	31,693	21,140	10,553	1,328	352	482	111
2005	31,415	20,599	10,816	1,469	406	576	152

FARS Fire Data - Frontal Damage					Fire &	MHE	MHE
Year	All Fatal	No Frontal	Frontal	All Fire	Frontal	All Fire	Frontal
1979	35,017	19,770	15,247	1,575	679	640	242
1980	34,961	19,972	14,989	1,457	644	717	307
1981	33,755	20,066	13,689	1,512	608	659	235
1982	29,708	17,636	12,072	1,338	575	566	247
1983	29,201	17,722	11,479	1,225	517	457	184
1984	30,116	18,454	11,662	1,287	523	437	193
1985	29,901	17,494	12,407	1,216	572	360	157
1986	32,261	19,564	12,697	1,567	656	572	239
1987	33,190	20,034	13,156	1,455	617	539	246
1988	34,114	20,606	13,508	1,591	701	575	225
1989	33,614	20,080	13,534	1,411	662	463	197
1990	32,693	19,601	13,092	1,423	678	466	194
1991	30,776	18,617	12,159	1,418	658	466	207
1992	29,485	17,646	11,839	1,308	635	391	178
1993	30,077	17,632	12,445	1,333	675	404	173
1994	30,901	18,390	12,511	1,383	664	388	144
1995	31,991	19,223	12,768	1,428	691	440	169
1996	32,438	19,420	13,018	1,296	634	386	186
1997	32,448	19,329	13,119	1,337	665	381	165
1998	31,899	19,239	12,660	1,415	726	284	140
1999	32,127	19,923	12,204	1,433	675	296	138
2000	32,225	19,768	12,457	1,509	791	366	180
2001	32,043	19,730	12,313	1,454	712	356	163
2002	32,598	20,289	12,309	1,480	760	407	221
2003	31,904	19,868	12,036	1,378	641	419	211
2004	31,693	19,989	11,704	1,328	652	482	233
2005	31,415	19,857	11,558	1,469	719	576	272
2005	31,415	20,599	10,816	1,469	406	576	152

FARS Fire Data - Rear Damage					Fire &	MHE	MHE
Year	All Fatal	No Rear	Rear	All Fire	Rear	All Fire	Rear
1979	35,017	34,069	948	1,575	156	640	75
1980	34,961	34,012	949	1,457	126	717	71
1981	33,755	32,677	1,078	1,512	142	659	82
1982	29,708	28,828	880	1,338	89	566	62
1983	29,201	28,275	926	1,225	93	457	57
1984	30,116	29,178	938	1,287	105	437	38
1985	29,901	28,791	1,110	1,216	93	360	29
1986	32,261	31,019	1,242	1,567	142	572	66
1987	33,190	31,829	1,361	1,455	140	539	55
1988	34,114	32,731	1,383	1,591	136	575	59
1989	33,614	32,401	1,213	1,411	96	463	47
1990	32,693	31,544	1,149	1,423	100	466	65
1991	30,776	29,687	1,089	1,418	97	466	55
1992	29,485	28,392	1,093	1,308	82	391	46
1993	30,077	28,936	1,141	1,333	84	404	44
1994	30,901	29,658	1,243	1,383	118	388	49
1995	31,991	30,793	1,198	1,428	77	440	50
1996	32,438	31,120	1,318	1,296	81	386	39
1997	32,448	31,098	1,350	1,337	91	381	36
1998	31,899	30,501	1,398	1,415	96	284	21
1999	32,127	30,722	1,405	1,433	102	296	28
2000	32,225	30,738	1,487	1,509	91	366	45
2001	32,043	30,491	1,552	1,454	128	356	59
2002	32,598	31,045	1,553	1,480	83	407	35
2003	31,904	30,421	1,483	1,378	105	419	39
2004	31,693	30,315	1,378	1,328	87	482	45
2005	31,415	30,003	1,412	1,469	105	576	60
2005	31,415	20,599	10,816	1,469	406	576	152

FARS Fire Data - Right Damage					Fire &	MHE	MHE
Year	All Fatal	No Right	Right	All Fire	Right	All Fire	Right
1979	35,017	31,072	3,945	1,575	120	640	55
1980	34,961	31,104	3,857	1,457	117	717	58
1981	33,755	30,016	3,739	1,512	131	659	49
1982	29,708	26,212	3,496	1,338	125	566	47
1983	29,201	25,786	3,415	1,225	109	457	26
1984	30,116	26,303	3,813	1,287	128	437	28
1985	29,901	26,044	3,857	1,216	114	360	26
1986	32,261	28,299	3,962	1,567	144	572	42
1987	33,190	29,255	3,935	1,455	132	539	33
1988	34,114	29,873	4,241	1,591	151	575	48
1989	33,614	29,371	4,243	1,411	133	463	29
1990	32,693	28,653	4,040	1,423	136	466	33
1991	30,776	27,000	3,776	1,418	128	466	30
1992	29,485	25,786	3,699	1,308	117	391	18
1993	30,077	26,418	3,659	1,333	96	404	30
1994	30,901	27,130	3,771	1,383	120	388	27
1995	31,991	28,126	3,865	1,428	148	440	39
1996	32,438	28,468	3,970	1,296	100	386	21
1997	32,448	28,528	3,920	1,337	113	381	30
1998	31,899	28,230	3,669	1,415	99	284	16
1999	32,127	28,493	3,634	1,433	108	296	13
2000	32,225	28,423	3,802	1,509	114	366	23
2001	32,043	28,369	3,674	1,454	95	356	17
2002	32,598	28,974	3,624	1,480	113	407	28
2003	31,904	28,202	3,702	1,378	92	419	25
2004	31,693	28,028	3,665	1,328	117	482	50
2005	31,415	27,989	3,426	1,469	95	576	36
2005	31,415	20,599	10,816	1,469	406	576	152

FARS Fire Data - Left Damage					Fire &	MHE	MHE
Year	All Fatal	No Left	Left	All Fire	Left	All Fire	Left
1979	35,017	31,014	4,003	1,575	107	640	42
1980	34,961	31,123	3,838	1,457	109	717	44
1981	33,755	30,210	3,545	1,512	84	659	42
1982	29,708	26,470	3,238	1,338	67	566	19
1983	29,201	25,926	3,275	1,225	104	457	43
1984	30,116	26,582	3,534	1,287	97	437	24
1985	29,901	26,389	3,512	1,216	91	360	19
1986	32,261	28,424	3,837	1,567	105	572	22
1987	33,190	29,219	3,971	1,455	103	539	27
1988	34,114	29,950	4,164	1,591	115	575	31
1989	33,614	29,330	4,284	1,411	112	463	37
1990	32,693	28,514	4,179	1,423	100	466	25
1991	30,776	26,801	3,975	1,418	134	466	36
1992	29,485	25,701	3,784	1,308	92	391	21
1993	30,077	26,298	3,779	1,333	105	404	27
1994	30,901	26,885	4,016	1,383	97	388	29
1995	31,991	27,687	4,304	1,428	105	440	23
1996	32,438	28,231	4,207	1,296	102	386	33
1997	32,448	28,204	4,244	1,337	104	381	24
1998	31,899	27,735	4,164	1,415	95	284	17
1999	32,127	27,704	4,423	1,433	133	296	26
2000	32,225	27,959	4,266	1,509	90	366	17
2001	32,043	27,900	4,143	1,454	96	356	22
2002	32,598	28,307	4,291	1,480	90	407	15
2003	31,904	27,685	4,219	1,378	96	419	25
2004	31,693	27,487	4,206	1,328	89	482	24
2005	31,415	27,480	3,935	1,469	90	576	26
2005	31,415	20,599	10,816	1,469	406	576	152

APPENDIX B – FARS FIRE DATA FOR EXTRACTION AND ROLLOVER

Crashes Where Fire Occurred: Occupant Fatality Count by Impact Direction (principal impact point)								
		Crashes with no Rollover						
Year	No Collision	Front	Right	Rear	Left	Top	Undercarrage	Unknown
1994	11	761	125	118	101	5	14	15
1995	7	792	159	80	115	5	10	26
1996	8	722	107	82	104	10	5	25
1997	20	731	121	94	110	6	8	21
1998	9	829	104	104	105	11	9	25
1999	4	777	113	106	138	8	3	28
2000	10	893	119	94	92	5	12	28
2001	14	811	101	129	104	6	5	15
2002	9	860	118	87	97	7	8	42
2003	11	764	97	109	100	2	6	29

		Crashes with Rollover						
Year	No Collision	Front	Right	Rear	Left	Top	Undercarrage	Unknown
1994	44	209	44	17	23	27	8	25
1995	51	242	30	27	31	16	9	19
1996	41	214	50	21	21	20	6	9
1997	44	203	38	18	21	27	10	18
1998	60	208	37	18	30	30	11	22
1999	60	238	33	19	25	43	6	30
2000	71	230	29	23	39	31	8	23
2001	72	214	37	20	39	25	8	29
2002	85	237	35	20	34	18	11	20
2003	74	232	45	23	47	24	5	26

Fire Crashes Requiring Extrication Where Fire Occurred: Occupant Fatality Count by Impact Direction (principal impact point)

Year	No Collision	Crashes with no Rollover					Undercarrage	Unknown
		Front	Right	Rear	Left	Top		
1994	0	143	30	23	17	2	6	0
1995	0	164	27	15	17	0	2	4
1996	0	161	11	15	21	1	0	4
1997	10	197	24	21	23	3	1	3
1998	0	213	26	31	18	0	0	6
1999	0	187	19	29	41	4	1	8
2000	0	265	28	33	31	2	3	2
2001	4	241	31	38	29	2	1	4
2002	0	248	27	30	32	2	1	11
2003	2	227	26	40	32	0	2	9

Year	No Collision	Crashes with Rollover					Undercarrage	Unknown
		Front	Right	Rear	Left	Top		
1994	1	32	10	2	6	3	1	0
1995	12	39	9	14	4	3	1	3
1996	6	39	4	4	2	1	3	4
1997	5	39	6	6	3	3	2	5
1998	7	40	10	4	4	6	1	0
1999	7	65	2	5	7	9	1	7
2000	12	52	6	9	11	8	1	1
2001	14	62	12	6	7	9	0	3
2002	11	68	5	5	7	6	4	4
2003	7	59	9	3	12	4	1	6

Crashes With Fire as MHE: Occupant Fatality Count by Impact Direction (principal impact point)								
		Crashes with no Rollover						
Year	No Collision	Front	Right	Rear	Left	Top	Undercarrage	Unknown
1994	7	174	27	49	30	0	12	3
1995	6	197	40	50	25	3	7	15
1996	8	206	24	40	33	6	2	6
1997	19	185	31	37	26	0	7	10
1998	9	177	16	23	18	1	4	6
1999	4	160	14	28	27	3	1	6
2000	9	192	23	47	18	0	4	4
2001	11	187	18	59	23	1	2	6
2002	8	253	30	36	16	3	3	5
2003	9	249	26	39	28	1	1	12

		Crashes with Rollover						
Year	No Collision	Front	Right	Rear	Left	Top	Undercarrage	Unknown
1994	18	63	20	13	5	12	3	10
1995	15	99	5	15	14	8	3	10
1996	8	62	9	11	7	4	4	2
1997	10	65	16	7	8	3	4	8
1998	12	43	13	6	10	3	6	5
1999	9	53	10	8	11	8	3	9
2000	12	67	6	5	7	9	1	7
2001	22	53	9	4	3	3	1	8
2002	23	60	10	4	10	3	2	7
2003	13	62	10	12	16	9	1	8

Fire Crashes Requiring Extrication With Fire as MHE: Occupant Fatality Count by Impact Direction (principal impact point)

Year	No Collision	Crashes with no Rollover					Undercarrage	Unknown
		Front	Right	Rear	Left	Top		
1994	0	37	8	10	5	0	5	0
1995	0	33	8	15	2	0	0	0
1996	0	33	1	2	4	1	0	0
1997	10	40	7	6	6	0	1	1
1998	0	34	3	10	4	0	0	1
1999	0	40	2	9	11	2	0	3
2000	0	45	5	23	8	0	3	1
2001	4	56	2	17	6	1	0	2
2002	0	70	7	10	7	0	0	0
2003	2	63	9	13	12	0	0	3

Year	No Collision	Crashes with Rollover					Undercarrage	Unknown
		Front	Right	Rear	Left	Top		
1994	1	7	6	0	3	0	0	0
1995	7	16	1	10	2	1	1	3
1996	3	8	0	2	0	1	2	0
1997	3	12	4	4	0	1	1	2
1998	2	8	4	0	0	0	1	0
1999	0	21	0	2	4	5	0	3
2000	5	15	2	2	3	2	0	0
2001	7	22	3	1	2	0	0	1
2002	1	24	2	1	3	1	0	1
2003	3	22	2	2	1	1	0	1

APPENDIX C – FARS DATA ON ROLLOVERS

Rollover and Non-Rollover Passenger Vehicle Deaths by Crash Year and Impact Direction (principal impact point FARS 1979-2005)

Crashes with no Rollovers

Year	Non-Collision	Front	Right	Rear	Left	Top	Under-carriage	Other	Unk.
1979	429	15,247	3,945	792	4,003	258	114	170	393
1980	469	14,989	3,857	768	3,838	199	73	96	432
1981	457	13,689	3,739	829	3,545	139	82	153	1,322
1982	425	12,072	3,496	667	3,238	174	93	162	1,083
1983	530	11,479	3,415	701	3,275	204	102	148	1,108
1984	500	11,662	3,813	700	3,534	151	65	162	1,032
1985	462	12,407	3,857	849	3,512	177	70	157	126
1986	751	12,697	3,962	930	3,837	187	87	157	179
1987	709	13,156	3,935	1,024	3,971	178	75	152	189
1988	335	13,508	4,241	1,048	4,164	206	104	153	217
1989	329	13,534	4,243	900	4,284	195	68	148	224
1990	281	13,092	4,040	857	4,179	137	70	157	261
1991	296	12,159	3,776	759	3,975	149	70	128	206
1992	221	11,839	3,699	757	3,784	143	65	129	212
1993	289	12,445	3,659	837	3,779	110	80	145	172
1994	266	12,511	3,771	888	4,016	165	65	-	238
1995	252	12,768	3,865	846	4,304	164	58	-	197
1996	213	13,018	3,970	946	4,207	148	90	-	222
1997	242	13,119	3,920	969	4,244	143	76	-	208
1998	218	12,660	3,669	976	4,164	136	64	-	239
1999	239	12,204	3,634	1,008	4,423	131	54	-	294
2000	217	12,457	3,802	1,040	4,266	133	85	-	266
2001	224	12,313	3,674	1,106	4,143	150	67	-	209
2002	227	12,309	3,624	1,086	4,291	144	60	-	191
2003	204	12,036	3,702	1,051	4,219	95	54	-	167
2004	175	11,704	3,665	954	4,206	170	67	5	194
2005	188	11,558	3,426	955	3,935	194	70	44	229

Rollover and Non-Rollover Passenger Vehicle Deaths by Crash Year and Impact Direction (principal impact point FARS 1979-2005)

Crashes with Rollovers

Year	Non-Collision	Front	Right	Rear	Left	Top	Under-carriage	Other	Unk.
1979	1,835	1,724	645	156	665	4,239	50	1	351
1980	3,144	2,362	595	181	620	3,015	97	-	226
1981	3,167	2,509	642	249	572	2,070	155	5	431
1982	2,639	2,417	538	213	479	1,522	143	3	344
1983	2,752	2,485	604	225	513	1,133	158	27	342
1984	2,717	2,674	652	238	576	1,133	143	8	356
1985	2,697	2,587	631	261	556	1,210	171	8	163
1986	3,117	3,160	722	312	636	1,148	197	4	178
1987	3,361	2,978	754	337	598	1,318	226	14	215
1988	3,379	3,135	726	335	683	1,363	236	7	274
1989	3,042	3,226	801	313	686	973	233	11	404
1990	2,976	3,416	815	292	778	636	251	3	452
1991	2,790	3,242	711	330	743	846	256	12	328
1992	2,480	3,125	690	336	674	800	200	17	314
1993	2,590	3,037	787	304	667	710	201	4	261
1994	2,623	3,251	762	355	686	673	185	-	446
1995	2,724	3,588	878	352	781	548	232	-	434
1996	2,888	3,443	916	372	802	561	227	-	415
1997	2,746	3,432	789	381	806	688	238	-	447
1998	2,838	3,360	838	422	876	760	188	-	491
1999	3,047	3,340	822	397	833	949	235	-	517
2000	3,076	3,371	791	447	794	867	202	-	411
2001	3,071	3,693	836	446	831	664	241	-	375
2002	3,240	3,826	875	467	854	737	234	-	433
2003	3,142	3,699	962	432	903	637	200	-	401
2004	2,626	3,882	928	424	984	993	222	15	479
2005	2,497	3,933	921	457	938	1,342	157	20	551