Fire Safety Library

and

Data Analysis

Automotive and Fire Safety Research

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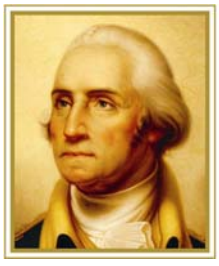
January 2005



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This report is submitted by the FHWA/NHTSA National Crash Analysis Center at The George Washington University to the Motor Vehicle Fire Research Institute. The report is the fulfillment of tasks associated with a contract with the Motor Vehicle Fire Research Institute. This report includes submission of a crash query tool, a detailed crash data analysis, and a fire safety library. The deliverables include development, documentation and delivery of an automated tool for fire crash case analysis, summaries of fire crash data analyses of NASS/CDS 1994-2002 data, and clinical case reviews of fire/fuel spill crashes.

The body of this report is divided into three main sections: automated crash query tool, analysis of historical crash data, and a literature review. Firstly, the development and usage of the automated crash query tool are described. The tool can be found and utilized at www.ox.ncac.gwu.edu.

The second section of this report presents historical data, analysis and conclusions regarding several aspects of motor vehicle fires. Presented separately will be five crash data topics: (1) crashes with fires; (2) rollover crashes with fires; (3) engine compartment fires; (4) engine compartment fires with occupant entrapment; and (5) damage profiles vs. fire occurrence. As subdivisions to these topics, several issues are presented and analyzed. Those include fire severity (minor/major fire), fire origin (tank, engine compartment, etc), fuel tank location, fuel leak and fuel leak location, body type vs. fire severity, and crash mode vs. fire severity. Clinical case reviews have been conducted to understand fire occurrence in more detail. These reviews are grouped and categorized at the end of this section.

Finally, a compilation of literature and resources regarding fire, motor vehicle fires, and fire safety is submitted. This compilation serves as a comprehensive list of articles and resources related to fire and fire safety. In conjunction with this collection, a library of fire crash test data, reports, and videos are available through the NCAC library. A list of those data, test reports, and test videos housed at the NCAC library is also provided.

I. Automated Crash Query Tool

A crash query and case summary reporting tool has been developed to help researchers quickly and easily review historical crash data that has been collected through the NASS/CDS. This is a web based query tool capable of compiling cases via specific crash characteristics or on a case-by-case basis. The result of the query tool is viewed in PDF form. The result consists of six parts: (1) a summary of the crash dynamics; (2) scene diagram (when available); (3) occupant information (including occupant location, restraint usage, height, weight, etc); (4) injury information (including MAIS, specific injury data and injury source); (5) fire data (including fire severity, fire location, fuel leakage location, etc); and (6) vehicle and scene photographs (when available). This tool offers a concise summary of information pertinent to a study of fire crashes.

The query tool is a set of Apache/mod_perl applications written in Perl 5.8. The programs use a DBI interface to query a MySQL database which contains NASS/CDS data. The

NASS/CDS data is converted from SAS files which are available for download at ftp://ftp.nhtsa.dot.gov/.

The query tool server also contains a copy of crash pictures published at http://www-nass.nhtsa.dot.gov. The application embeds the images into reports. A special module allows a user to pick a set of pictures associated with a certain case, vehicle and occupant which will be displayed on the summary PDF printout.

A custom class tree has been developed for easy and flexible query interfaces development. The class tree consists of three main classes and eight auxiliary classes

NASS::Request - general query interface
NASS::Casedata - data set for case overview forms
NASS::OAdata - data set for occupant assessment forms

NASS::OA_PDF - occupant assessment page
NASS::Case_PDF - case overview page
NASS::Images_PDF - generates a PDF book of all case images
NASS::DamageProfile - damage and fire origin diagram plotter
NASS::User - authorization & authentication module
NASS::Value - SAS code explanation lookup
NASS::Model - SAS code for vehicle models lookup
NASS::Config - server environment settings

A list of CGI applications, based on the classes listed, has been developed:

nass_query.cgi - HTML, general query interface, an entry point
show_case.cgi - HTML, case summary page
oa.cgi - HTML, occupant assessment form
imglib.cgi - HTML, image library editor
fire_and_damage - HTML, fire and damage profile plotter
NASS_cases.pdf - PDF book generator
exporter.txt - TXT raw data file generator

The generated crash summary/report provides several case pictures (scene, vehicle, etc). Using the `imlib.cgi' application, a user can create custom picture sets to be associated with a particular vehicle or occupant. The image library editor is available from the occupant assessment report form. If a user would rather display pictures more pertinent to his or her study, rather than the ‘generic picks,’ then the user may change the pictures using the image library editor. Because the image sets are stored in the user's profile, any number of picture sets can be stored.

The crash summary lists crash characteristics most often investigated by researchers. For instance, make and model of vehicle, delta v, occupant age and injuries. Because the needs of a researcher changes depending on the study, several summary templates have been developed in order to provide crash characteristics pertinent to that study. Currently

there are five templates: "Fire," "Rollover," "Child Safety," "Far Side Crash," and "Brief Summary."

II. Crash Data Analysis

The second section explores motor vehicle crashes which involve or result in a motor vehicle fire. This fire safety research investigated 531 fire crashes representing over 78,000 (weighted) vehicle fires which occurred over a nine year period from 1994 through 2002. To put in perspective, in 1990, the National Highway Traffic Safety Administration (NHTSA) reported the total number of fire-related crashes as 23,600 annually for passenger cars and 5,200 annually for light trucks. (NHTSA, 1990)

For the preliminary analysis, crashes of all crash modes are investigated. Several fire crash characteristics are explored. These include (1) fire severity, (2) fire origin, (3) fuel leakage, (4) location of fuel tank, (5) vehicle body type, and (6) crash mode.

First, fire severity is a characterization of the fire extent or magnitude. This label is often times assigned and taken from the police accident report. Fire severity is either “minor” or “major.” The NASS/CDS definition of a fire severity is:

MINOR: “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.”

MAJOR: “identifies those situations where the vehicle experiences a greater fire involvement than defined under “minor” above and is used in the following situations: combined engine and passenger compartment fire (either partial or total passenger compartment involvement); total passenger compartment fire; combined trunk and passenger compartment fire (either partial or total passenger compartment involvement); combined tire(s) and passenger compartment (either partial or total passenger compartment involvement).

UNKNOWN: “is used when it cannot be determined if this vehicle sustained a fire related to the crash, e.g. a fire was reported, but this vehicle was repaired prior to inspection and it cannot be determined if this vehicle was involved in a fire.”

Second, the fire origin variable describes where on the vehicle the fire initiated. The possible origins are vehicle exterior (front, back, side, top), exhaust system, fuel tank (and other fuel retention system parts including vent lines, tank filler necks, fuel filler cap, etc), engine compartment, cargo/trunk compartment, instrument panel, passenger compartment area, other location (specify) or unknown. Further details regarding the fire origin are not available in NASS/CDS, although sometimes it is offered in the crash summary based on observations of the crash investigator.

Third, if there was a fuel leak, the variable ‘fuel leakage’ describes from where the leaking occurred. The possibilities are from the tank, filler neck, cap, lines/pump/filter,

vent/emission recovery, other (specify), unknown. This description is based on crash investigator or police observation.

Fourth, the location of the fuel tank, in conjunction with the fuel leakage, is vital in determining if the fire was fuel fed. The possible variables for the fuel tank location are aft of the rear axle (centered, on the right or left), forward of the rear axle (centered, on the right or left), centered at the rear axle, other (specify) or unknown.

An analysis of the frequency of vehicle body types and fire crashes was conducted as the precise location of the fuel (with respect to the ground) differs with each body type. The body type categories explored are passenger car, SUV, pick-up, or other. This analysis was done to understand the influence of ride height, structural features related to the fuel system, as well as crash modes common to different vehicle types (i.e. rollover).

Crash mode is the direction of the crash relative to the crashed vehicle. These variables are frontal, nearside and farside (with respect to the driver) and rear. This is a crash characteristic defined by this research and used to analyze how and why fire crashes occur.

The following subsections will discuss fire crashes in general and then rollover crashes where a fire resulted. Finally, this discussion will conclude with that of engine compartment fire crashes.

A. Crashes with Fire Occurrence

An analysis of the 1994-2002 NASS/CDS database was conducted with regard to all crashes where a fire was a result. During this time period, 78,690 fires (weighted) were reported in motor vehicle crashes. Of these cases, about 46% of the fires were minor. A major fire started in the remaining 40,485 cases. The weighted and unweighted breakdown is shown in Table 1.

1994-2002 NASS/CDS - All Crashes with Resultant Fires						
	Fire		Minor		Major	
	Unweighted	Weighted	Unweighted	Weighted	Unweighted	Weighted
Total	531	78,690	245	38,205	286	40,485
Annual Average	59	8,500	27	4,000	32	4,500

TABLE 1

FIRE ORIGIN

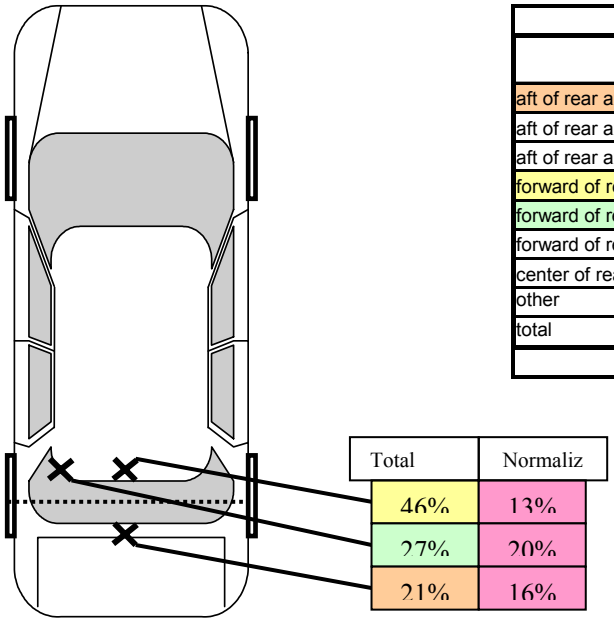
Table 2 is the breakdown of fire location vs. fire severity for NASS/CDS 1994-2002. The primary area where the fire is located is in the engine compartment 77% of the time. Of all the minor fires reported with a known origin, 86% of them occur in the engine compartment. Of all the reported major fires, 70% of them occur in the engine compartment. The second most frequent fire location is the fuel tank at 12%. The fuel tank is the location of 23% of the major fires and only 1.3% of minor fires.

FIRE ORIGIN vs. FIRE SEVERITY			
	Minor (Raw) (Weighted)	Major (Raw) (Weighted)	% of Total
Vehicle Exterior	6 393	8 404	1%
Fuel Tank	8 484	68 9,101	12%
Engine Compartment Fires Only	206 31,070	172 28,306	77%
Cargo Trunk Compartment	3 934	1 943	2%
Instrument Panel	5 3,081	6 336	4%
Other	11 426	12 1,325	2%
Total	239 36,388	267 40,415	98%

TABLE 2

FUEL TANK LOCATION

The location of the fuel tank vs. fire severity is shown in Table 3. Figure 1 shows the positions of these most frequent tank locations for vehicles involved in crashes with fires. The majority of the vehicles with reported fires have fuel tanks forward of the rear axle and centered on the vehicle (46%). Tanks located forward of the rear axle and to the left are in 27% of the reported vehicle fires. The third most frequent tank location in the vehicle fires is behind the rear axle at the center of the vehicle (21%).



Location of Fuel Tank vs. Fire Severity			
	Minor	Major	% of Total Fires
aft of rear axle, centered	11,473	4,670	21%
aft of rear axle, left side	18	161	0.2%
aft of rear axle, right side	208	491	1%
forward of rear axle, centered	20,419	15,274	46%
forward of rear axle, left side	3,316	17,720	27%
forward of rear axle, right side	1,068	3,086	5%
center of rear axle	99	91	0.2%
other	0	222	0.3%
total	36,602	41,716	

TABLE 3

FIGURE 1

Table 3, in the last column, shows the percentage of fuel tank location in fires normalized with the fuel tank location for all vehicles in the NASS/CDS database. This percentage is the number of fires (with specified tank location) divided by the number of vehicles in

NASS/CDS with that specific tank location. The tank location at "forward of rear axle, left side" is the location with the highest percentage involved in fire crashes. As mentioned above, it is the 2nd most common tank location for fires at 27%.

Of all possible locations for the tank, the "forward of rear axle, center" is generally most guarded from damage due to its placement about the vehicle structure. Almost ½ of the tanks are mounted in this position, followed by the "forward of rear axle, centered" position.

With regard to damage to the fuel tank, no significant damage was reported in minor fire cases in NASS/CDS. Only 8% of the major fire cases had fuel tank deformation and 6% had a fill neck separation.

BODY TYPE

The precise location (relative to the ground) of the fuel tank will differ with each vehicle make and model/body type. Chart 1 shows the breakdown of the body types involved in fire crashes. In all crashes where fire results, passenger cars have a fire more frequently (over ½ the time) than any other body type has a fire. Pick-up trucks are the next most frequent body type followed then by SUV's, van and other body types.

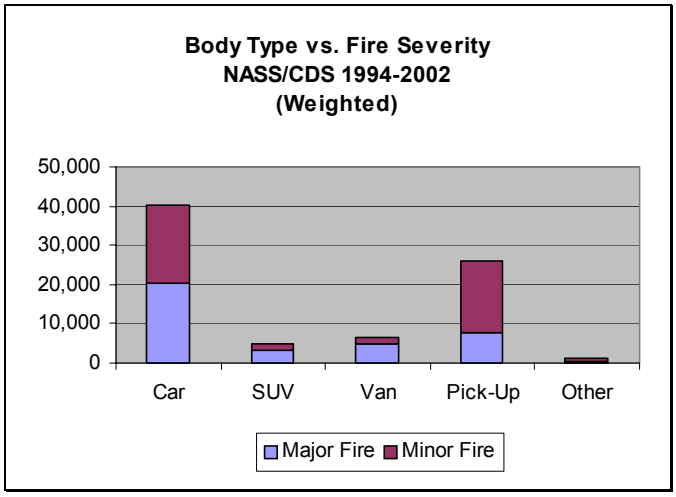


CHART 1

Fire Origin vs. Body Type						
	Car	**SUV**	**Van**	**Pick-up**	**Other**	**% of Total**
Vehicle Exterior	452	11	118	242	0	1%
Exhaust System	72	0	0	142	0	0.3%
Fuel Tank	7,435	79	130	1,295	646	12%
Engine Compartment	24,647	4,638	6,291	23,187	492	77%
Cargo Trunk	1,745	132	0	0	0	2%
Instrument Panel	3,350	43	0	24	0	4%
Passenger Area	97	0	48	0	0	0.2%
Other Location	1,257	0	11	127	0	2%
Total	39,150	4,905	6,600	25,018	1,138	

TABLE 4

Table 4 shows that over 90% of the fires began in the engine compartment for SUV's, van's and pick-up crashes. About 63% of the fires began in the engine compartment in passenger car crashes and about 19% of the passenger car fires originate near the fuel tank. In the 'other' body type category, the percentage of fires originating in the fuel tank and engine compartment was split almost evenly. These vehicles represent less than 2% of the vehicle population discussed here.

FUEL LEAKAGE

Fuel leakage is a great concern because of the possibility of feeding an already existing fire or promoting the onset of one. Table 5 shows the breakdown of fuel leakage versus fire severity. The majority of the all fire crashes had no fuel leak (82%). When there was a fuel leakage, 92% of the fires were major. The filler neck is most commonly the fuel leakage point at 60% of all leakage possibilities.

Fuel Leakage vs. Fire Severity			
	Minor	**Major**	**% of Total**
No Fuel Leakage	34,881	14,672	82%
Tank	336	1,820	4%
Filler Neck	171	6,135	10%
Cap	36	83	0.2%
Line/Pump/Filter	241	321	1%
Other	65	2,007	3%
Total	35,731	25,039	

TABLE 5

CRASH MODE

The influence of crash mode (crash direction) on fire severity and fire origin are shown in Table 6 and Table 7. The majority of crashes which resulted in fire were frontal collisions (73%). The breakdown of minor and major fires among all crash modes was almost evenly split. Though they occurred only 4% of the time, both rear and near side collisions where a fire occurred resulted in major fires over 70% of the time.

Crash Mode vs. Fire Severity			
	Minor	**Major**	**% of Total**
Frontal	26,049	27,038	
	49%	51%	73%
Near Side	698	1,981	
	26%	74%	4%
Far Side	4,263	4,116	
	51%	49%	11%
Rear	378	2,412	
	14%	86%	4%
Total	36,048	36,931	

TABLE 6

As shown in Table 7, the engine compartment was the origin of fire for most frontal collisions which resulted in fire. In near side collisions, it is an even split at 49% for the

engine compartment and fuel tank as the fire origin. (In a 'Near Side' crash, the driver is on the side of the vehicle where the striking occurs. In a 'Far Side' crash, the driver is on the non struck side.) Just under ½ of the fires in far side crashes resulted in the fuel tank, similar to that of the near side collisions. Most fires in rear end collisions originated in the fuel tank. This corresponds to the data in Table 6 where 86% of the rear end collision fires were major.

Crash Mode vs. Fire Origin				
	Engine Compartment	**Fuel Tank**	**Instrument Panel**	**Other**
Frontal	49,551 95%	522 1%	244 0.5%	1,771 3%
Near Side	1,303 49%	1,291 49%	0 0.0%	46 1.7%
Far Side	3,459 42%	3,891 47%	92 1%	835 10%
Rear	435 17%	1,835 70%	0 0%	365 14%
Total	57,229 80%	7,762 11%	3,324 5%	3,348 5%

TABLE 7

Table 8 shows the characteristics which are most often involved and associated with crashes resulting in fires. The frequency of vehicle types has been normalized by the number of registered vehicles. Per registered vehicle, the van is most often subject to a minor fire. The pick-up is most frequently involved in crashes where a major fire results.

Characteristics of High Frequency of Crashes with Fire				
(All Fires)				
	Minor Fire		**Major Fire**	
	Characteristic	% of total	Characteristic	% of total
Vehicle Type (normalized)	Van	8%	Pick-up	33%
Crash Mode	Frontal	73%	Frontal	72%
Fire Origin	Engine Comp.	85%	Engine Comp.	70%
Tank Location	forward of rear axle, centered	55%	forward of rear axle, left side	42%
Leak Location	Fuel Tank	9%	Filler Neck	25%

TABLE 8

It is during frontal collisions that most fires result. Almost ¾ of fire crashes are subsequent to a frontal collision. About 72% of all minor fires follow a frontal collision. A frontal collision is the crash mode in 73% of all major fires.

In both minor and major fires, the majority of fire origin location is in the engine compartment. The tank location in over ½ of the minor fires is centered and forward of the rear axle. The location of the tank in major fires is most commonly forward of the rear axle and to the left. If a fuel leakage occurs, it is most commonly at the fuel tank in minor fires and most commonly at the filler neck in major fires.

FARS Fire Rates per Registered Vehicle Years and Engine Compartment Fires

A previous paper began to look at fire-related crashes in the 1991 – 2000 FARS data system. (Digges, 2003) Unpublished work[1] at MVFRI reported an analysis of FARS data (1991 through 2000) regarding the assessment of fire safety technologies in today's vehicles. Of the 76 vehicle platforms researched, 29 had statistically higher fire rates than the industry average, 13 had fire rates statistically equivalent to the industry average, and 34 had fire rates statistically better than the industry average.

This FARS study showed that the Dodge Neon and the Chrysler Cirrus (Stratus/Breeze) stood out among the rest in fire occurrence rate. (The Neon is generally considered a small car and the Cirrus and its corporate twins are generally considered med- size cars.) These rates are based on fire occurrences per million vehicle registered years. The Neon and Cirrus fire occurrence rates for 1991-2000 are 19.08 (±1.23) and 18.08 (±0.96) (respectively) where the next highest occurrence (Dodge Durango) was 11.87 (±2.24).

The FARS data provides sufficient information regarding the occurrence of fires in today's vehicles, but it lacks in specific details regarding any further information about the fire. FARS does not include data such as location of the fire, fuel leakage or fire severity. NASS/CDS does provide such information, but due to sampling practices, the data is not abundant enough to warrant a *specific* make or model study.
As such, a NASS/CDS data analysis and case reviews of the Dodge Neon and the Chrysler Cirrus (and other models with high FARS fire occurrence rates) are presented here to highlight these specific models with regard to vehicle fires and the characteristics therein.

Can statements be made about a particular make and model (of a vehicle) given we have a sample gathered in the NASS/CDS files? The value of a statistic—such as number of fires per 100 crashes—is nevertheless a single estimate of the true value describing the population of that make and model. But the sample is only an approximation for the population, so the statistic is also only an approximation. If you extract a separate group of observations, it is most likely the number of fires per 100 crashes will have an altered rate.
Statistics exist to use a sample from a make and model population based on NASS/CDS. These statistics can use the NASS/CDS sample to compute an extent within which the actual value for the population is most likely to be. The extent is generally based on the 95% level of confidence. Roughly speaking, the true metric for the population will fall within the calculated interval 95% of the time. The calculated interval is called the confidence interval.

The precision of an estimate is bound up with the confidence interval. All other things being equal, an estimate falling in a narrow confidence interval has high precision. An estimate falling within a broad confidence interval has less precision. The analysis in this report is investigating the generation of meaningful ways to study crashes with fires.

[1] Analysis of FARS 1991-2000 for the Assessment of Fire Safety Technologies and Potential Fire Occurrence Under-reporting, www.MVFRI.org.

Based on the NASS/CDS files, estimates will be made of metrics associated with particular makes and models. The analysts do not include confidence intervals for the metrics based on particular makes and models. The analysts work out the methodology of investigating crashes with fires. Because confidence intervals are not provided, the metrics based on makes and models are estimates without any certainty that they are likely the true value.

Table 9 shows the breakdown of fire severity and crash mode for NASS/CDS Neon and Cirrus crashes where a fire was reported.

NASS/CDS 1994-2002									
Fire Severity			Crash Mode						
Minor	Major		Frontal	Near	Far	Rear	Other	Total Weighted	Total Unweighted
	Dodge/Chrysler/Plymouth								
86%	14%	Neon	89%		5.4%	5.7%		878	13
0.5%	99.5%	Cirrus	1%			98%	1%	3,594	5
27%	73%	Caravan/ Town&Country	12%			1%	87%	4,902	17
2%	98%	B Series Van	99.8%			0.16%		7,116	13
		Chevrolet							
9%	91%	CK Series/ Suburban	40%	8%	10%		43%	8338	29
TABLE 9									

As the Dodge Neon and the Chrysler Cirrus are the vehicle models with the highest fire occurrence rates (FARS) per million registered vehicle years, Table 9 shows that in corresponding NASS/CDS data, the majority of Neon fires are minor (86%) in severity and almost all of the Cirrus fires reported are major. Most of the Neon fires are resultant of a frontal collision whereas rear collisions are more frequent with fires in the Cirrus. The majority of fires are 'major' for the four other models mentioned in Table 9. In these, the majority of collisions are classified as frontal or 'other.'

The Neon and Cirrus fuel tanks are located forward of the rear axle and centered in the vehicle. This location is consistent with almost ½ of the NASS/CDS vehicles where a fire was reported. As with any fire, there is concern with feeding the fire due to fuel leaks. Table 10 is a breakdown of leakage location for the Neon and Cirrus. In most cases for both the Neon and Cirrus, there is no fuel leakage reported. Note that in only 2% of the Cirrus cases (i.e. 98% missing data in 74 cases) is this variable (fueleak1) reported. These data suggest that fuel leakage is not a problem in these vehicles with high fire occurrence rates.

Leakage Location							
	No Leakage	Tank	Filler Neck	Cap	Lines	Other	Data Missing
Dodge							
Neon	94%	6%					0%
Chrysler							
Cirrus	50%	16%				34%	98%
TABLE 10							

B. Rollover Crashes and Fire Occurrence

Crashes which involved rollover and where a fire resulted are investigated from 1997-2002 in NASS/CDS. These data are unweighted due to the limited number of available cases in NASS/CDS. Table 11 shows that the majority (67%) of the fires occurred in the engine compartment subsequent to a rollover. Of these, over ½ were minor fires in severity. In the 3% of crashes where the fire was in the instrument panel, 2 out of 2 crashes resulted in a major fire. When the fire occurred in the fuel tank/filler (19%), 71% of the resulting fires were major.

Fires in Rollover Crashes			
	Fire Severity		
Fire Location	**Major**	**Minor**	**All**
Engine Compartment	20	28	48
Fuel Tank/Filler	10	4	14
Instrument Panel	2	0	2
Exhaust System	0	1	1
Other/Unk	2	5	7
Total	34	38	72

TABLE 11

Engine compartment fires will be the main focus as this is the most frequent location for both minor and major fires. However, fuel tank/filler fires are also high in frequency. As shown in Table 12, when the fire was in the tank or filler line only (29% of these cases), the majority of them were located in the neck and 80% of those crashes resulted in major fires. In all locations but the cap, the majority of the resulting fires were major (71%).

Tank/Filler Fires Only in Rollover Crashes			
	Fire Severity		
Leak Locations	**Major**	**Minor**	**All**
Neck	4	1	5
Line	1	0	1
Tank	2	1	3
Unknown	3	1	4
Cap	0	1	1
Total	10	4	14

TABLE 12

The vehicle type, number of quarter turns in the rollover, the vehicle's trip location and final rest position are shown versus fire severity in Table 13 (Charts 2 and 3). This table includes only those cases where the fire was in the engine compartment after a rollover occurred. The crashes with engine compartment fires only were about 67% of all rollover crashes resulting in fire.

Engine Compartment Fires Only in Rollover Crashes			
	Fire Severity		
Vehicle Types	**Major**	**Minor**	**All**
Passenger Cars	7	15	22
Comp PU	1	6	7
Lg PU	4	1	5
SUV	7	3	10
Minivan	1	2	3
Lg Van	0	1	1
Total	20	28	48
Trip Location	**Major**	**Minor**	**All**
End Plane	2	8	10
Side Plane	3	1	4
Undercarriage	4	5	9
Wheels	10	13	23
Non Contact	1	1	2
Total	20	28	48
Nr Qtr Turns	**Major**	**Minor**	**All**
1 to 4	12	22	34
5 to 8	6	3	9
9+	2	3	5
Total	20	28	48
Final Rest Position	**Major**	**Minor**	**All**
Wheels	5	9	14
Top	11	10	21
Side	4	9	13
Total	20	28	48
Leakage Location	**Major**	**Minor**	**All**
Cap/Filler Tube	2	1	3
Fuel Lines	1	0	1
Tank	1	0	1
No Fuel Leak	11	25	36
Other	1	0	1
Unknown	4	2	6
	20	28	48
TABLE 13			

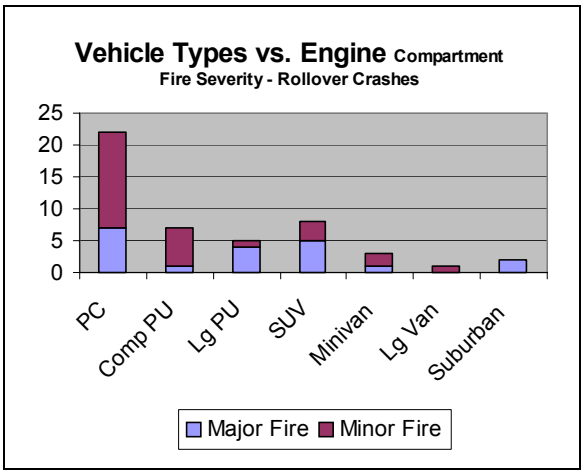


Chart 2

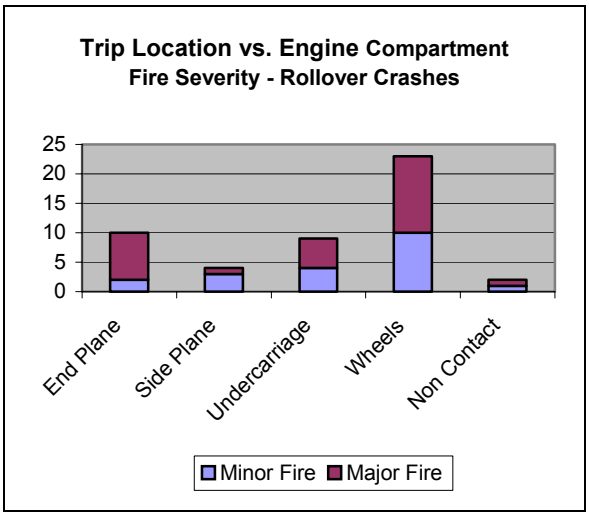


Chart 3

Within this subset, where crashes with both a rollover and a fire were a part of the crash, more minor fires than major fires were reported (58% of reported fires were minor). Most of these rollover crashes involved passenger cars (46%). Almost 70% of those passenger cars had only minor fires. Major fires, however, were reported most frequently in passenger cars followed by SUV's and large pickup trucks.

The pickup trucks (compact and large), SUV's and vans together accounted for less than ½ of the minor fire cases and more than ½ of the major fires. Of the 10 SUV's and 5 large pickups reported as rollover crashes with fires, 70% and 80%, respectively, were major fires. These are the only body type categories with more major fires than minor in this set of rollover crashes with fire.

The rollover trip location was most frequently at the wheels (48%). At this trip location, about ½ of the fires were minor severity and ½ were major. The undercarriage and the end plane were also frequent trip locations (about 20%), with both reporting more minor

fires. There were 2 non-contact trip mechanisms resulting in 1 minor and 1 major fire. 80% of end plane trips resulted in minor fires. 75% of side plane trips resulted in major fires. More detail regarding the side place trip location is warranted to look for correlation to impact point, fire origin and/or leakage location.

The number of quarter turns following the trip was 4 or less over 70% of the time when fire occurred. When 4 or fewer quarter turns occurred, (65%), minor fires most often resulted. In the 5-8 quarter turn grouping, 2/3 of the fires were major. Five cases rolled 9 or more quarter turns resulting in 3 minor fires and 2 major fires. These results suggest the possibility that higher severity rollovers increase the chance of a major fire and that it is during the 2nd roll that the chance of a major fire increases. However, the population of rollover fire crashes presented here is not sufficient to draw any statistical conclusions.

Just under ½ (44%) of these crashes ended with the top of the vehicle in contact with the ground. 11 of those 21 cases were reported as major fires. When the vehicles landed on the wheels or the side, the majority of the fires were reported as minor in this dataset.

With regard to these limiting circumstances, the scenarios which bear the highest frequency of a minor/major fire resulting from a rollover crash are shown in Table 14.

Characteristics of HighFrequency of Fire Severity				
(Engine Compartment Fires Only)				
	Major Fire		**Minor Fire**	
	Characteristic	% of total	Characteristic	% of total
Vehicle Type	SUV	17%	Compact Pickup	15%
Trip Location	side plane	8%	end plane	21%
Nbr Quarter Turns	5-8	19%	1-4	71%
Final Rest Position	top	44%	side	27%
TABLE 14				

The crashes with major fires are more likely to impose a larger threat on the occupants. The characteristics SUV, side plane (trip location), and 5-8 quarter turns are below 20% in overall frequency. Almost ½ of the final resting positions are on the top in these major fire crashes. As the vehicle comes to rest on its roof, fuel and flammable under-hood fluids leakage and the origin of the fire adds to the increased chance of a major fire.

In Table 13, it was reported that 75% of these crashes (engine compartment fires only in rollover crashes) had no fuel leak. However, Table 13 notes that, when there was a fuel leakage reported, 75% of the fires were reported as major fires. In light of this, a trip location on the side plane might introduce damage to these areas of reported leakage in addition to damage sustained during the 1st of (up to) two rolls.

C. Engine Compartment Fires

Using NASS/CDS, analysis has shown that 77% of vehicle fires originate in the engine compartment. As such, an analysis and investigation of this phenomenon is warranted.

The information in Table 15 includes only those 1994-2002 NASS/CDS cases where the fire originated in the engine compartment. The percentages are based on weighted numbers.

1994-2002 NASS/CDS Crashes with Engine Compartment Fires

Fire Severity		Fuel Leak		Body Type		Crash Mode	
Minor	Major	no fuel leak	86%	PC	63%	Far Side	2.3%
28%	72%	tank	2.7%	Pickup	15%	Frontal	82%
		filler neck	0.1%			Near Side	1.8%
		cap	3.1%			Rear	1.0%
		lines/pump	6.8%			Other	13%
		other	1.1%				

Entrapment

	Minor	Major	Total
Not Entrapped	28%	72%	94%
Occupant Mechanically Restrained	13%	87%	4.9%
Vehicle Doors Jammed	36%	64%	1.3%

TABLE 15

There are documented over 78 thousand weighted vehicle fires reported in 1994-2002 NASS/CDS. Of these, 28% are reported as minor in severity and major fires were reported in 72% of the engine compartment fires.

The vast majority of the engine compartment fire crashes did not report any fuel leaks. However, about 7% of the fires were associated with the lines/pumps. Over 80% of these engine compartment fires were subsequent to a frontal collision.

There is no coding available for a flammable substance (under-hood fluids) leakage within the vehicle other than a fuel system leakage. Consequently, there might have been a power steering fluid, brake fluid, coolant, window washer fluid leakage, or oil pan leakage that was responsible for feeding the fire but was not reported. As noted in Table 15, the majority of these engine compartment fires are reported as major fires. This may suggest that these engine fires are fed by the flammable substances found within the engine compartment.

In the majority of engine compartment fires, there was no entrapment reported. 6.2% of all crashes with engine compartment fires had entrapment. Where there was entrapment in vehicles with engine compartment fires, most fires were major and almost 40% of the injured occupants were categorized with MAIS = 6 injuries. In about 90% of the MAIS = 6 injured occupants in engine compartment fire crashes, there was entrapment. Where entrapment and an engine compartment fire were reported, 66% of the injuries were MAIS $\geq$ 3.

In all crashes with fire in general (not just those with fires in the engine compartment), entrapment was reported in 6.6% of all fire crashes. About 58% of cases of fire with entrapment have MAIS $\geq$ 3 injuries. About 92% of MAIS = 6 injuries are coincident with crashes reporting both fire and entrapment.

D. Damage Profiles and Fire Occurrence

Crashes with fires and without fires, from NASS/CDS 1994-2002, were isolated in order to compare damage profiles verses fire occurrence. Typically, NASS/CDS cases provide six c-value crush measurements per damaged vehicle. Because the six crush measurements could span the entire side of the vehicle, or could span only a smaller portion, a plot of the average crush would be sporadic and difficult to interpret.

In order to create a smoother average crush curve, the vehicle profiles were divided into 200 equidistant sections. The six c-values of each crash were used to interpolate values for the remaining 194 segments for each vehicle. Therefore, for each crashed vehicle, there are 200 crush measurements placed across the given side or end of the vehicle. Because wheelbase, and not vehicle length, is provided in NASS/CDS, the span of the 200 sections on the vehicle sides begins at the front axle and extends to the rear axle. Regarding the vehicle ends, the track width is provided and therefore the 200 sections span the track width.

The average crush values of all the vehicles in the database were calculated for each side and end along the 200 segments. For instance, all of the crush values at segment 1 (of the 200 segments) were averaged for vehicles with frontal damage where the crash involved a fire. The same was done for segments 2-200. Therefore, the resulting curve represents the average crush value (based on all of the frontal collisions with fires in NASS/CDS 1994-2002) at a given point on a vehicle. The same procedure was completed for each side and end where the crashes had no fire resulting. (This procedure did not take into account crashes where there was overlapping side and end damage.)

Table 16 shows a breakdown of the number of fire and no-fire crashes in NASS/CDS 1994-2002 for passenger cars. As a whole, there are significantly more no-fire crashes than fire crashes. Of each crash mode for passenger cars, there are more frontal mode fire crashes than any other fire crash. Almost 72% of weighted fire crashes and 75% of unweighted fire crashes are frontal collisions.

NASS/CDS 1994-2002 for Passenger Cars					
	Fire Crashes			No-Fire Crashes	
	unweighted	weighted		unweighted	weighted
Front	206	22,780		19,950	10,490,113
Rear	29	2,281		2,850	2,325,971
Left	22	1,940		2,983	1,323,360
Right	19	4,612		2,566	1,210,576

TABLE 16

Several charts are shown below which display the average crush values for fire and no-fire crashes, also as weighted and unweighted data. In each of these charts, the black line represents the *weighted* average crush in crashes *without* fires. The green curves represent the *unweighted* average crush in crashes *without* fires. The blue curves represent the *weighted* average crush in crashes *with* fires. The orange curves represent the *unweighted* average crush in crashes *with* fires.

In each of the charts, the y-axis unit is meters. The x-axis is centered at zero which represents the center of the vehicle, i.e. one-half the wheelbase or one-half the track width. For both the right and left side crashed vehicles, the negative values represent the rear portion of the vehicle and the positive values represent the front portion of the vehicle. For the front or rear crashes, the negative values on the x-axis are the left side of the vehicle and the positive values represent the right side of the vehicle (while facing the vehicle).

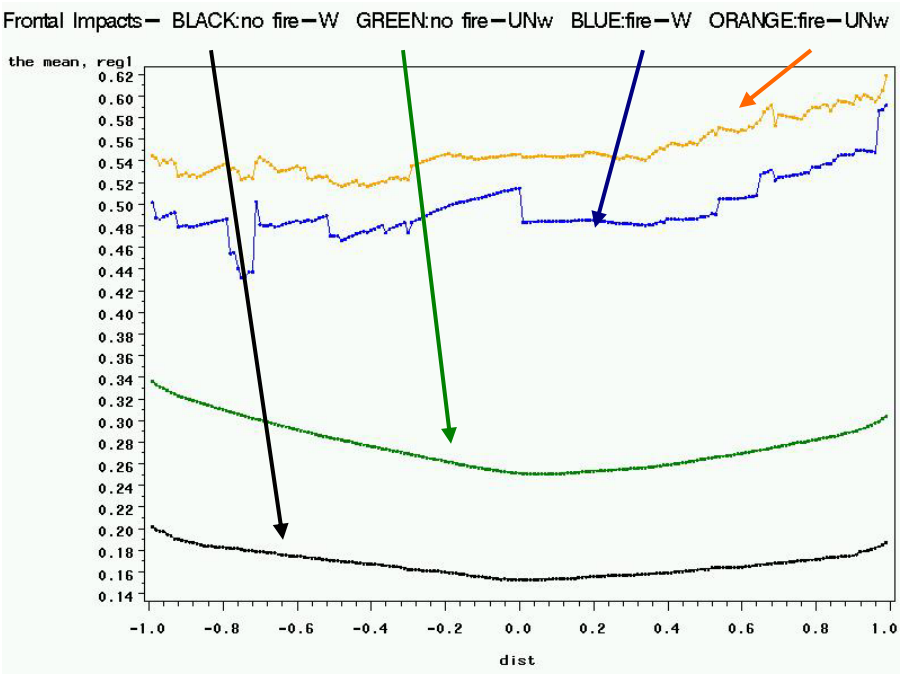


CHART 4 – FRONTAL IMPACTS FOR PASSENGER CARS (CRUSH IN METERS)

Chart 4 shows the average damage profiles for a frontal crash mode in crashes with and without fires. The black line is the weighted damage profile for frontal collisions in no-fire crashes. The green line is the same data without the weighting factor. The orange and blue lines represent average frontal fire crash damage profiles, both weighted and unweighted. The difference in damage profiles between the fire and no-fire crashes is about 0.2 to 0.3 meters.

This, and the remaining charts, represents 200 sections along the sides and ends of a vehicle. Therefore, any point on the curve shows the average crush of vehicles at that point. For example, at point 104 (which is .04 meters forward of the center of the wheelbase), the average crush value is about .16 meters. Therefore, if there is damage at this location on any given vehicle, the average crush is 0.16 meters.

A word of caution is in order for viewing these charts. The viewer should think about the number of observations underlying the calculation of average crush. The Iowa Department of Public Health stated the situation succinctly.

There are two limitations involving small numbers. One involves a small number of occurrences for a particular vital event. The other involves rates or ratios calculated for a small population even though the number of occurrences of that event may not be considered small. Caution should be exercised concerning the use of such data. Statistical stability cannot be assured when small numbers are used in some formulas. Determination of what constitutes as a small number must be made by the individual user. Numbers smaller than 16 and populations less than 100 are generally considered unstable for use in most statistical computations.

Chart 4 visually shows the affect of small numbers. The lines for the crashes with no fire are based on roughly 19,950 observations and are continuous. The lines for the crashes with a fire are based on roughly 206 observations and are reasonably continuous with small local discontinuities.

The following charts show similar results where the damage profile of the fire crashes is greater than that of the no-fire crashes in rear, left and right side collisions.

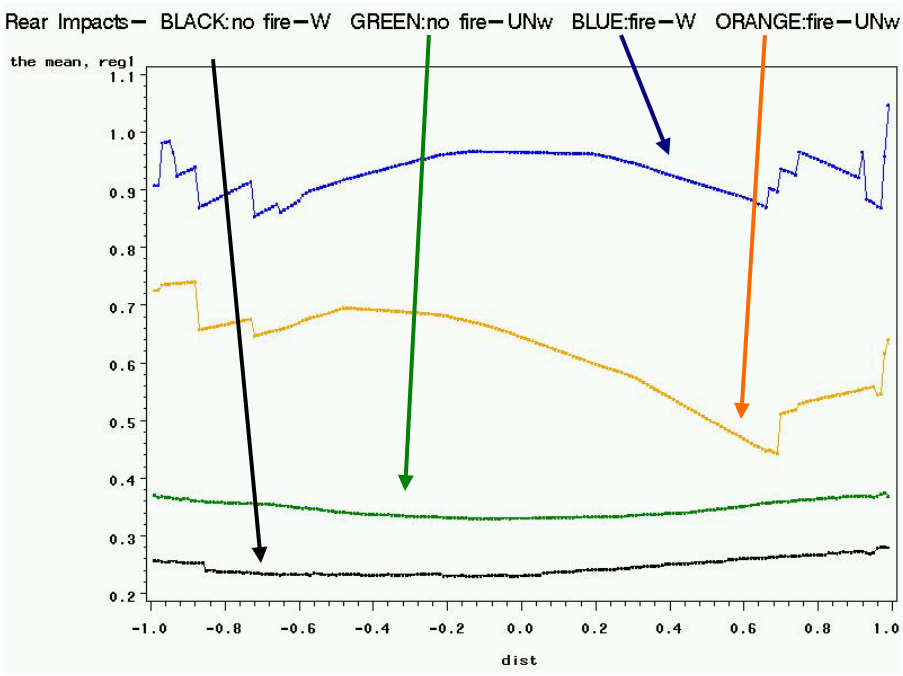


CHART 5 – REAR IMPACTS FOR PASSENGER CARS (CRUSH IN METERS)

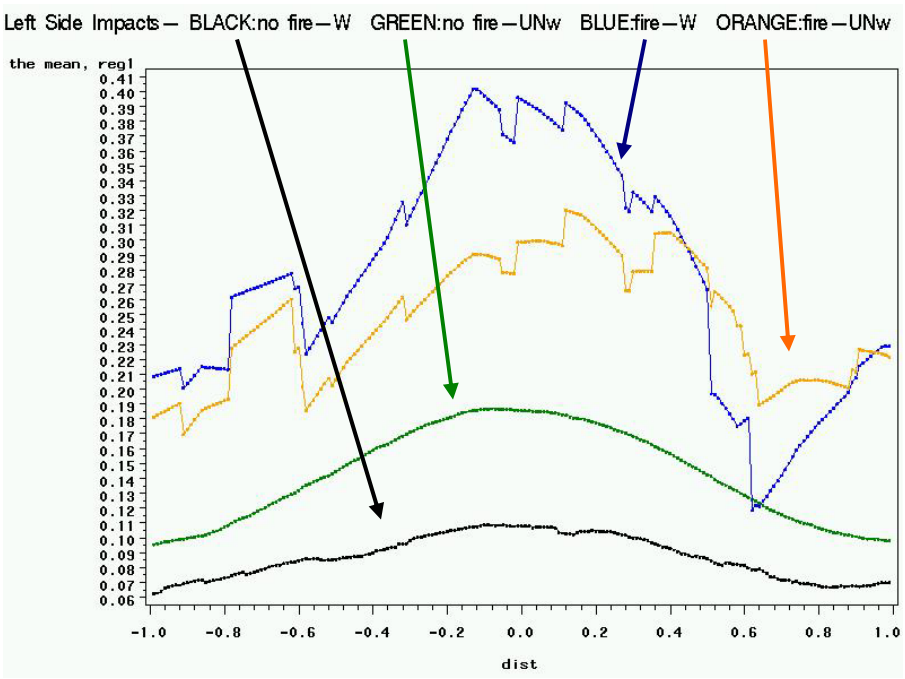


CHART 6 – LEFT IMPACTS FOR PASSENGER CARS (CRUSH IN METERS)

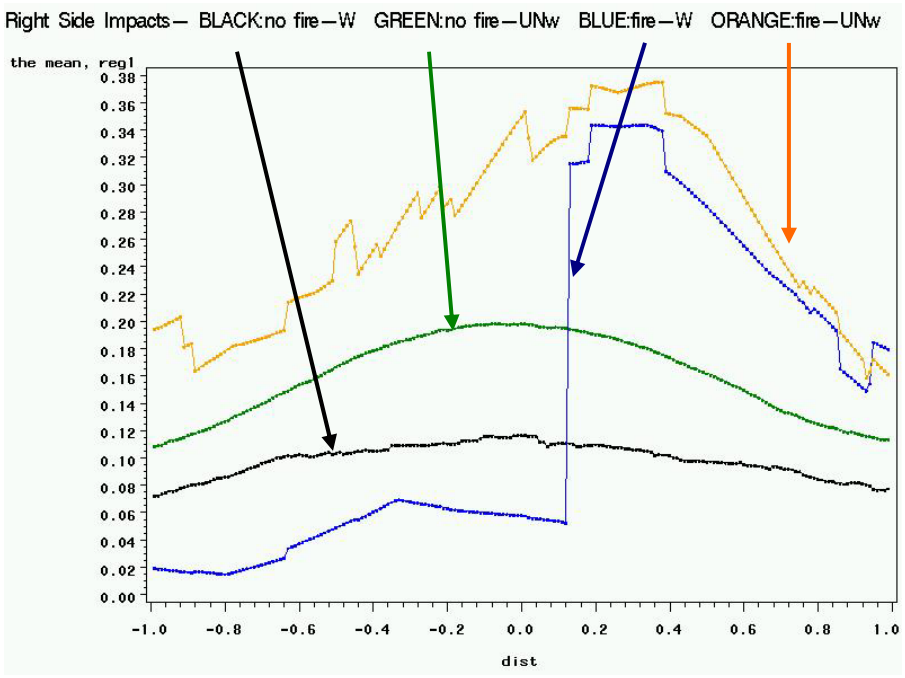


CHART 7 – RIGHT IMPACTS FOR PASSENGER CARS (CRUSH IN METERS)

Both the weighted and unweighted data were displayed in these charts to show justification for the comparison of *unweighted* fire data with *weighted* no-fire data. Firstly, as compared to crashes with no fire, fire crashes are far less common. When separated by sides, the total crashes are at most only 206 unweighted cases (frontals). There are only about 19 unweighted right side fire crash cases. Weighted, there are about

4,612 of these cases. In contrast, there are about 2,566 unweighted no-fire crashes and roughly 1,210,576 weighted right impact, no-fire crashes.

The most obvious effect that the weighting factors have on the fire data is in the right side impacts. As shown above, it is at segment 113 and segment 114 that there is a jump in the average crush data for the weighted data in fire crashes with right side impacts. Table 17 shows that the data is missing beginning—as noted by the '*'— at segment 114. 'Missing data' means that there was no crush for that vehicle at that location. Note that the weighting factor for case 2002-43-188 is 3,459 and is the highest value by over 2600 for the data on the right side. Therefore, the crush averages at these segments (segments 1-113) are pulled extremely low by the values given by this single case.

				Right Side Crush Values at Segment				
Year	**PSU**	**Caseno**	**Weight**	**112**	**113**	**114**	**115**	**116**
2002	43	188	3459.3	0.0015	0.00044	*	*	*
Table 17								

Due to the dramatic influence of weighting factors in so few fire cases, the *unweighted* results of the fire crash data are compared to that of the *weighted* no-fire crash data. With more data collection, this study can be expanded to justly compare weighted fire crash data to weighted no-fire crash data.

In all crash modes, the average crush values (across the span of the wheelbase) for the fire crashes outweighs those of the no-fire crashes. Independent of crash mode, when crashes result in fires, there is on average more damage than in crashes where no fires result.

The greatest difference in crush distance between the fire and no-fire crashes is seen in the frontal mode. Where the fire crashes are on average above .5 meters of crush in frontal collisions (unweighted), no-fire crashes are on average below .20 meters of crush (weighted).

Chart 8 shows the average (unweighted) damage profiles for the front, rear, left and right sides in fire crashes. In fire crashes, the rear end (shown in orange) is most damaged, on average, around 0.9 meters. The front end (blue) is on average damaged about 0.55 meters. The left and right sides, on average, sustain very similar crush distances under about 0.3 meters for each side.

As shown in Table 16, most fires result from frontal collisions. The rear shows the fewest fire crashes (both weighted and unweighted) though the damage profiles are greater than the other crash directions. Figure 2 also shows the average (unweighted) damage profiles for the front, rear, left and right sides in fire crashes, but is not to scale.

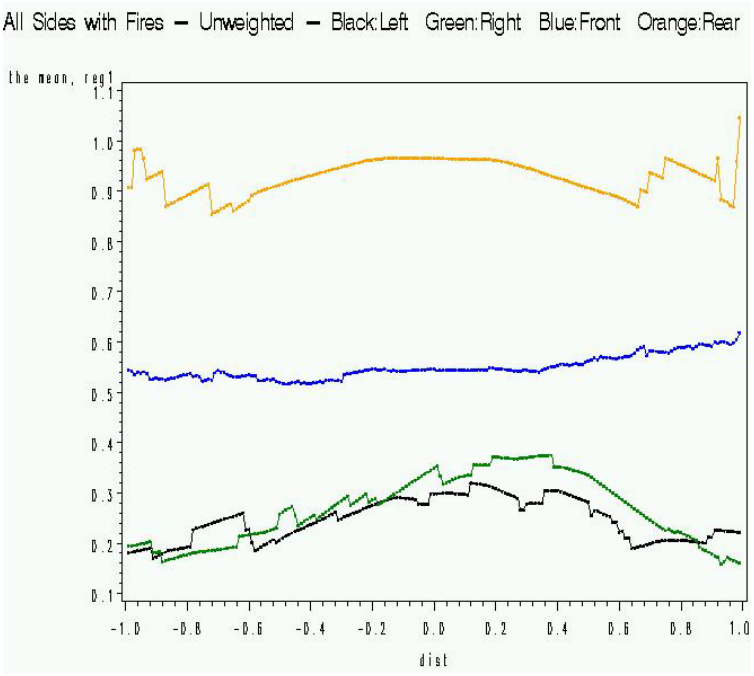


CHART 8 – Average Unweighted Crush for Front, Rear, Left Side, and Right Side in Crashes with a Fire

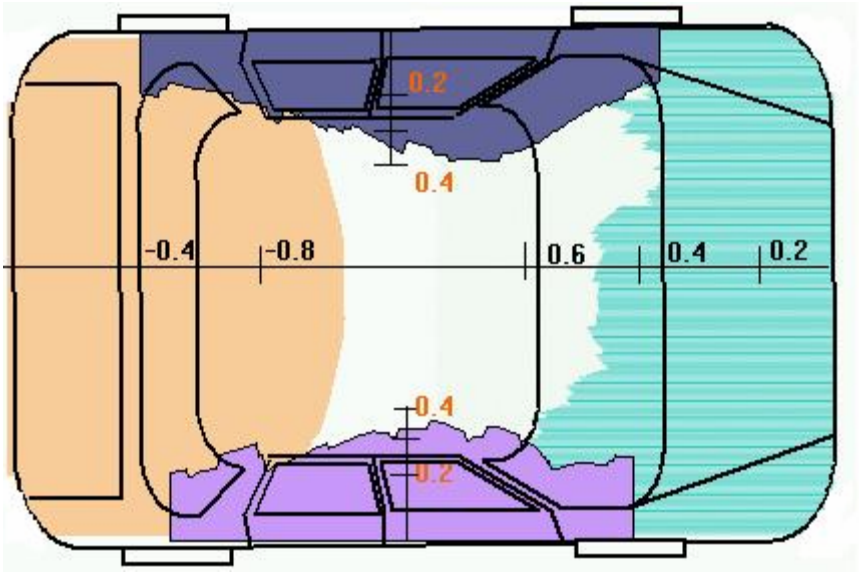


FIGURE 2 – Not to scale

This data analysis suggests that on average, vehicles in fire crashes sustain more crush damage than vehicles in no-fire crashes. Though the current weighted fire crash data is not suitable for drawing conclusions due to the limited number of cases, both the weighted and unweighted data support this finding. Until the database is abundant

enough to justify a comparison of weighted fire crash data, the current data could suggest that with more severe crashes, there is a greater likelihood of a fire resulting.

Based on these findings, specific fire origin locations should be studied with relation to crush damage. Did the fire start directly at the site of crush, or is it an effect of the crush? Crush damage should be kept in mind for all fuel leakage fire cases, as well. Did the fuel leak occur due to direct damage or was it an effect of crush? Since most fires originate in the engine compartment, an investigation of specific crush damage, possible flammable substances, and fire origination should be studied.

E. NASS/CDS Clinical Case Reviews

The following clinical case reviews will highlight crashes which have characteristics discussed previously. These characteristics are crashes with fire occurrence, rollover crashes with fire occurrence, and engine compartment fires with occupant entrapment. Also found here are the summary reports generated by the query tool for each of these cases.

Crashes with Fire Occurrence

1997-12-167

This collision involves a 1997 Chevrolet S-10 Pickup (Vehicle 1) driven by a 22 year old unrestrained male. The right front passenger was a 26 year old unrestrained male. The vehicle crossed the center line of a two way roadway and collided head on with an on coming vehicle. The subject vehicle rolled over 2 quarter turns. A minor fire started in the engine compartment. Air bags were not available in the S-10.

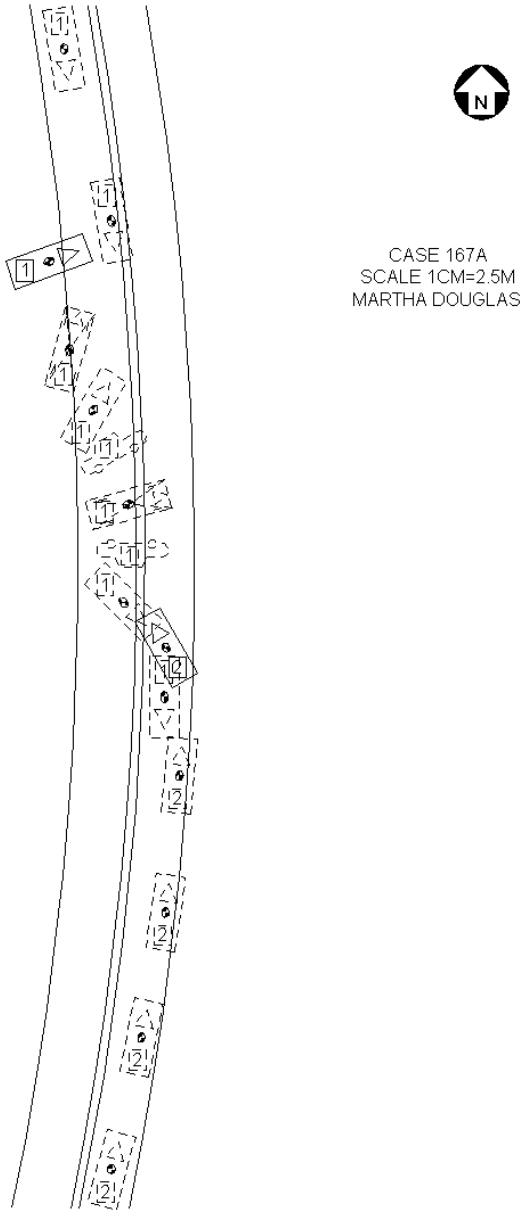
No fuel leaks were reported. The fuel tank is located forward of the rear axle on the left side. It was reported that the driver was ejected from the vehicle and front right passenger was entrapped due to vehicle damage.

The driver reportedly died as a result of his injuries. The front right passenger sustained MAIS = 5 injuries including: brain stem infarction, unconsciousness, intracerebral hemorrhage, subdual hematoma, subarachnoid hemorrhage, hemo/pneumothorax, lacerations/abrasions. This passenger sustained no injuries due to the fire. This case illustrates a crash followed by a fire in which one occupant died from impact trauma and another occupant had minor trauma but was entrapped. An engine compartment fire (in Vehicle 1) was detected and extinguished before it could possibly develop into a more deadly conflagration.

Case Number: 1997-12-167

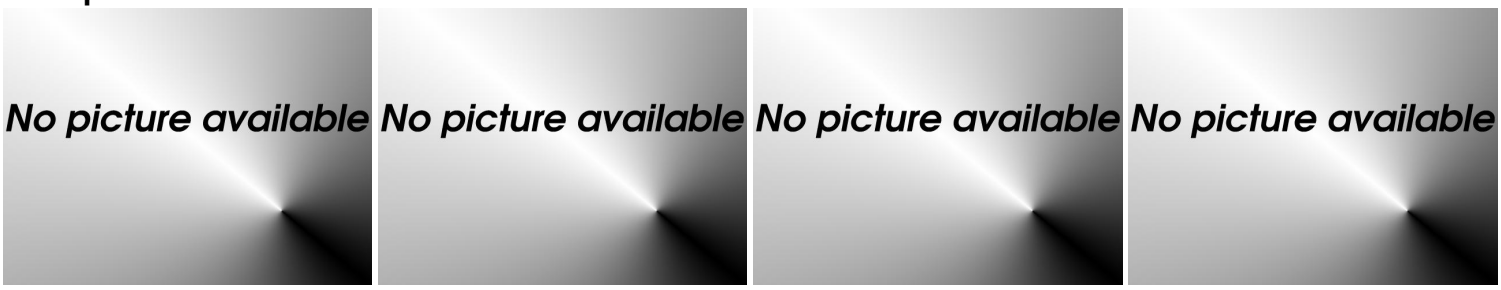
Summary:

VEHICLE 1 WAS HEADED SOUTH WHILE VEHICLE 2 WAS HEADED NORTH. AS VEHICLE 1 CROSSED THE CENTER LINE, VEHICLE 2 TRIED UNSUCCESSFULLY TO AVOID THE CRASH. THE 2 VEHICLES MET HEAD ON IN THE NORTH BOUND LANE KILLING THE DRIVER OF VEHICLE 1 AND SERIOUSLY INJURING THE PASSENGER AS WELL AS THE DRIVER OF VEHICLE 2. BOTH CARS WERE TOWED AND ALL THREE OCCUPANTS WERE TRANSPORTED. ALSO NOTE: A SMALL ENGINE COMPARTMENT FIRE WAS DETECTED AND PUT OUT QUICKLY RESULTING IN NO ADDITIONAL INJURIES.



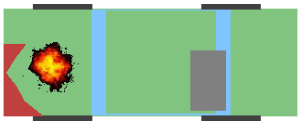
Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Chevrolet	S-10	1997	1	22	MALE	2=Moderate
1	COMPACT PICKUP	Chevrolet	S-10	1997	2	26	MALE	5=Critical
2	3DR/2DR HATCHBAK	Plymouth	Sundance	1992	1	22	FEMALE-NOT PREG	3=Serious

Occupant: 1997-12-167-1-1



Fire Information

Fire Occurence	Minor fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, left side
Fuel Cap Location	Left side, forward rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	998
Total, Longitudal, and Lateral δV	35 -35 6
Est. δV with sequence number	DELTA V CODED 1
CDC	12 F Y E W 4
Damage (C1-C6)	63 33 20 3 17 36
Crush (L and D)	148 -30
Object Contacted 1	VEHICLE NO. 2
Object Contacted 2	ROLLOVER-OVERTRN

NASS Weighting Factor

Weighting factor	31.341591072

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON ROADWAY
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet S-10
Year	1997
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	137

Pre-Crash Driver Data

Accident Type	50
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	No DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	Left TRAVEL LANE

DRIVER Factors

Age	22	Height	170	Weight	64
Gender			MALE		
Ejection			COMPLETE EJECT		
Ejection Area			Left FRONT		
Entrapment			Not ENTRAPPED		

Restraint Factors

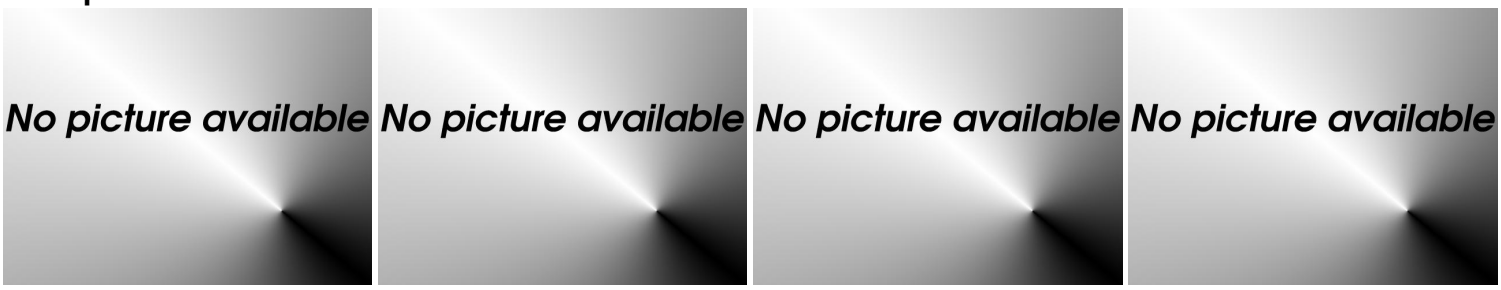
Restrain	None used/avail
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1^{st} Seat	DR BAG DEPLOYED
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1997-12-167-1-1
MAIS	2=Moderate
Seat Position	Front left side

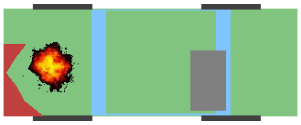
AIS Level	Injury Description	Contacts
2=Moderate	851605	Left apnel
1=Minor	Leg skin contusion (hematoma)	Steering rim
1=Minor	Upper extremity skin abrasion	Air bag-DR side
1=Minor	Abdominal skin abrasion	Left interior
1=Minor	Thoracic skin contusion	Steering rim
1=Minor	Neck skin contusion (hematoma)	Air bag-DR side
1=Minor	Facial skin laceration NFS	Steering rim
1=Minor	Tongue laceration NFS	Steering rim
1=Minor	Scalp abrasion	Left A pillar
1=Minor	Scalp laceration, NFS	Left A pillar

Occupant: 1997-12-167-1-2



Fire Information

Fire Occurence	Minor fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, left side
Fuel Cap Location	Left side, forward rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	998
Total, Longitudal, and Lateral δV	35 -35 6
Est. δV with sequence number	DELTA V CODED 1
CDC	12 F Y E W 4
Damage (C1-C6)	63 33 20 3 17 36
Crush (L and D)	148 -30
Object Contacted 1	VEHICLE NO. 2
Object Contacted 2	ROLLOVER-OVERTRN

NASS Weighting Factor

Weighting factor	31.341591072

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON ROADWAY
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet S-10
Year	1997
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	137

Pre-Crash Driver Data

Accident Type	50
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	No DRIVER
Pre-impact Stability	TRACKING
Pre-impact Location	Left TRAVEL LANE

PASSENGER Factors

Age	26	Height	180	Weight	82
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	None used/avail
AOPS	YES-RES DET
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	DR BAG DEPLOYED
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1997-12-167-1-2
MAIS	5=Critical
Seat Position	Front right side

AIS Level	Injury Description	Contacts
5=Critical	Unconsciousness >24 hours	Roof
4=Severe	Cerebral intraventricular hemorrhage	Roof
5=Critical	Intracerebral hematoma, small, bilateral	Roof
4=Severe	Cerebral subdural hematoma, NFS	Roof
5=Critical	Brainstem compression (includes herniation)	Roof
3=Serious	Cerebral subarachnoid hemorrhage	Roof
3=Serious	Cerebral subarachnoid hemorrhage	Roof
3=Serious	Thoracic cavity injury NFS, with hemo-/pneumothorax	Center panel
2=Moderate	Knee laceration into joint	Right panel
1=Minor	Leg skin abrasion	Seat, back
1=Minor	Facial skin abrasion	Mirror
1=Minor	Scalp abrasion	Mirror
1=Minor	Scalp contusion	Mirror
1=Minor	Scalp laceration, minor	Roof
5=Critical	Brain stem infarction	Roof

1997-48-129

This collision involves a 1997 Mazda Pickup driven by a 35 year old unrestrained male. The vehicle traveled off the right side of the road and struck a large tree at the front plane. A major fire started in the engine compartment which eventually burned the entire vehicle completely.

A fuel leak was reported at the fuel tank which is located forward of the rear axle and on the left side. The driver was entrapped in the vehicle.

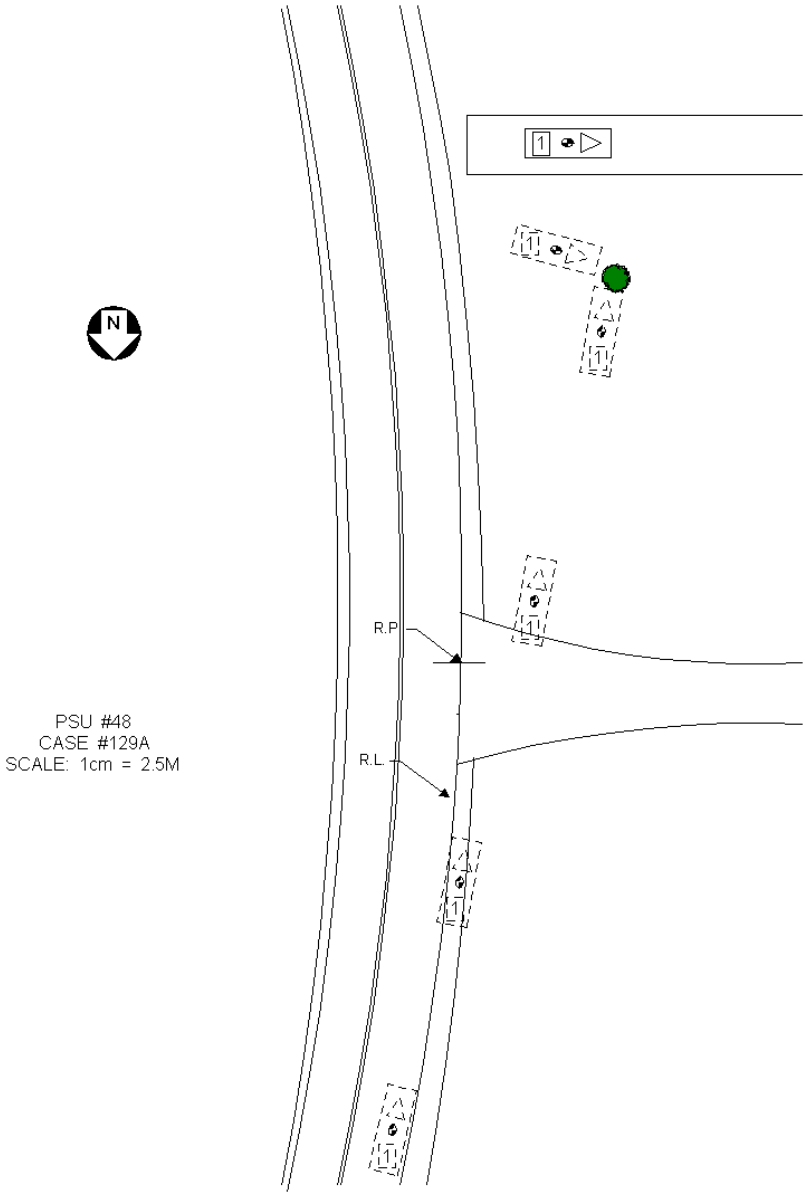
The driver died as a result of the crash. The injuries listed in NASS/CDS include 2nd or 3rd degree burns over 90% of his body and inhalation injury (20-40% carbon monoxide level in blood).

This occupant was not restrained by the safety belt, there is no air bag in this model year vehicle, and a '5' extent of damage was reported. No delta v was given. Without other detailed information regarding his injuries, it is difficult to assess survival possibilities had there been no fire in this crash.

Case Number: 1997-48-129

Summary:

V1 WAS SOUTHBOUND ON A TW0-LANE COUNTY ROADWAY THAT CURVED TO THE LEFT. V1 TRAVELED OFF THE RIGHT SIDE OF THE ROAD AND STRUCK A LARGE TREE WITH ITS FRONTAL PLANE. V1 ROTATED CLOCKWISE VERY RAPIDLY AND SLID INTO A DITCH RUNNING EAST/WEST. V1 CAUGHT FIRE IN THE ENGINE COMPARTMENT AND BURNED COMPLETELY. THE DRIVER OF V1 WAS FATALLY INJURED AND TRANSPORTED TO THE MEDICAL EXAMINER'S OFFICE. V1 WAS TOWED FROM THE SCENE.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Mazda	Pickup	1997	1	35	MALE	6=Maximum

Occupant: 1997-48-129-1-1




Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	Tank
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, left side
Fuel Cap Location	Left side, forward rear axle
Fuel Tank Damage	Other damage
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	998
Total, Longitudal, and Lateral δV	71 -70 -12
Est. δV with sequence number	DELTA V CODED 1
CDC	72 F D E W 5
Damage (C1-C6)	0 24 50 76 98 103
Crush (L and D)	160 43
Object Contacted 1	LARGE TREE
Object Contacted 2	DITCH/CULVERT

NASS Weighting Factor

Weighting factor	298.29110947

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Mazda Pickup
Year	1997
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	152

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	No DRIVER
Pre-impact Stability	No DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	35	Height	175	Weight	77
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	YES-RES DET
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1st Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1997-48-129-1-1
MAIS	6=Maximum
Seat Position	Front left side

AIS Level	Injury Description	Contacts
6=Maximum	Burn, 2nd or 3rd degree, >90% (includes incineration)	Fire in vehicle
4=Severe	Inhalation injury, moderate (CO level 20-40 mg%)	Fire in vehicle

1998-82-118

This collision involves a 1982 Toyota Pickup (Vehicle 1) driven by a 38 year old unrestrained male. This driver was attempting a left hand turn in front of the impacted vehicle. The front end of this vehicle struck the front of vehicle 2. A fire started in the engine compartment destroying it and the passenger compartment.

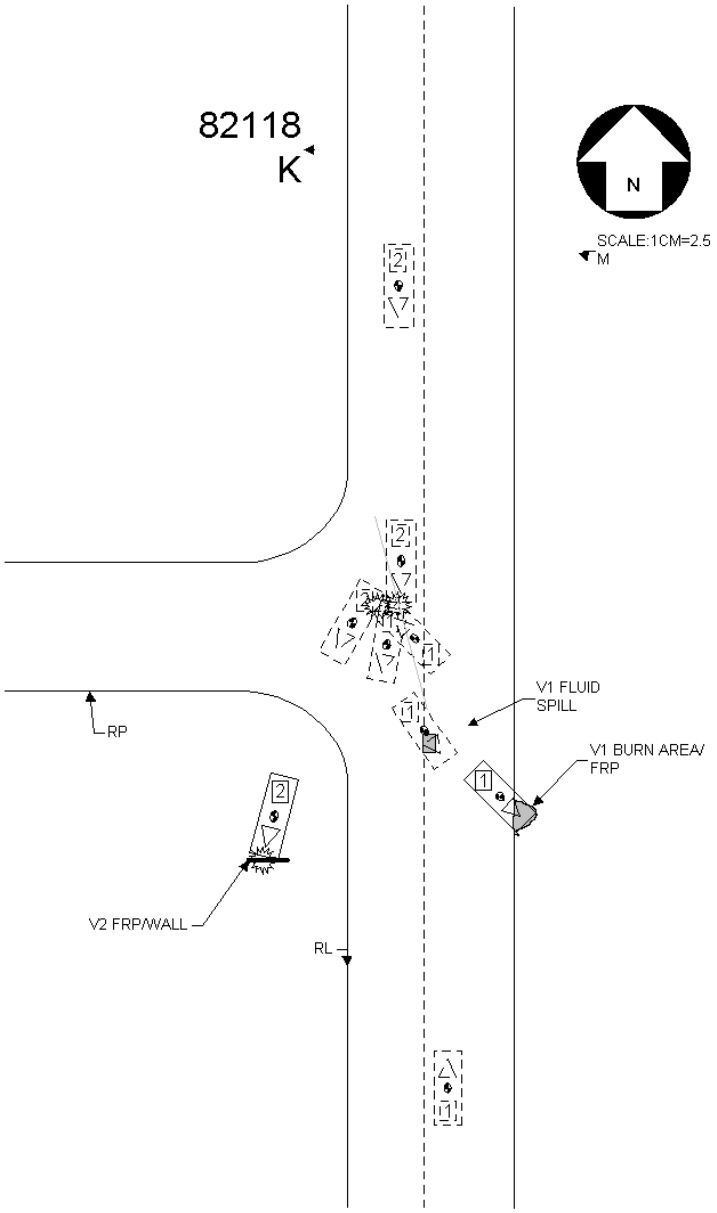
No fuel leak was reported in this crash. The fuel tank is located forward of the rear axle and on the right side. The driver was not entrapped in the vehicle and exited with assistance. This vehicle was not equipped with an air bag.

The driver received MAIS = 3 injuries as a result of the crash. The injuries listed in NASS/CDS include concussion, cerebral contusions, laceration and contusions. This occupant sustained no thermal injuries.

Case Number: 1998-82-118

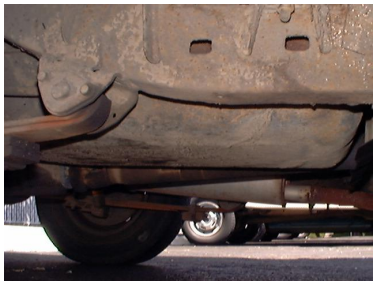
Summary:

VEHICLE 1 WAS EAST IN LANE 1 OF A 2 LANE, 2 WAY ROADWAY. VEHICLE 2 WAS WEST IN LANE 1 OF A 2 LANE, 2 WAY ROADWAY. VEHICLE 2 WAS PASSING THROUGH THE INTERSECTION. VEHICLE 1 WAS TURNING LEFT AT THE INTERSECTION. THE FRONT OF VEHICLE 1 IMPACTED THE FRONT OF VEHICLE 2. VEHICLE 1 CAME TO REST ON THE SOUTH CURB AND THE ENGINE AND PASSENGER COMPARTMENTS WERE DESTROYED BY FIRE. VEHICLE 2 CAME TO REST AFTER IMPACTING A WALL ON THE N/W CORNER. 1 OCCUPANT WAS TRANSPORTED DUE TO INJURIES. 2 VEHICLES WERE TOWED DISABLED.



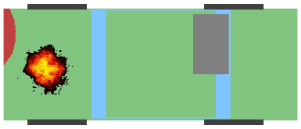
Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	COMPACT PICKUP	Toyota	Pickup	1982	1	38	MALE	3=Serious
2	4-DR SEDAN/HDTOP	Volvo	240/242/244/245	1991	1	20	MALE	1=Minor

Occupant: 1998-82-118-1-1

Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, right side
Fuel Cap Location	Right side, forward rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	MINOR 1
CDC	1 F R E E 5
Damage (C1-C6)	0 11 15 17 14 8
Crush (L and D)	106 179
Object Contacted 1	VEHICLE NO. 2
Object Contacted 2	VEHICLE NO. 2

NASS Weighting Factor

Weighting factor	2.9096352511

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	INTERSECTION REL
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Toyota Pickup
Year	1982
Class	TRUCK
Body Type	COMPACT PICKUP
Weight	114

Pre-Crash Driver Data

Accident Type	68
Pre-event Movement	TURNING LEFT
Critical Pre-crash Event	TURN LEFT-INTERS
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	STAYED IN LANE

DRIVER Factors

Age	38	Height	188	Weight	86
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1998-82-118-1-1
MAIS	3=Serious
Seat Position	Front left side

AIS Level	Injury Description	Contacts
2=Moderate	Awake on admission, unconscious <1 hour	Unknown SOURCE
3=Serious	Cerebral contusions, multiple, bilateral, small	Unknown SOURCE
1=Minor	Facial skin laceration, minor	Unknown SOURCE
1=Minor	Upper extremity skin contusion	Unknown SOURCE
1=Minor	Leg skin contusion (hematoma)	Unknown SOURCE

Rollover Crashes with Vehicle Fire Occurrences

The rollover crashes featured here involve occupants who sustained injury specifically due to the fire that resulted from the rollover collision.

1997-5-154: Rollover Crash with Fire/Thermal Injuries Resultant

This collision involves a 1986 Honda Accord driven by a 16 year old unrestrained male. The driver was traveling too fast and lost control of the vehicle. The vehicle left the road way and impacted a tree at the right front bumper. This impact caused the vehicle to roll 2 quarter turns and come to final rest on its roof. This vehicle was not inspected and therefore it is unknown if the vehicle had an air bag or if it deployed during the collision.

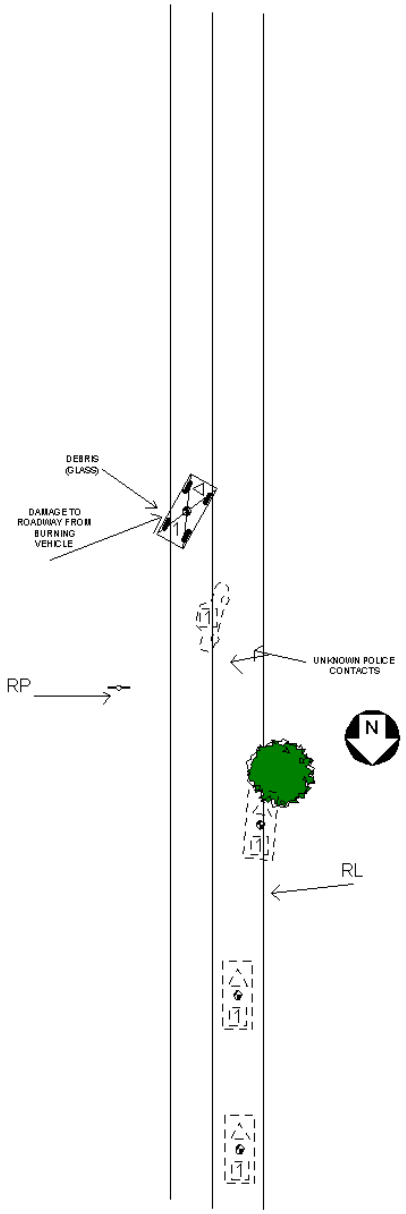
The collision caused a fuel line to break which started a fire that was reported as major. Though there is limited data given because the vehicle was not inspected, it is known that there was a leak from the fuel line. It was reported that the driver was entrapped due to vehicle damage. Due to the fire, the driver could not be rescued.

The driver sustained 2^{nd} or 3^{rd} degree thermal burns over 90% of his body. He ultimately died as a result. The other documented injuries included facial skin lacerations and abrasions. The four remaining occupants escaped the fire and received minor to moderate injuries. The given information suggests that had the fire not started, the driver would have survived this crash.

Case Number: 1997-5-154

Summary:

V1 WAS TRAVELING SOUTHBOUND ON A TWO LANE UNDIVIDED ROADWAY. V1 LOST CONTROL AND IMPACTED A TREE WITH ITS RIGHT FRONT BUMPER AND THIS CAUSED V1 TO ROLLOVER ONTO ITS ROOF THEN TRAVELED TO FINAL REST. AT FINAL REST V1 CAUGHT ON FIRE DUE TO THE FUEL LINE BROKE AND THE CONTINUEING FLOW OF GAS MADE IT IMPOSSIBLE FOR THE DRIVER TO BE RESCUED. V1 WAS TOWED FROM THE SCENE AND ALL FOUR PASSENGERS WERE TRANSPORTED TO A LOCAL TRAUMA CENTER FOR TREATMENT. THE DRIVER WAS FATALLY INJURIED IN THE ACCIDENT.

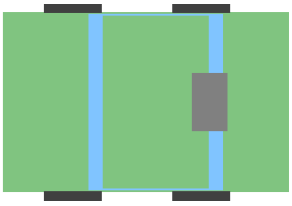


Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Honda	Accord	1986	1	16	MALE	6=Maximum
1	4-DR SEDAN/HDTOP	Honda	Accord	1986	2	15	MALE	1=Minor
1	4-DR SEDAN/HDTOP	Honda	Accord	1986	3	15	MALE	1=Minor
1	4-DR SEDAN/HDTOP	Honda	Accord	1986	4	14	MALE	7=Unk. sev.
1	4-DR SEDAN/HDTOP	Honda	Accord	1986	5	16	MALE	2=Moderate

Occupant: 1997-5-154-1-1

Fire Information

Fire Occurence	No data
Fire Origin	No data
Location of Fuel Leakage	No data
Type of Fuel Tank	No data
Fuel Tank Location	No data
Fuel Cap Location	No data
Fuel Tank Damage	No data
Fuel Type	No data



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 0
CDC	No data No data No data No data No data No data
Damage (C1-C6)	No data No data No data No data No data No data
Crush (L and D)	No data No data
Object Contacted 1	No data
Object Contacted 2	No data

NASS Weighting Factor

Weighting factor	37.727678508

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	LARGE TREE
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Honda Accord
Year	1986
Class	Unknown
Body Type	4-DR SEDAN/HDTOP
Weight	117

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	16	Height	168	Weight	68
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

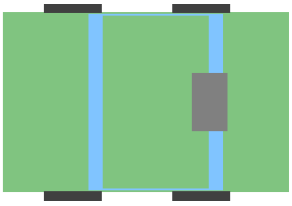
Occupant	1997-5-154-1-1
MAIS	6=Maximum
Seat Position	Front left side

AIS Level	Injury Description	Contacts
6=Maximum	Burn, 2nd or 3rd degree, >90% (includes incineration)	Fire in vehicle
1=Minor	Facial skin abrasion	Unknown SOURCE
1=Minor	Facial skin laceration, minor	Unknown SOURCE
1=Minor	Facial skin laceration, minor	Unknown SOURCE
1=Minor	Facial skin laceration, minor	Unknown SOURCE

Occupant: 1997-5-154-1-2

Fire Information

Fire Occurence	No data
Fire Origin	No data
Location of Fuel Leakage	No data
Type of Fuel Tank	No data
Fuel Tank Location	No data
Fuel Cap Location	No data
Fuel Tank Damage	No data
Fuel Type	No data



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 0
CDC	No data No data No data No data No data No data
Damage (C1-C6)	No data No data No data No data No data No data
Crush (L and D)	No data No data
Object Contacted 1	No data
Object Contacted 2	No data

NASS Weighting Factor

Weighting factor	37.727678508

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	LARGE TREE
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Honda Accord
Year	1986
Class	Unknown
Body Type	4-DR SEDAN/HDTOP
Weight	117

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	15	Height	0	Weight	0
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

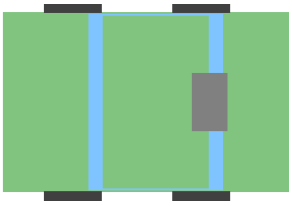
Occupant	1997-5-154-1-2
MAIS	1=Minor
Seat Position	Front right side

AIS Level	Injury Description	Contacts
1=Minor	Scalp injury, NFS	Unknown SOURCE

Occupant: 1997-5-154-1-3

Fire Information

Fire Occurence	No data
Fire Origin	No data
Location of Fuel Leakage	No data
Type of Fuel Tank	No data
Fuel Tank Location	No data
Fuel Cap Location	No data
Fuel Tank Damage	No data
Fuel Type	No data



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 0
CDC	No data No data No data No data No data No data
Damage (C1-C6)	No data No data No data No data No data No data
Crush (L and D)	No data No data
Object Contacted 1	No data
Object Contacted 2	No data

NASS Weighting Factor

Weighting factor	37.727678508

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	LARGE TREE
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Honda Accord
Year	1986
Class	Unknown
Body Type	4-DR SEDAN/HDTOP
Weight	117

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	15	Height	0	Weight	0
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

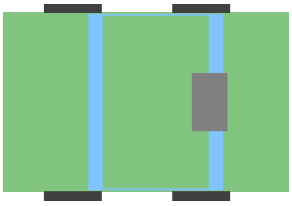
Occupant	1997-5-154-1-3
MAIS	1=Minor
Seat Position	Second left

AIS Level	Injury Description	Contacts
1=Minor	Leg skin abrasion	Unknown SOURCE
1=Minor	Leg skin abrasion	Unknown SOURCE
1=Minor	Wrist (carpus) joint sprain	Unknown SOURCE
1=Minor	Leg skin contusion (hematoma)	Unknown SOURCE

Occupant: 1997-5-154-1-4

Fire Information

Fire Occurence	No data
Fire Origin	No data
Location of Fuel Leakage	No data
Type of Fuel Tank	No data
Fuel Tank Location	No data
Fuel Cap Location	No data
Fuel Tank Damage	No data
Fuel Type	No data



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 0
CDC	No data No data No data No data No data No data
Damage (C1-C6)	No data No data No data No data No data No data
Crush (L and D)	No data No data
Object Contacted 1	No data
Object Contacted 2	No data

NASS Weighting Factor

Weighting factor	37.727678508

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	LARGE TREE
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Honda Accord
Year	1986
Class	Unknown
Body Type	4-DR SEDAN/HDTOP
Weight	117

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	14	Height	0	Weight	0
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

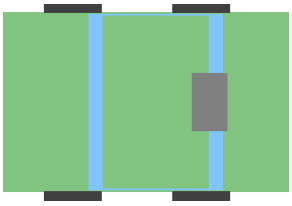
Occupant	1997-5-154-1-4
MAIS	7=Unk. sev.
Seat Position	Second middle

AIS Level	Injury Description	Contacts

Occupant: 1997-5-154-1-5

Fire Information

Fire Occurence	No data
Fire Origin	No data
Location of Fuel Leakage	No data
Type of Fuel Tank	No data
Fuel Tank Location	No data
Fuel Cap Location	No data
Fuel Tank Damage	No data
Fuel Type	No data



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 0
CDC	No data No data No data No data No data No data
Damage (C1-C6)	No data No data No data No data No data No data
Crush (L and D)	No data No data
Object Contacted 1	No data
Object Contacted 2	No data

NASS Weighting Factor

Weighting factor	37.727678508

Rollover Characteristics

Number of Events	3
Rollover Initiation Type	BOUNCE-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	LARGE TREE
Location on Vehicle where Principal Tripping Force was Applied	END PLANE
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	UPHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Honda Accord
Year	1986
Class	Unknown
Body Type	4-DR SEDAN/HDTOP
Weight	117

Pre-Crash Driver Data

Accident Type	2
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/ LOCKUP
Pre-impact Stability	LONGITUDINAL SKID
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	16	Height	0	Weight	0
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1997-5-154-1-5
MAIS	2=Moderate
Seat Position	Second right

AIS Level	Injury Description	Contacts
2=Moderate	Carpus or metacarpus fracture	Unknown SOURCE
2=Moderate	Clavicle fracture	Unknown SOURCE
1=Minor	Scalp abrasion	Unknown SOURCE

2002-9-103: Vehicle Fire with Entrapment

This collision involves a 2002 Mazda Protege driven by a 20 year old restrained female. The driver fell asleep and the vehicle ran off the roadway, tripped on the unpaved shoulder and rolled 2 quarter turns. The vehicle came to rest on its roof. A fire in the engine compartment resulted and was reported as major. Moderate vehicle damage was sustained due to the rollover. The occupant compartment sustained moderate to minimal intrusion. The NASS/CDS database reports that due to the fire it is unknown if the driver's air bag deployed.

There was no fuel leakage reported. The fuel tank was located forward of the rear axle and centered. Figure 3 is a photograph of the left side of the vehicle showing crush and fire damage.

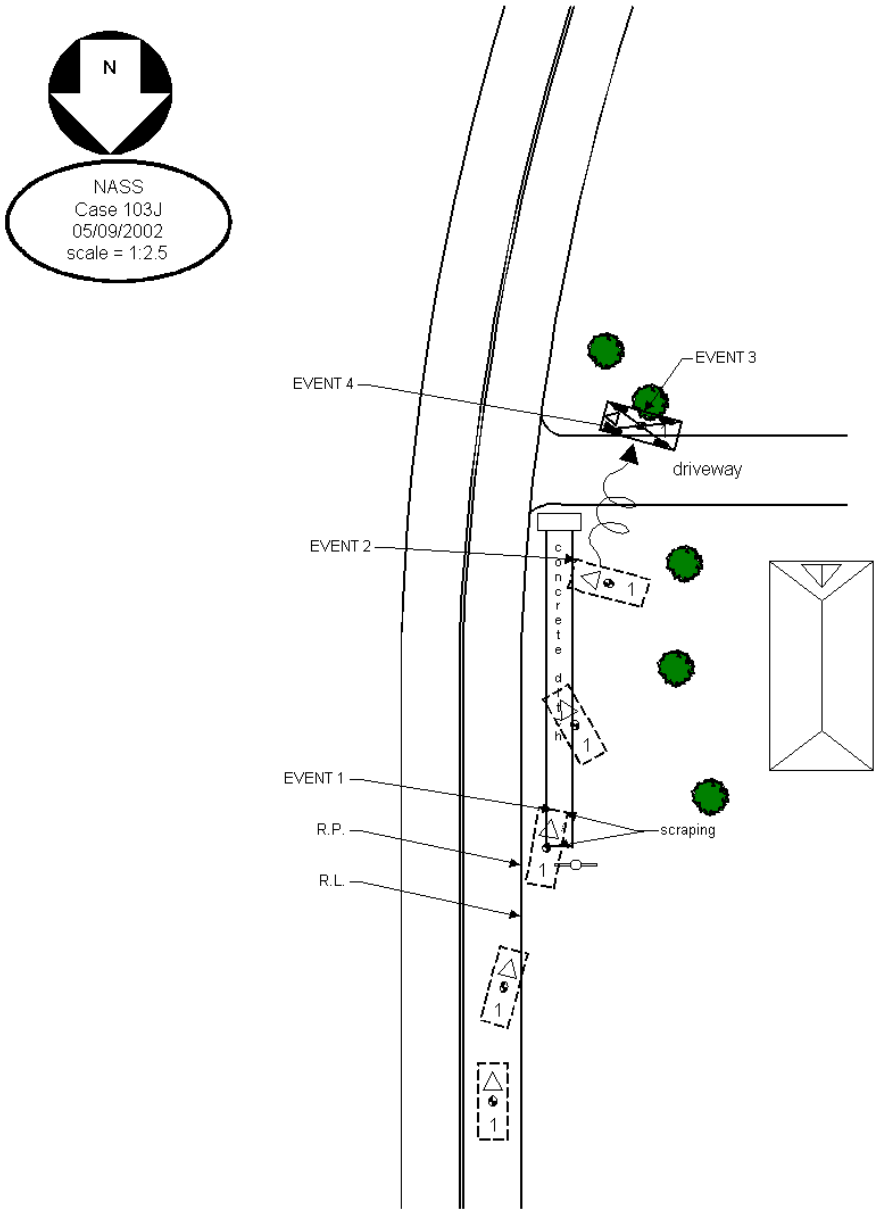
FIGURE 3

The collision caused the vehicle doors to be jammed, and thus the occupant was entrapped within the burning vehicle. This occupant sustained multiple injuries (MAIS2) which included: foot fractures; lumbar fracture without cord injury; multiple lacerations, abrasions, contusions; concussion. This occupant escaped without thermal injuries.

Case Number: 2002-9-103

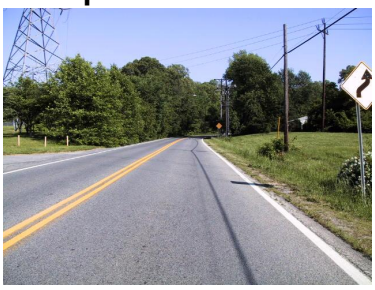
Summary:

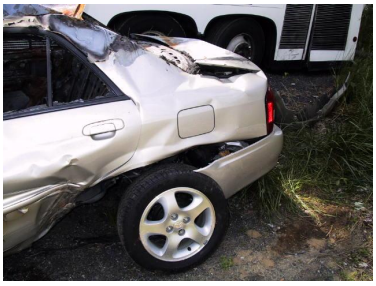
Vehicle 1 (2002 Mazda Protege) was traveling south on a two-way, two-laneroadway when the driver fell asleep and departed the road to the right. Theundercarriage struck the cement culvert (EVENT 1), then rotated about 90 degreescounter clockwise. V1 then overturned two quarter rotations (EVENT 2). When V1was about to rotate another quarter turn it's left plane contacted a tree (EVENT3). V1 came to a final rest on it's roof and subsequently caught fire (EVENT4). V1 was towed from the scene and sustained moderate damage to it's leftplane, top plane, and undercarriage. It was equipped with dual frontal airbags;it is unknown whether they deployed due to fire damage. V1 contained only adriver, no other occupants. The driver was transported to the hospital via airfor reported incapaciting injuries. The driver was admitted due to extremityfractures.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Mazda	GLC/323/Protege	2002	1	20	FEMALE-NOT PREG	2=Moderate

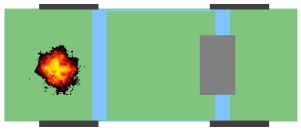
Occupant: 2002-9-103-1-1



Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, centered
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	Deformed
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	52 U F D W 5
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0
Object Contacted 1	DITCH/CULVERT
Object Contacted 2	ROLLOVER-OVERTRN

NASS Weighting Factor

Weighting factor	20.863

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON SHLDER-UNPAVE
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL RIGHT

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	10

Vehicle Factors

Make-Model	Mazda GLC/323/Protege
Year	2002
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	120

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	20	Height	188	Weight	82
Gender			FEMALE-NOT PREG		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1st Seat	DR&PAS BAG DEPLY
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	2002-9-103-1-1
MAIS	2=Moderate
Seat Position	Front left side

AIS Level	Injury Description	Contacts
2=Moderate	Metatarsal or tarsal fracture	Floor
2=Moderate	Fibular lateral malleolus fracture	Floor
2=Moderate	Calcaneus fracture	Floor
2=Moderate	Lumbar fracture without cord injury NFS	Unknown SOURCE
2=Moderate	Knee laceration into joint	Left apnel
2=Moderate	Ankle jt dislocation without involving articular cartilage	Floor
2=Moderate	Lethargic on admission, unconscious (length NFS)	Unknown SOURCE
1=Minor	Facial skin abrasion	Unknown SOURCE
1=Minor	Abdominal skin abrasion	Unknown SOURCE
1=Minor	Upper extremity skin contusion	Unknown SOURCE
1=Minor	Mouth injury NFS	Unknown SOURCE

2001-12-100: Rollover Crash with Fire

This collision involves a 2000 S-10 Blazer driven by a 42 year old restrained male. This vehicle was impacted on the right side by a vehicle that went out of control. This vehicle then contacted the trailer of a 3rd vehicle and rotated clockwise. This vehicle rolled 8 quarter turns before it came to rest. The major fire engulfed the engine compartment. The Blazer's air bags did not deploy during this collision sequence.

There was no fuel leak in this collision. The fuel tank, located forward of the rear axle on the left, was not damaged during the collision. The driver was not entrapped within the vehicle and exited from it with assistance. Figure 4 is a photograph of the front left side of the vehicle showing structural and fire damage.

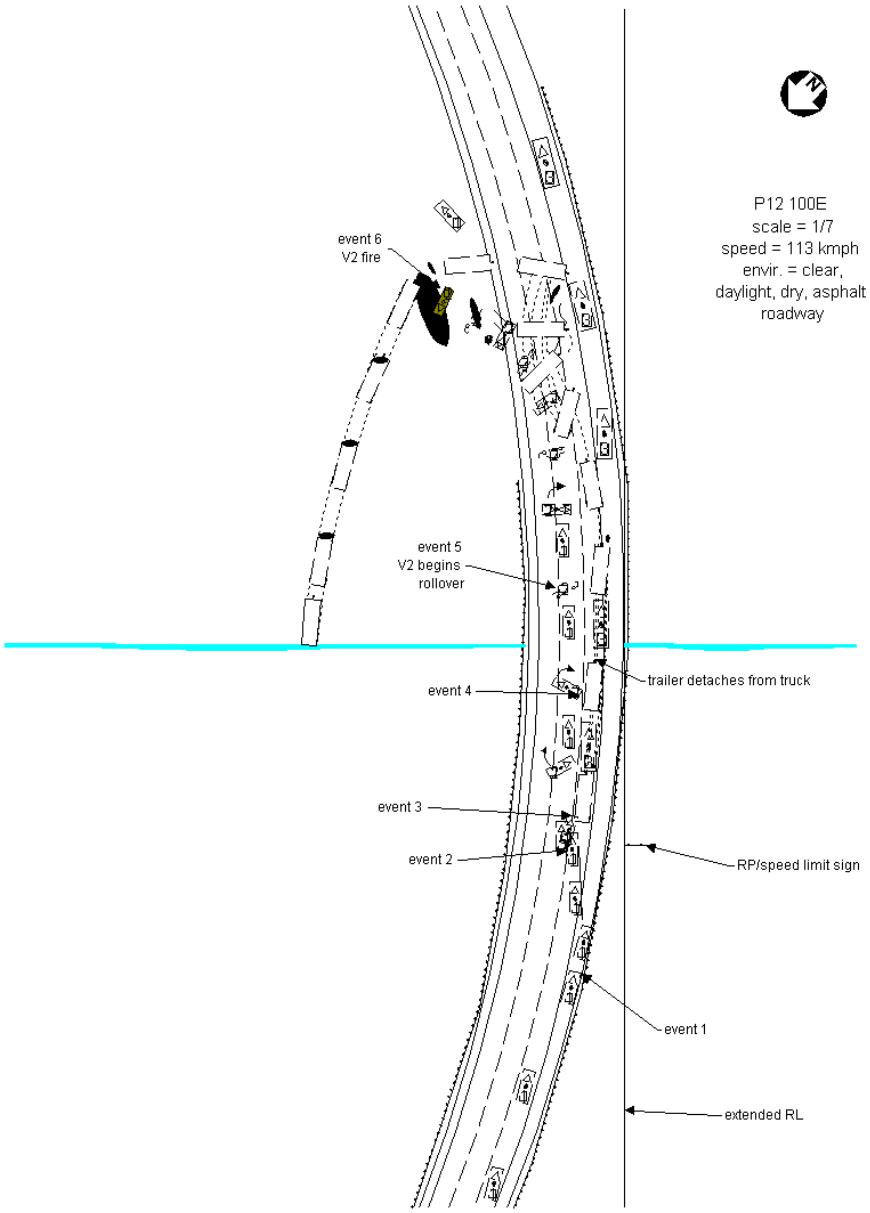
FIGURE 4

The driver sustained AIS = 1 thermal injuries as a result of the crash and fire. The other documented injuries included cervical and thoracic spine strain without fracture and scalp and upper extremity skin abrasions.

Case Number: 2001-12-100

Summary:

Vehicles 1, 2, & 3 were heading south down a 3 lane, 1 way, divided expresswaywithout positive barrier. It was a clear day and the asphalt road was dry.Vehicle 1 was in the first lane and went off the road on the right sidecontacting a guardrail causing moderate damage to the vehicle. Vehicle 1reentered the roadway and the left side contacted the right side of vehicle 2,which was travelling in the second lane, causing minor damage to both vehicles.Vehicle 2 then contacted the back of a trailer that vehicle 3 was towing, andbegan to rotate clockwise. After this impact to the trailer, the trailer cameloose from vehicle 3 and started rotating clockwise. The back of vehicle 2contacted the left side of the trailer and began to rollover. Vehicle 2 rolledleft 8 quarter turns before final rest in the median facing in a north westerlydirection and caught on fire. Vehicle 1 went off the road on the left side aswell facing north easterly just south of vehicle 2 at final rest. The trailer,after rotating 90 degress, began to roll backwards and rolled, off road, betweenvehicles 1 & 2 before final rest down an embankment by a creek. Vehicle 1 wastowed due to damge. The trailer that vehicle 3 was towing was also towed.Occupant 1 of vehicle 2 was transported to a local trauma center for treatmentof his injuries.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
2	COMPACT UTILITY	Chevrolet	S-10 Blazer	2000	1	42	MALE	1=Minor

Occupant: 2001-12-100-2-1

Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Non-metallic
Fuel Tank Location	Forward of rear axle, left side
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	8 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 5
CDC	0 T D D O 5
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0
Object Contacted 1	ROLLOVER-OVERTRN
Object Contacted 2	VEHICLE NO. 3

NASS Weighting Factor

Weighting factor	269.159

Rollover Characteristics

Number of Events	6
Rollover Initiation Type	TRIP-OVER
Location of Rollover Initiation	ON ROADWAY
Rollover Initiation Object Contacted	GROUND
Location on Vehicle where Principal Tripping Force was Applied	WHEELS/TIRES
Direction of Initial Roll	ROLL LEFT

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	CURVE LEFT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Chevrolet S-10 Blazer
Year	2000
Class	TRUCK
Body Type	COMPACT UTILITY
Weight	187

Pre-Crash Driver Data

Accident Type	98
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	Same DIR-OV RGHT
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	STAYED IN LANE

DRIVER Factors

Age	42	Height	175	Weight	77
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	NONDEPLOYED
Airbag Deployment - 1st Seat	NONDEPLOYED
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	2001-12-100-2-1
MAIS	1=Minor
Seat Position	Front left side

AIS Level	Injury Description	Contacts
1=Minor	690202	Unknown SOURCE
1=Minor	690402	Unknown SOURCE
1=Minor	Acute cervical spine strain without fracture or dislocation	Roof
1=Minor	Thoracic spine strain, acute without fracture or dislocation	Other noncontact
1=Minor	Scalp abrasion	Roof
1=Minor	Upper extremity skin abrasion	Belt webb/buckle

NASS/CDS 1998-13-199: Rollover Crash with Fire/Thermal Injury

This collision involves a 1983 Chevrolet Caprice/Impala driven by a 72 year old unrestrained female. The vehicle drifted off the road and struck a large tree prior to rolling over 1 quarter turn to its right. No air bags were available in this vehicle.

The collision caused damage to a line or pump causing a fuel leak. The fire, reported to be within the engine compartment, was documented as a major fire. The fuel tank, noted behind the rear axle and centered, had no reported damage. The driver was entrapped in the vehicle due to structural damage. The driver was rescued from the fire, but not before sustaining thermal injuries. Figure 3 is a photograph of the front left of the vehicle showing structural and fire damage.

FIGURE 3

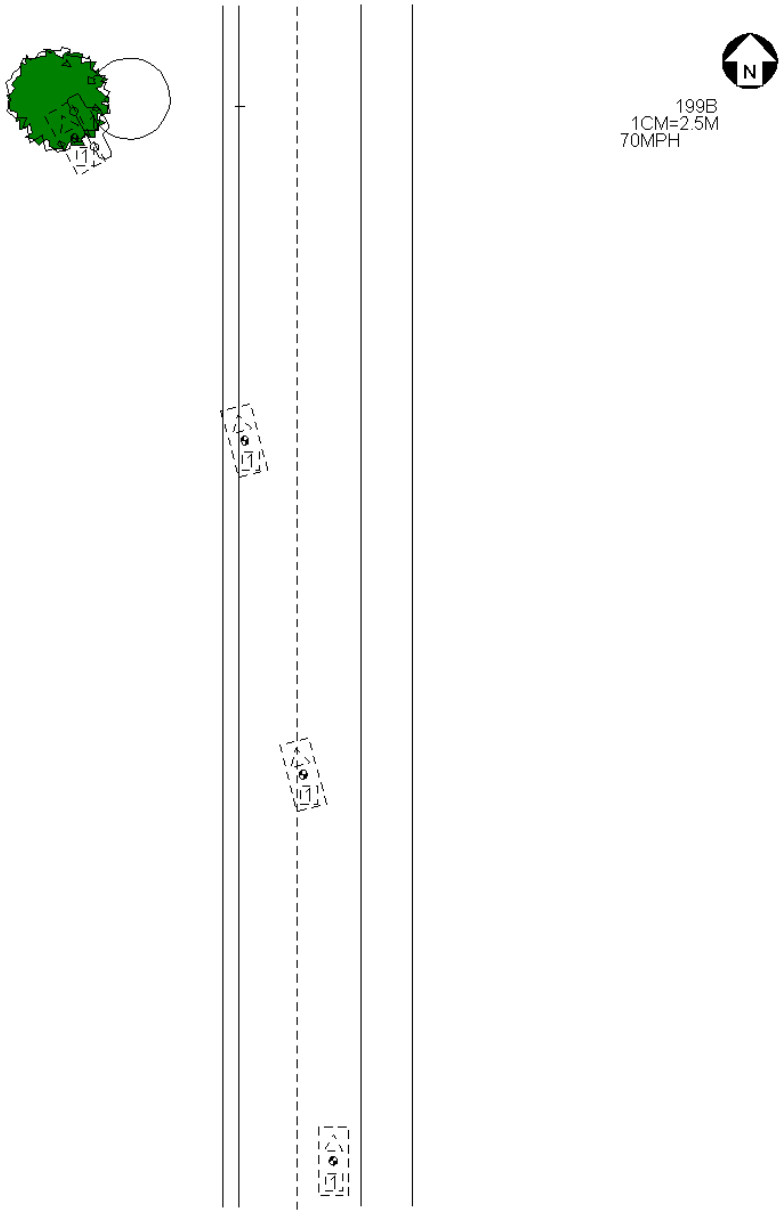
The driver ultimately died as a result of her injuries. She sustained 2nd or 3rd degree thermal burns over 90% of her body in addition to multiple traumatic injuries to her head, chest and abdomen. The autopsy states that she ultimately died due to her traumatic injuries. Given the extent of the thermal burns, it is likely they too were contributory to her death.

The front right passenger was not entrapped in the vehicle. She was found unconscious and removed from the burning vehicle prior to sustaining thermal injury. The front right passenger was unrestrained and received multiple traumatic injuries including multiple fractures. He was hospitalized for 12 days due to these injuries.

Case Number: 1998-13-199

Summary:

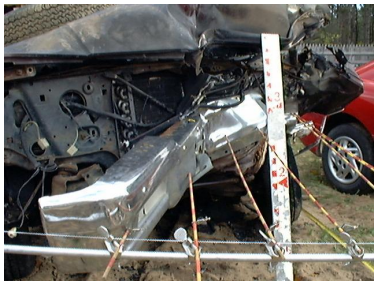
VEHICLE # 1 WAS NORTH BOUND IN THE RIGHT LANE ON A 4 LANE DRY, 70MPH, DIVIDED HIGHWAY AND DRIFTED TO THE LEFT GOING INTO THE MEDIUM STRIKING A TREE HEADON AND ROLLING ONTO ITS SIDE AND BURNING. WHAT WAS LEFT OF THE VEHICLE WAS TOWED FROM THE SCENE DUE TO DAMAGE. THE DRIVER BURNED IN THE CAR AND THE OCCUPANT WAS REMOVED BY A PASSERBY AND HOSPITALIZED. Occupant 1-01 died from trauma, not the fire (per autopsy).



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Chevrolet	Caprice/Impala	1983	1	72	FEMALE-NOT PREG	6=Maximum
1	4-DR SEDAN/HDTOP	Chevrolet	Caprice/Impala	1983	2	73	FEMALE-NOT PREG	3=Serious

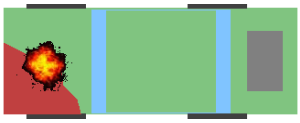
Occupant: 1998-13-199-1-1






Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	Line/pump/filter
Type of Fuel Tank	Metallic
Fuel Tank Location	Behind rear axle, centered
Fuel Cap Location	On back plane
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	92 F Y E W 5
Damage (C1-C6)	142 135 109 106 51 0
Crush (L and D)	181 -59
Object Contacted 1	LARGE TREE
Object Contacted 2	ROLLOVER-OVERTRN

NASS Weighting Factor

Weighting factor	81.51723587

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	FLIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	SMALL TREE
Location on Vehicle where Principal Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL RIGHT

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	4

Vehicle Factors

Make-Model	Chevrolet Caprice/Impala
Year	1983
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	163

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	Oth CRIT EVENT
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	72	Height	165	Weight	77
Gender			FEMALE-NOT PREG		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

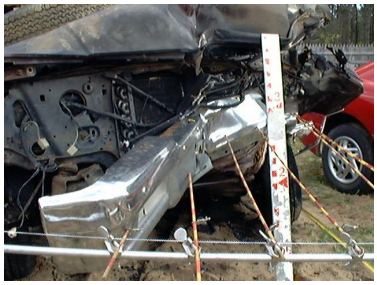
Injuries

Occupant	1998-13-199-1-1
MAIS	6=Maximum
Seat Position	Front left side

AIS Level	Injury Description	Contacts
6=Maximum	Burn, 2nd or 3rd degree, >90% (includes incineration)	Fire in vehicle
4=Severe	>3 rib fxs on each side, stable chest	Steering comb
2=Moderate	Humeral fracture NFS	Center panel
3=Serious	Humeral fracture, open/displaced/comminuted	Left apnel
2=Moderate	Sternoclavicular joint dislocation	Steering rim
2=Moderate	Sternoclavicular joint dislocation	Steering rim
2=Moderate	851605	Left apnel
2=Moderate	Tibial fracture NFS	Left apnel
2=Moderate	Foot fracture NFS	Floor
4=Severe	Thoracic cord incomplete syndrome, with fx & dislocation	Steering comb
2=Moderate	Hepatic contusion, minor (subcapsular, <50% surface, <2cms)	Steering comb
3=Serious	Lung laceration, unilateral NFS	Steering comb
4=Severe	Lung contusion, bilateral	Steering comb
5=Critical	Thoracic aortic laceration, major, & mediastinal bleeding	Sterring hub
3=Serious	Myocardial contusion, minor	Sterring hub
4=Severe	Hepatic laceration, major (<50% parenchyma, burst, lacs>3cms	Steering comb
5=Critical	Brain stem hemorrhage	Left apnel
3=Serious	Cerebral subarachnoid hemorrhage	Left apnel

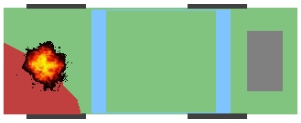
Occupant: 1998-13-199-1-2






Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	Line/pump/filter
Type of Fuel Tank	Metallic
Fuel Tank Location	Behind rear axle, centered
Fuel Cap Location	On back plane
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	2 QUARTER TURNS
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	92 F Y E W 5
Damage (C1-C6)	142 135 109 106 51 0
Crush (L and D)	181 -59
Object Contacted 1	LARGE TREE
Object Contacted 2	ROLLOVER-OVERTRN

NASS Weighting Factor

Weighting factor	81.51723587

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	FLIP-OVER
Location of Rollover Initiation	ROADSIDE/MEDIAN
Rollover Initiation Object Contacted	SMALL TREE
Location on Vehicle where Principal Tripping Force was Applied	UNDERCARRIAGE
Direction of Initial Roll	ROLL RIGHT

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	FOUR
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	4

Vehicle Factors

Make-Model	Chevrolet Caprice/Impala
Year	1983
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	163

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	Oth CRIT EVENT
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	73	Height	168	Weight	73
Gender			FEMALE-NOT PREG		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	None used/avail
AOPS	NO
Airbag Deployment	Not EQUIP/AVAIL
Airbag Deployment - 1^{st} Seat	Not EQUIP/AVAIL
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	1998-13-199-1-2
MAIS	3=Serious
Seat Position	Front right side

AIS Level	Injury Description	Contacts
3=Serious	Unconscious on admission (GCS<=8) NFS	Unknown SOURCE
1=Minor	Leg skin abrasion	Right panel
1=Minor	Thoracic skin contusion	Right panel
1=Minor	Upper extremity skin contusion	Right interior
1=Minor	Upper extremity skin contusion	Right panel
1=Minor	Facial skin laceration NFS	Unknown SOURCE
1=Minor	Leg skin contusion (hematoma)	Left apnel
1=Minor	Leg skin laceration, minor	Right panel
2=Moderate	Pelvic fracture NFS	Right panel
2=Moderate	Pelvic fracture, closed	Seat, back
2=Moderate	Fibular head, neck, or shaft fracture	Floor
2=Moderate	Ankle joint dislocation NFS	Floor
2=Moderate	Tibial fracture NFS	Floor
3=Serious	Lung contusion NFS	Right panel
1=Minor	297602	Unknown SOURCE
1=Minor	Scalp laceration, minor	Unknown SOURCE
1=Minor	Facial skin avulsion, superficial	Unknown SOURCE
1=Minor	Facial skin laceration NFS	Unknown SOURCE

Engine Compartment Fires with Occupant Entrapment

The following case reviews will highlight crashes where the driver was entrapped in the vehicle following the collision where a fire started in the engine compartment.

NASS/CDS 2002-49-117: Vehicle Fire with Entrapment

This collision involves a 1991 Cadillac Deville driven by a 21 year old restrained male. The vehicle left the road way and impacted a tree at the left front. The driver's air bag deployed as a result of the collision. After rotating 90 degrees counterclockwise about the tree, the vehicle came to rest. The engine compartment caught fire as a result of the collision and it was reported as a major fire. There was no fuel leakage and no damage to the fuel tank which is located forward of the rear axle and centered. The CDC is 12FLAE6 with significant intrusion. Figure 6 is a photograph of the left side of the vehicle showing crush and fire damage.

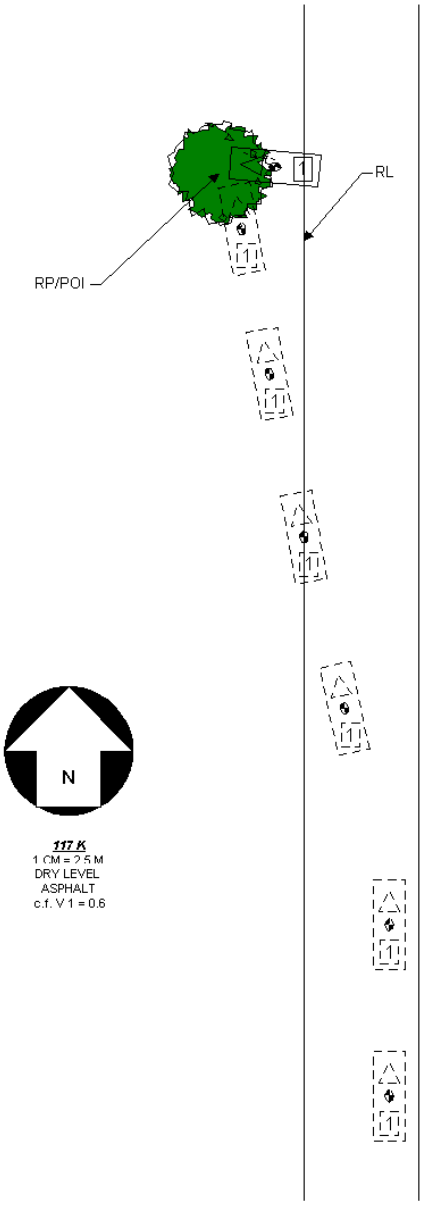
FIGURE 6

The driver was entrapped in the burning vehicle due to jamming of the vehicle. He sustained thermal burns as a result, was hospitalized and ultimately died. His other injuries included: flail chest with lung contusion (AIS = 4); multiple thermal burns of face, upper and lower extremities (AIS = 2); internal abdominal lacerations (AIS = 2); mandible fracture; multiple foot and lower leg fractures (AIS = 2); C-spine fracture (AIS = 2); upper extremity fractures (AIS = 2).

Case Number: 2002-49-117

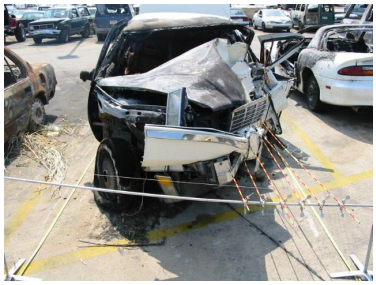
Summary:

Vehicle 1 was traveling north in the first lane of an undivided, unmarked twoway road way. Vehicle 1 drove over the south bound lane to it's left anddeparted road. V 1's left front impacted a tree. The vehicle rotated counterclockwise about 90 degrees around the tree. V 1 came to rest facing the tree.Fire started in V 1 engine compartment. The driver airbag of V 1 deployed duringthe crash. The fire inside the vehicle burned about 2/3 of the already deployedairbag. The restrained driver was hospitalized with multiple arm, face and footburns, multiple rib fractures with lung contusions, bilateral leg fractures,right arm fractures, and multiple abdominal internal lacerations. The vehiclewas towed from the scene.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Cadillac	Deville/Fleetwood	1991	1	21	MALE	4=Severe

Occupant: 2002-49-117-1-1

Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, centered
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	101
Total, Longitudal, and Lateral δV	86 -86 < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 1
CDC	12 F L A E 6
Damage (C1-C6)	177 171 112 87 58 29
Crush (L and D)	172 -76
Object Contacted 1	LARGE TREE
Object Contacted 2	0

NASS Weighting Factor

Weighting factor	12.55

Rollover Characteristics

Number of Events	2
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE LEFT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	17

Vehicle Factors

Make-Model	Cadillac Deville/Fleetwood
Year	1991
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	164

Pre-Crash Driver Data

Accident Type	6
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-LEFT
Attempted Avoidance Maneuver	No DRIVER
Pre-impact Stability	No DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	21	Height	168	Weight	86
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1^{st} Seat	DR BAG DEPLOYED
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	2002-49-117-1-1
MAIS	4=Severe
Seat Position	Front left side

AIS Level	Injury Description	Contacts
4=Severe	Flail chest, with lung contusion	Steering comb
2=Moderate	792012	Fire in vehicle
2=Moderate	892008	Fire in vehicle
1=Minor	292002	Fire in vehicle
2=Moderate	Hepatic laceration, minor (<3cms deep, EBL<20%, simple cap.)	Steering rim
2=Moderate	Colonic laceration without perforation (partial thickness)	Steering rim
2=Moderate	Mesenteric laceration, minor	Steering rim
1=Minor	Mandible fracture, closed, location NFS	Steering comb
2=Moderate	Ankle jt dislocation without involving articular cartilage	Floor
2=Moderate	Tibial fracture medial malleolus, open/displaced/comminuted	Floor
2=Moderate	Fibular head, neck, or shaft fracture	Knee bolster
3=Serious	Tibial shaft fracture, open/displaced/comminuted	Knee bolster
3=Serious	Supracondylar femoral fracture	Knee bolster
3=Serious	Tibial condylar fracture, open/displaced/comminuted	Knee bolster
2=Moderate	Cervical vertebral body fracture, no cord injury, <20%	Steering comb
2=Moderate	Ulnar fracture, closed	Left apnel
2=Moderate	Humeral fracture, closed	Left apnel
3=Serious	Knee complete disruption of posterior cruciate	Knee bolster
1=Minor	Facial skin laceration, minor	Steering comb
1=Minor	297402	Steering comb
1=Minor	297402	Steering comb
1=Minor	Abdominal skin abrasion	Steering rim

2001-49-245: Vehicle Fire with Entrapment

This collision involves a 2000 Dodge Durango driven by a 35 year old restrained male. The vehicle left the road way and impacted a large concrete bridge pillar. The driver's air bag deployed as a result of the collision. After rotating counterclockwise about the tree, the vehicle came to rest. The engine compartment caught fire as a result of the collision and it was reported as a major fire. Though the fuel tank, located forward of the rear axle on the left side, was damaged as a result of the crash, there was no fuel leakage reported. The CDC is 12FDAW7 with significant intrusion. Figure 7 is a photograph of the left side of the vehicle showing crush and fire damage.

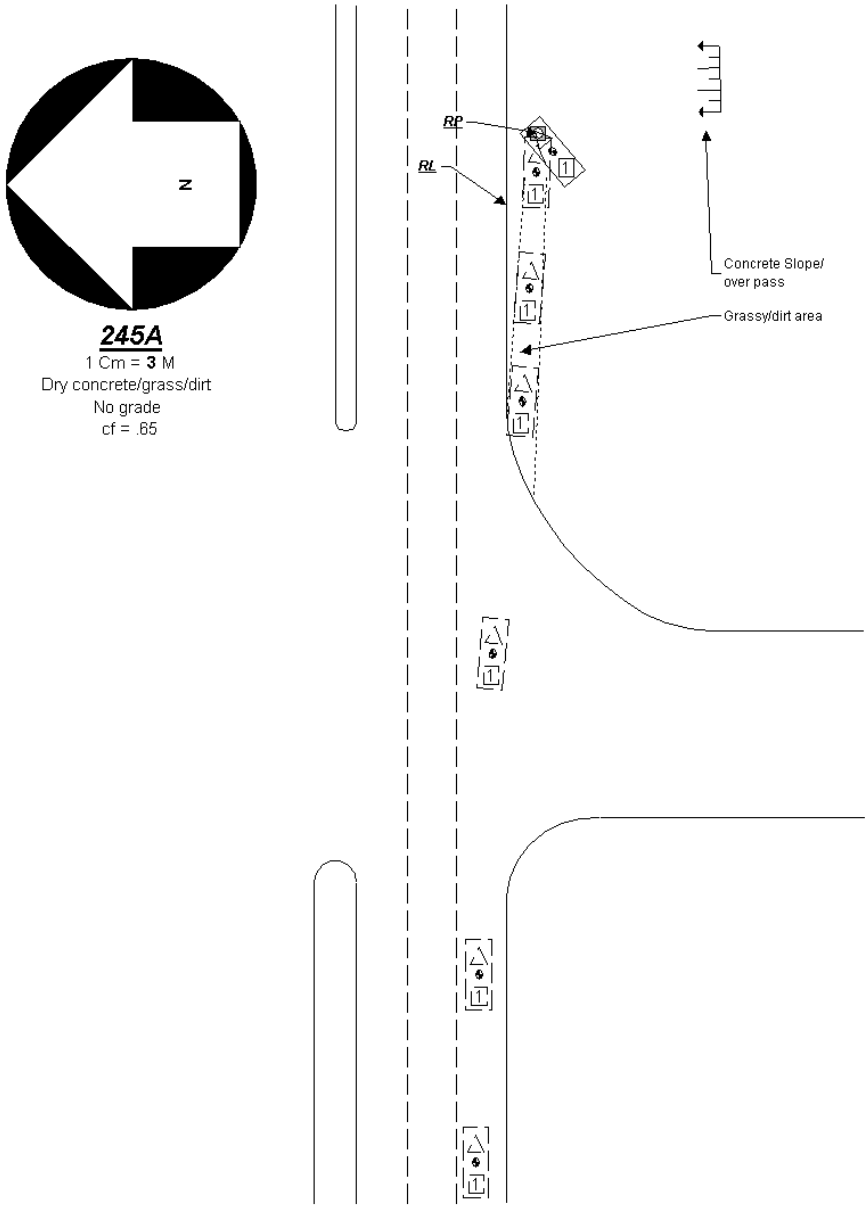
FIGURE 7

The driver was entrapped in the burning vehicle due to jamming of the vehicle door. He sustained thermal burns and other injuries as a result. This occupant died due to his multiple injuries. His other injuries included: multiple traumatic chest trauma (aortic laceration, septal laceration, myocardial laceration, pericardial laceration, sternal fracture, multiple rib fractures); cervical spinal cord laceration; liver and splenic lacerations; multiple abdominal trauma; subarachnoid hemorrhage; multiple skin lacerations and abrasions.

Case Number: 2001-49-245

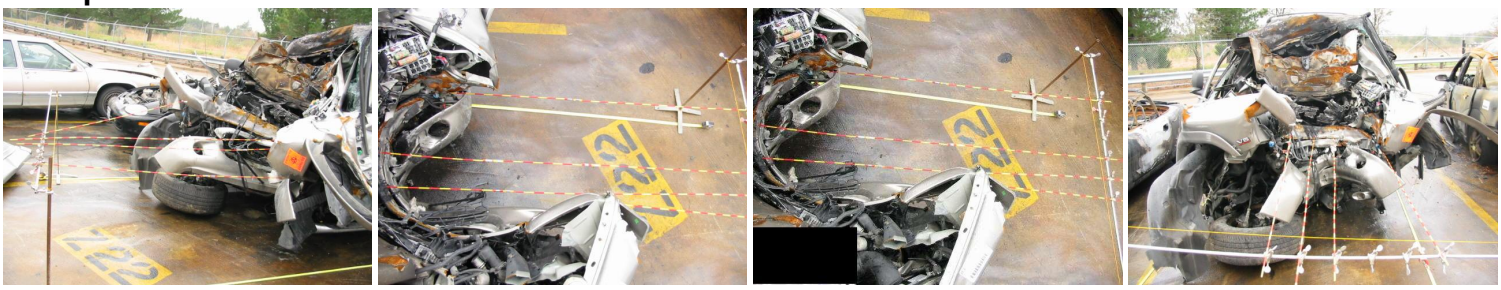
Summary:

Vehicle 1 was traveling east in the first lane of a three-lane, divided roadway.The vehicle went off the road to the right and the front collided with a largeconctete bridge pillar. Upon contact, the vehicle caught fire but did notcompletely burn up. The vehicle was equipped with driver and passenger airbagswhich deployed at impact. The driver was fatally injured with spinal cord andaorta transection as well as multiple heart lacerations, rib fractures was wellas other internal injuries, and the vehicle was towed.



Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	LARGE UTILITY	Dodge	422	2000	1	35	MALE	6=Maximum

Occupant: 2001-49-245-1-1



Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Non-metallic
Fuel Tank Location	Forward of rear axle, left side
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	Deformed
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	> 159.5KMPH
Total, Longitudal, and Lateral δV	155 -155 < 0.5 KMPH
Est. δV with sequence number	DELTA V CODED 1
CDC	12 F D A W 7
Damage (C1-C6)	162 186 195 197 191 84
Crush (L and D)	162 -13
Object Contacted 1	BRIDGE
Object Contacted 2	0

NASS Weighting Factor

Weighting factor	11.07

Rollover Characteristics

Number of Events	2
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	DVDED/NO BARRIER
Number of Travel Lanes	THREE
Roadway Alignment	CURVE RIGHT
Roadway Profile	LEVEL
Roadway Surface Type	CONCRETE
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	INTERCHANGE REL
Traffic Control Device	
Police Reported Alcohol Presence	No ALCOHOL
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Dodge 422
Year	2000
Class	TRUCK
Body Type	LARGE UTILITY
Weight	198

Pre-Crash Driver Data

Accident Type	1
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	OFF EDGE-RIGHT
Attempted Avoidance Maneuver	No DRIVER
Pre-impact Stability	No DRIVER
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	35	Height	173	Weight	86
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			JAMMED DOOR/FIRE		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1st Seat	DR&PAS BAG DEPLY
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	2001-49-245-1-1
MAIS	6=Maximum
Seat Position	Front left side

AIS Level	Injury Description	Contacts
5=Critical	Thoracic aortic laceration, major, & mediastinal bleeding	Steering comb
6=Maximum	Cord laceration, complete, C3 or above, with dislocation	Steering comb
5=Critical	Intraventricular or intra-atrial septal laceration/rupture	Steering comb
6=Maximum	Myocardial laceration with complex perforation	Steering comb
2=Moderate	Pericardial laceration (puncture)	Steering comb
4=Severe	Lung contusion, bilateral	Steering comb
5=Critical	>3 rib fxs on each side, stable chest & hemo-/pneumothorax	Steering comb
2=Moderate	Sternal fracture	Steering comb
2=Moderate	Hepatic laceration NFS	Steering comb
2=Moderate	Splenic laceration NFS	Steering comb
3=Serious	Symphysis pubis separation or fracture	Steering comb
2=Moderate	Bladder contusion (hematoma)	Steering comb
2=Moderate	Mesenteric contusion NFS	Steering comb
2=Moderate	Small bowel contusion (hematoma)	Steering comb
2=Moderate	Patellar fracture	Knee bolster
3=Serious	853405	Knee bolster
2=Moderate	852002	Knee bolster
3=Serious	Cerebral subarachnoid hemorrhage	Steering comb
3=Serious	292016	Fire in vehicle
3=Serious	792016	Fire in vehicle
2=Moderate	792012	Fire in vehicle
2=Moderate	492012	Fire in vehicle
2=Moderate	892012	Fire in vehicle
1=Minor	Facial skin laceration, minor	Steering comb
1=Minor	Facial skin laceration, minor	Steering comb
1=Minor	Facial skin laceration, minor	Steering comb
1=Minor	Scalp laceration, minor	Left A pillar
1=Minor	Leg skin abrasion	Steering rim
1=Minor	Leg skin abrasion	Knee bolster

2002-74-99: Vehicle Fire with Entrapment

This collision involves a 1990 Cadillac Eldorado driven by a 23 year old restrained male. The vehicle entered an intersection and impacted the side of a tractor trailer and spun out from underneath it. Major damage and intrusion was sustained on the front and left side of the vehicle. The driver's air bag deployed as a result of the collision. The engine compartment caught fire as a result of the collision and it was reported as a major fire. Passersby were able to extinguish the fire. There was no fuel leakage. The fuel tank was located forward of the rear axle on the left side and was not damaged as a result of the crash. Figure 8 is a photograph of the front and left side of the vehicle showing crush and fire damage.

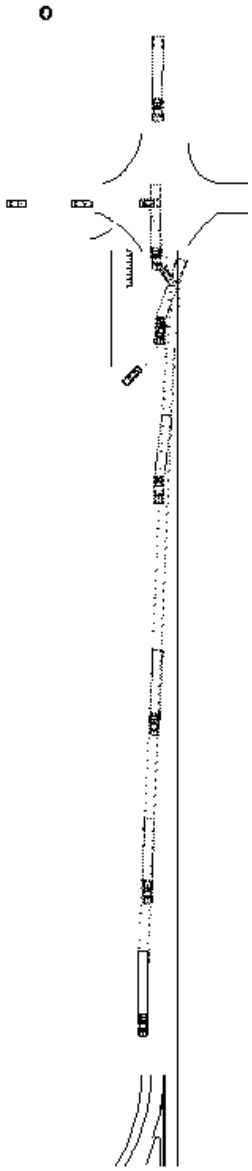
FIGURE 8

The driver was entrapped in the burning vehicle due to jamming of the vehicle door. This occupant died due to his multiple injuries which included: multiple head trauma; traumatic brain injuries; abdominal contusions; leg fractures; multiple lacerations, contusions, abrasions.

Case Number: 2002-74-99

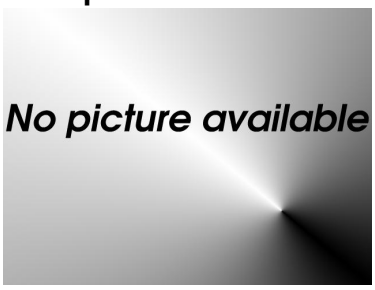
Summary:

This rural two-vehicle collision occurred in the late morning at 1120 hours on aclear day with no adverse weather conditions. The crash occurred on a level,four-leg intersection with two travel lanes in each direction of theintersecting roadways. There were no traffic controls for the North/Southlanes, but there were stop signs posted for the East/West travel lanes.Vehicle one, a 1990 Cadillac Eldorado was westbound on a two-lane undividedroadway. Vehicle one approached the intersection, which is regulated by a stopsign, proceeded through the intersection with no signs of braking. Meanwhile,vehicle two, a 1997 Kenworth tractor with an empty semi trailer, was northboundon an intersecting two-lane highway with no traffic controls. After the tractorpassed through the intersection the driver felt a thump to the rear of thetrailer. The driver looked out his right side mirror and saw a car under hisright rear trailer wheels. The driver then hit the brakes and the car under thetrailer broke away and spun off the right side of the roadway to final rest. Thedriver of vehicle two pulled off the right side of the road to help the driverof vehicle one. Upon arrival at vehicle one, the driver of vehicle two noticed asmall fire had developed in vehicle ones' engine compartment. The driver ofvehicle two went back to his truck to get a fire extinguisher. Along with thehelp of another passerby, the driver of vehicle two helped put out the fire. Thedriver of vehicle two observed that the driver of vehicle one was wearingseatbelts and the driver airbag had deployed. The driver of vehicle one wastransported to the hospital by air ambulance in critical condition. Later thatweek the driver died from his injuries that included multiple skull and facialfractures, brain contusion and swelling, and multiple leg fractures. Vehicle onewas towed from the scene. The driver of vehicle two was not injured. Thetrailer of V2 had to be towed from the scene due to damage to the number fouraxle and air brakes.

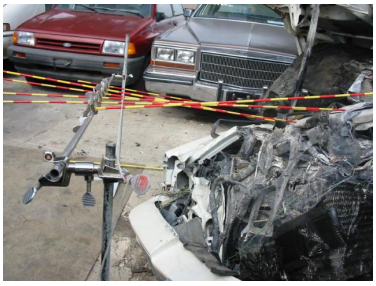


Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	2DR SEDAN/HT/CPE	Cadillac	Eldorado	1990	1	23	MALE	5=Critical

Occupant: 2002-74-99-1-1

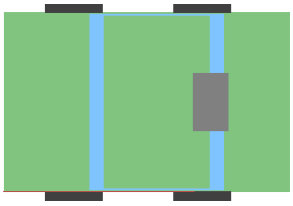






Fire Information

Fire Occurence	Minor fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Forward of rear axle, centered
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline



Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	9 L Y A A 9
Damage (C1-C6)	0 0 0 0 0 0
Crush (L and D)	0 0
Object Contacted 1	VEHICLE NO. 2
Object Contacted 2	0

NASS Weighting Factor

Weighting factor	8.921

Rollover Characteristics

Number of Events	2
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	STRAIGHT
Roadway Profile	LEVEL
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DAYLIGHT
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	INTERSECTION REL
Traffic Control Device	
Police Reported Alcohol Presence	ALCOHOL PRESENT
Alcohol Test (< 95 indicates BAC 0.xx)	1

Vehicle Factors

Make-Model	Cadillac Eldorado
Year	1990
Class	PASSENGER CAR
Body Type	2DR SEDAN/HT/CPE
Weight	155

Pre-Crash Driver Data

Accident Type	90
Pre-event Movement	GOING STRAIGHT
Critical Pre-crash Event	CROSS OVER INTER
Attempted Avoidance Maneuver	No AVOIDANCE
Pre-impact Stability	TRACKING
Pre-impact Location	STAYED IN LANE

DRIVER Factors

Age	23	Height	183	Weight	93
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			ENTRAPPED		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1st Seat	DR BAG DEPLOYED
Airbag Deployment - Oth Seat	Not EQUIP W/ OTH

Injuries

Occupant	2002-74-99-1-1
MAIS	5=Critical
Seat Position	Front left side

AIS Level	Injury Description	Contacts
5=Critical	Cerebral diffuse axonal injury	Steering comb
4=Severe	Basilar skull fracture, open, with brain tissue loss.	Steering comb
4=Severe	Cerebral brain swelling, moderate	Steering comb
4=Severe	Cerebral brain swelling, moderate	Steering comb
3=Serious	Cerebral subarachnoid hemorrhage	Steering comb
3=Serious	Cerebral subarachnoid hemorrhage	Steering comb
3=Serious	Cerebral contusions, multiple, bilateral but NFS	Steering comb
3=Serious	Skull fracture, vault, comminuted (compound, depressed)	Steering comb
3=Serious	Orbit fracture, open/displaced/comminuted	Steering comb
3=Serious	Orbit fracture, open/displaced/comminuted	Steering comb
2=Moderate	Nose fracture, open/displaced/comminuted	Steering comb
2=Moderate	Mandible body (+/- ramus) fracture, open/displaced/comminute	Steering comb
2=Moderate	Colonic contusion (hematoma)	Belt webb/buckle
3=Serious	Thoracic cavity injury NFS, with hemo-/pneumothorax	Belt webb/buckle
3=Serious	Femoral neck fracture	Knee bolster
3=Serious	Femoral shaft fracture	Knee bolster
3=Serious	Supracondylar femoral fracture	Knee bolster
3=Serious	Femoral shaft fracture	Knee bolster
2=Moderate	Fibular head, neck, or shaft fracture	Knee bolster
2=Moderate	Fibular head, neck, or shaft fracture	Knee bolster
3=Serious	Tibial shaft fracture, open/displaced/comminuted	Knee bolster
3=Serious	Tibial shaft fracture, open/displaced/comminuted	Knee bolster
1=Minor	Scalp contusion	Steering comb
1=Minor	Scalp contusion	Steering comb
1=Minor	Facial skin abrasion	Steering comb
1=Minor	Facial skin laceration, minor	Steering comb
1=Minor	297402	Steering comb
1=Minor	297402	Steering comb
1=Minor	Facial skin abrasion	Steering comb
1=Minor	Facial skin abrasion	Steering comb
1=Minor	Gingival laceration	Steering comb
1=Minor	Thoracic skin abrasion	Belt webb/buckle
1=Minor	Leg skin contusion (hematoma)	Belt webb/buckle
1=Minor	Leg skin contusion (hematoma)	Knee bolster
1=Minor	Upper extremity skin contusion	Air bag-DR side
1=Minor	Upper extremity skin abrasion	Air bag-DR side
1=Minor	Upper extremity skin lac-	Left apnel

2002-81-4: Vehicle Fire with Entrapment

This collision involves a 2002 Lincoln Town Car driven by a 21 year old restrained male. While the driver attempted to negotiate a curve, the vehicle exited the roadway to the left. The vehicle traveled down an embankment and impacted a tree with its left side. While rotating counterclockwise, the vehicle struck another truck at the front. A fire started in the right engine compartment. The fire was reported as major. The vehicle sustained major damage due to the impacts and the fire. The occupant compartment sustained moderate to severe intrusion. The air bags deployed as a result of the impacts.

There was no fuel leakage reported. The fuel tank was located aft of the rear axle and centered. No damage was reported to the fuel tank. Figure 9 is a photograph of the left side of the vehicle showing crush/fire damage and an interior view showing intrusion and fire damage.

FIGURE 9

The collision caused the driver to be mechanically entrapped due to the vehicular intrusion. No thermal injuries were sustained. The maximum AIS injury was a fractured femur due to contacting the knee bolster. The other injuries sustained by the driver were a finger fracture and minor lacerations and abrasions. The front seat passenger was not entrapped and escaped with no thermal injuries. He did sustain AIS = 2 abdominal injuries.

All of the fires highlighted in this case review of fire crashes with entrapment were reported as major. In many of these cases, the impact was to the driver's side and/or to the front of the vehicle. Three of the 4 drivers in these crashes died as result of the impact forces and associated injuries. Two of the deceased drivers sustained burn/thermal

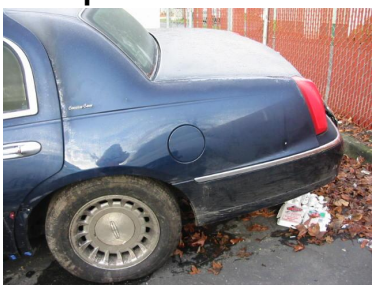
Case Number: 2002-81-4

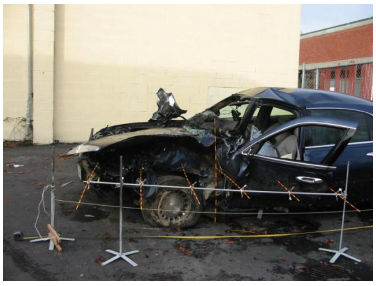
Summary:

Vehicle #1, a 2002 four door Lincoln Town Car, was traveling southbound, in laneone of one, on a three lane roadway with a center turn lane. The roadway had a5% negative grade and made a sharp curve to the right. As vehicle #1 attemptedto negotiate the curve, the driver lost control and exited the roadway to theleft. The vehicle traveled down an embankment through a thicket of blackberrybushes. At the bottom of the embankment the vehicle struck a tree (which wasuprooted by the impact) with it's left side. As the vehicle rotatedcounterclockwise, the front end struck another tree, with the left front corner,and shrubbery. A fire started in the right side of the engine compartment.The driver of the vehicle was pinned in the vehicle and the right front occupantexited the vehicle under his own power. The vehicle was equipped withadvanced dual stage airbags and side impact airbags. The driver, passenger andleft side airbags all deployed as a result of the crash. Both of the front seatoccupants were transported to a trauma center for treatment of their injuries.The driver was treated for a fractured left femur and occupant #2 suffered alacerated spleen and fractured rib.

Vehicle	Body type	Make	Model	Year	Occ. #	Age	Occupant's sex	Maximum known occupant ais
1	4-DR SEDAN/HDTOP	Lincoln	TownCar/Continental	2002	1	21	MALE	3=Serious
1	4-DR SEDAN/HDTOP	Lincoln	TownCar/Continental	2002	2	20	MALE	2=Moderate

Occupant: 2002-81-4-1-1



Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Behind rear axle, centered
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	11 L F E W 3
Damage (C1-C6)	25 52 60 51 26 18
Crush (L and D)	231 109
Object Contacted 1	LARGE TREE
Object Contacted 2	LARGE TREE

NASS Weighting Factor

Weighting factor	41.853

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	Not REPORTED
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Lincoln TownCar/Continental
Year	2002
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	246

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/O LOCKUP
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

DRIVER Factors

Age	21	Height	175	Weight	64
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			ENTRAPPED		

Restraint Factors

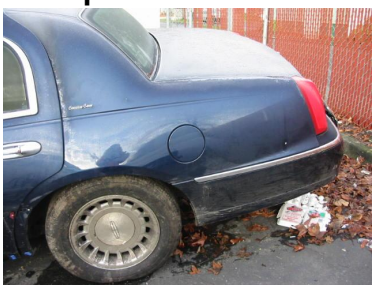
Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1st Seat	DR&PAS BAG DEPLY
Airbag Deployment - Oth Seat	BAG DEPLOYED

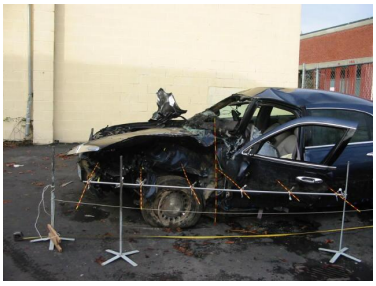
Injuries

Occupant	2002-81-4-1-1
MAIS	3=Serious
Seat Position	Front left side

AIS Level	Injury Description	Contacts
3=Serious	Subtrochanteric femoral fracture	Knee bolster
1=Minor	Finger fracture	Air bag-DR side
1=Minor	Leg skin abrasion	Knee bolster
1=Minor	Leg skin abrasion	Steering rim
1=Minor	Leg skin laceration, minor	Foot controls

Occupant: 2002-81-4-1-2



Fire Information

Fire Occurence	Major fire
Fire Origin	Engine compart
Location of Fuel Leakage	No fuel leakage
Type of Fuel Tank	Metallic
Fuel Tank Location	Behind rear axle, centered
Fuel Cap Location	Left side, behind rear axle
Fuel Tank Damage	No damage
Fuel Type	Gasoline

Crash Severity

Nr. Quarter Turns	No rollover
Impact Speed	< 0.5KMPH
Total, Longitudal, and Lateral δV	< 0.5 KMPH < 0.5 KMPH < 0.5 KMPH
Est. δV with sequence number	SEVERE 1
CDC	11 L F E W 3
Damage (C1-C6)	25 52 60 51 26 18
Crush (L and D)	231 109
Object Contacted 1	LARGE TREE
Object Contacted 2	LARGE TREE

NASS Weighting Factor

Weighting factor	41.853

Rollover Characteristics

Number of Events	4
Rollover Initiation Type	No rollover
Location of Rollover Initiation	No rollover
Rollover Initiation Object Contacted	No rollover
Location on Vehicle where Principal Tripping Force was Applied	No rollover
Direction of Initial Roll	No rollover

Pre-Crash Environment

Traffic Flow	Not DIVIDED
Number of Travel Lanes	TWO
Roadway Alignment	CURVE RIGHT
Roadway Profile	DOWNHILL GRADE
Roadway Surface Type	ASPHALT
Roadway Surface Condition	DRY
Light Conditions	DARK/LIGHTED
Atmospheric Conditions	No ADVERSE COND
Relation to Intersection	NONINTER/NONJUNC
Traffic Control Device	
Police Reported Alcohol Presence	Not REPORTED
Alcohol Test (< 95 indicates BAC 0.xx)	0

Vehicle Factors

Make-Model	Lincoln TownCar/Continental
Year	2002
Class	PASSENGER CAR
Body Type	4-DR SEDAN/HDTOP
Weight	246

Pre-Crash Driver Data

Accident Type	7
Pre-event Movement	NEGOTIATE CURVE
Critical Pre-crash Event	TRAVEL TOO FAST
Attempted Avoidance Maneuver	BRAKE W/O LOCKUP
Pre-impact Stability	TRACKING
Pre-impact Location	DEPARTED ROADWAY

PASSENGER Factors

Age	20	Height	180	Weight	82
Gender			MALE		
Ejection			No EJECTION		
Ejection Area			No EJECTION		
Entrapment			Not ENTRAPPED		

Restraint Factors

Restrain	Lap and shoulder
AOPS	YES-RES DET
Airbag Deployment	BAG DEPLOYED
Airbag Deployment - 1st Seat	DR&PAS BAG DEPLY
Airbag Deployment - Oth Seat	BAG DEPLOYED

Injuries

Occupant	2002-81-4-1-2
MAIS	2=Moderate
Seat Position	Front right side

AIS Level	Injury Description	Contacts
2=Moderate	Splenic laceration, minor (tear<3cms deep, no major vessel)	Belt webb/buckle
2=Moderate	Hepatic laceration, minor (<3cms deep, EBL<20%, simple cap.)	Belt webb/buckle
1=Minor	Single rib fracture	Belt webb/buckle
1=Minor	Upper extremity skin contusion	Air bag-PS side

inhalation injuries during the crashes. Though the thermal injuries were contributory, it is not likely that they died solely due to those injuries.

Several pieces of information are missing from the NASS/CDS data which would prove to be useful in fire studies such as these. These are listed below. These questions can not be answered in every case, but this information would make data analysis and clinical reviews more definitive in terms of fire safety, causation and occupant protection.

1. the suspected cause of the fire (e.g., flammable substance ignited due to heat from crash)
2. the suspected location of the under-hood fire (e.g., frontal location near battery, right engine compartment near the window washer fluid container, and so on)
3. was fire extinguished before/after the occupant was out of the vehicle
4. what was means of fire extinguishing (fire department, passerby)

III. A Literature Review of Fire Safety in Automobiles

This section of the report contains a listing of published reports, test film, and test data associated with the fire safety of automobiles. The reports, test film, and test data are mostly found at the FHWA/NHTSA National Crash Analysis Center Library.

A 1998 report by LaDue and Kononen noted that, "Over 1,000 scientific and technical articles, specifically chosen for their relevance to transportation fires, were incorporated into a searchable bibliography." (LaDue, 1998) LaDue and Kononen note that the literature in the searchable bibliography covers a wide range of topics.

> Transportation fire safety information within the scientific literature encompasses; the causes, propagation, severity, and extinguishment of fires in passenger carriers, as well as, the flammability characteristics of the fuels and materials used in such vehicles. By searching the sharply defined keywords, one can quickly locate scientific literature associated with very specific transportation fire topics (i.e., the radiant heat flux from a hydrocarbon pool fire or the critical heat flux required for the ignition of polypropylene).

The searchable bibliography is not copyrighted.

> *Searchable Transportation Fire Safety Bibliography* is a database which contains citations to and abstracts of scientific literature. The database was prepared by General Motors Corporation pursuant to an agreement with the U.S. Department of Transportation. General Motors Corporation claims no copyright in the citations or abstracts which may be freely reproduced and used by the public, without limitation.
>
> *Searchable Transportation Fire Safety Bibliography* was created using *Microsoft Access® Developer's Toolkit*, a copyrighted work of the Microsoft Corporation.

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In addition to the literature listed in this report, the readily available *Searchable Transportation Fire Safety Bibliography* is available for researchers into fire safety.

Fire test data, reports and test video housed at the NCAC Library.
For further information or for a copy of any data, report or test video listed here, please contact the request website at: **www.ncac.gwu.edu/filmlibrary/search.html**
C11408 - 1997 Chevrolet Camaro - 85 km/h offset moving deformable barrier
C11591 - 1997 Chevrolet - 55 km/h offset pole frontal impact
C11647 - 1997 Chevrolet Camaro - 105 km/h oblique moving deformable barrier frontal impact
C11108 - 1996 Dodge Caravan - 55 km/h offset pole frontal impact
C11167 - 1996 Dodge Caravan - 105 km/h oblique moving deformable barrier frontal impact
C11226 - 1996 ODGE Caravan - 60 km/h offset rigid barrier frontal impact
C11279 - 1996 Dodge Caravan - 55 km/h offset pole frontal impact
C11317 - 1997 Ford Explorer - 85 km/h offset moving deformable barrier rear impact
C11687 - 1997 Ford Explorer - 105 km/h oblique moving deformable barrier frontal impact
C11793 - 1997 Ford Explorer - 55 km/h offset pole frontal impact
C11990 - 1998 Honda Accord - 85 km/h offset moving deformable barrier rear impact
C12127 - 1998 Honda Accord - 105 km/h offset oblique moving deformable barrier frontal impact
C12174 - 1998 Honda Accord - 55 km/h offset pole frontal impact
Fire Safety Literature Comilation

ASTM: From the ASTM website (www.astm.orq) one finds the following tests related to transportation: D4809-95 (Heat of Combustion of Liquid Hydrocarbon Fuels); D-4868-90 (Heat of Combustion of BurnedDiesel Fuels); D6446-99 (Net Heat of Combustion - Specific Energy - of Aviation Fuels); D6227-99 (Standard Specification for Grade 82 Unleaded Aviation Gasoline); D6202-00a (Evaluation of Automotive Engine Oils on the Fuel Economy of Passenger Cars and Light-Duty Trucks in VIA Spark Ignition Engine); D5862-99a (Evaluation of Engine Oils in Two-Stroke Cycle Turbo-Supercharged 6V92TA Diesel Engine).
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CONCLUSIONS OF REPORT

This study has shown that 54% of fires that start as a result of a crash are major fires. When the crash mode was “near” or “rear” and resulted in a fire, the fires were major over 70% of the time. Frontal collisions are 73% of fires which is consistent with 77% of fires occurring in the engine compartment. Engine compartment fires are major 72% of the time.

The fuel tank location at “forward of the rear axle and to the left of center” has the highest percentage of fires and is not as structurally guarded as “forward of rear axle and centered”. There are few deformed fuel tanks in these cases overall and 82% of fire crashes have no fuel leak. When there is a reported fuel leak in a fire crash, 92% of the fires are major. 86% of engine compartment fires have no fuel leakage (does not include engine compartment fluids which could fuel the fire)

The Dodge Neon and the Chrysler Cirrus are the two vehicles with the highest fire occurrence rates (taken from FARS 1991-2000 and number of registered vehicles). In NASS/CDS, most Cirrus fires are reported as major. Most Neon fires are reported as minor. Based on the NASS/CDS files, the analysts do not include confidence intervals for the metrics based on particular makes and models. Because confidence intervals are not provided, the metrics based on makes and models are estimates without any certainty that they are likely the true value.

In rollovers, 58% of fires are minor. SUV and pickup fire crashes are mostly major fires. 70% of rollover fire crashes roll 4 or fewer quarter turns. Major fires result in rollover crashes most often when these independent characteristics occur: the vehicle is an SUV, the vehicle rolls 5-8 quarter turns, the trip location is on the side plane, the vehicle lands on its top.

Entrapment occurs with 6.2% of occupants in engine compartment fire crashes. Occupants are entrapped 66% of the time where a fire results in the engine compartment and are categorized as MASI3+ injured.

On average, fire results in crashes where there is a greater amount of crush. This is regardless of direction of impact – front, rear, left or right side.

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