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Analysis of Fatal Crashes Due to Signal and Stop Sign Violations

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16. Abstract

The 1999 and 2000 Fatality Analysis Reporting System databases were analyzed to gain a better understanding of fatal crashes involving light vehicles that violated traffic signals or stop signs. A total of 9,951 vehicles were involved in fatal crashes at traffic signals in 1999 and 2000 – 20% of these vehicles failed to obey the signal and 13% failed to yield the right-of-way. On the other hand, 13,627 vehicles were involved in fatal crashes at stop signs - 21% failed to obey the sign and 23% failed to yield the right-of-way. Fatal crashes involving light vehicles (passenger cars, sport utility vehicles, vans, and pickup trucks) that violated the traffic signal or the stop sign were separated into single vehicle, two-vehicle, and multi-vehicle crash categories. For each crash category, this report identified the crash scenarios, described the crash contributing factors, and characterized the infrastructure where these fatal crashes happened in 1999 and 2000. No major difference was found between the crash categories regarding the infrastructure where these fatal crashes occurred. Single vehicle crashes were almost three times as likely to involve alcohol than two-vehicle or multi-vehicle crashes. Furthermore, single vehicle crashes had the highest rate of speeding and inattention. Two-vehicle crashes had the second highest involvement rate of inattention and multi-vehicle had the second highest rate of speeding.

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PREFACE

The National Highway Traffic Safety Administration (NHTSA), in conjunction with the Research and Special Programs Administration Volpe National Transportation Systems Center (Volpe Center), is conducting an analysis of fatal crashes at traffic signals and stop signs in support of the Intelligent Vehicle Initiative (IVI). The IVI accelerates the development and deployment of vehicle-based and vehicle-infrastructure cooperative crash countermeasures using intelligent technologies over several problem areas: rear-end, off-roadway, lane change, crossing paths, driver impairment, reduced visibility, vehicle instability, pedestrian, and pedalcyclist crashes.

This report presents the results obtained from the analysis of crash data in the 1999-2000 Fatality Analysis Reporting System crash databases.

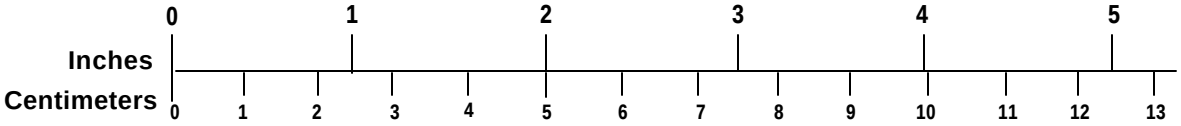
The authors of this report are Brittany N. Campbell, John D. Smith, and Wassim G. Najm of the Volpe Center.

The authors acknowledge the technical contributions of Dr. David L. Smith of NHTSA.

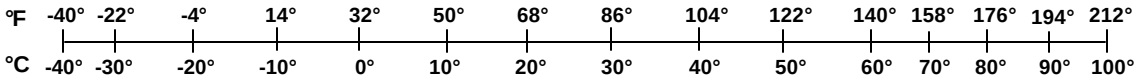
METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE)	**LENGTH** (APPROXIMATE)
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA** (APPROXIMATE)
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT** (APPROXIMATE)
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons
VOLUME (APPROXIMATE)	**VOLUME** (APPROXIMATE)
1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	
1 quart (qt) = 0.96 liter (l)	
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)	**TEMPERATURE** (EXACT)
[(x-32)(5/9)] °F = y °C	[(9/5) y + 32] °C = x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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Table of Contents

List of Figures

List of Tables

LIST OF ACRONYMS

DOT	Department of Transportation
FARS	Fatality Analysis Reporting System
FTO	Fail to Obey
FTY	Fail to Yield
GES	General Estimates System
GS-GS	Going Straight – Going Straight
GS-ST	Going Straight – Starting in Traffic Lane
GS-LT	Going Straight – Left Turn
ITS	Intelligent Transportation System
IVI	Intelligent Vehicle Initiative
LTAP/LD	Left Turn Across Path – Lateral Direction
LTAP/OD	Left Turn Across Path – Opposite Direction
LTCP	Left Turn Crossing Path
LTIP	Left Turn Into Path – Merge
NHTSA	National Highway Traffic Safety Administration
PAR	Police Accident Report
PR	Police – Reported
RTAP/LD	Right Turn Across Path – Lateral Direction
RTCP	Right Turn Crossing Path
RTIP	Right Turn Into Path – Merge
SCP	Straight Crossing Paths
SS	Stop Sign
TS	Traffic Signal
VTTI	Virginia Tech Transportation Institute

EXECUTIVE SUMMARY

The U.S. Department of Transportation's Intelligent Vehicle Initiative is focused on improving the safety of the nation's highways through the continued development and deployment of advanced-technology crash avoidance systems. This research supports the National Highway Traffic Safety Administration in developing performance specifications for stop sign/traffic signal violations and insufficient gap warning systems (e.g., left turn across path). Crash data for the analysis were obtained from the 1999-2000 Fatality Analysis Reporting System (FARS) crash databases. The FARS contains information on all fatal crashes involving a motor vehicle traveling on a public trafficway in the United States.

This analysis of fatal crashes is concerned with understanding the pre-crash scenarios, and concomitant circumstances, associated with traffic signal/stop sign violations in order to evaluate proposed countermeasure designs, or to offer insight to countermeasure development. The analysis began with all 1999 and 2000 fatal crashes and then segregated the crashes by the type of traffic control device at the crash site. These crashes were then examined to see if the driver violated the traffic signal or stop sign and what type of violation occurred. Traffic control device violations were classified into two violation categories: failure to obey and failure to yield. "Failure to obey" crashes primarily represent crashes in which the driver ran the stop sign or traffic signal. These crashes correspond to a definite violation of the sign/signal. "Failure to yield" crashes don't necessarily refer to a violation by definition; however, some police accident reports stated failure to yield as a crash factor. Moreover, failure to yield is sometimes used synonymously with failure to obey in police accident reports, and thus may indicate a possible violation of the sign/signal.

A total of 9,951 vehicles were involved in fatal crashes at traffic signals in 1999 and 2000 – 20% of these vehicles failed to obey the signals and 13% failed to yield the right-of-way. On the other hand, 13,627 vehicles were involved in fatal crashes at stop signs – 21% failed to obey the sign and 23% failed to yield the right-of-way. Fatal crashes associated with failure to obey by the light vehicle (passenger car, sport utility vehicle, van, and pickup truck) were 1.5 times higher at stop signs than at traffic signals. Moreover, the "failure to yield" fatal crashes by the light vehicle were 2.6 times higher at stop signs than at traffic signals.

Fatal crashes involving light vehicles that violated the traffic signal or the stop sign were separated into single vehicle, two-vehicle, and multi-vehicle (= 3 vehicles) crash categories. Single vehicle crashes accounted for 8% and 6%, two-vehicle crashes accounted for 75% and 87%, and multi-vehicle accounted for 18% and 7% of all light vehicle violation fatal crashes at traffic signals and stop signs, respectively. For each crash category, this report identified the crash scenarios, described the crash contributing factors, and characterized the infrastructure where these fatal crashes occurred in 1999 and 2000.

About 64% and 95% respectively of the "failure to obey" and the "failure to yield" single vehicle crashes at traffic signals were pedestrian crashes. On the other hand, 76% of the "failure to yield" crashes at stop signs were pedestrian crashes, while 95% of the "failure to obey" the stop sign crashes were other crashes such as run-off-road crashes. Single vehicle traffic signal crashes primarily (91%) occurred in urban areas, whereas 57% of stop sign crashes occurred in rural areas. Most single vehicle crashes occurred on two-lane roadways regardless of the type of violation.

Approximately 65% and 12% respectively of the "failure to obey" and the "failure to yield" two-vehicle crashes were straight crossing path crashes and, in contrast, 29% and 81% were left turn

crossing path crashes. Straight crossing path crashes were 2.24 times higher than left turn crossing path crashes for failure to obey violations. In contrast, left turn crossing path crashes were 6.55 times higher than straight crossing path crashes for failure to yield right-of-way violations. Similar to single vehicle crashes, most two-vehicle crashes occurred on two-lane roadways.

In 1999 and 2000, there were 889 fatal multi-vehicle crashes that involved violating light vehicles. About 58% happened at traffic signals while the remaining 42% occurred at stop signs. At traffic signals, drivers failed to obey the signal in 67% of the crashes and failed to yield the right-of-way in the remaining 33% of the crashes. In contrast, drivers failed to obey the sign in 40% of the stop sign crashes and failed to yield the right-of-way in 60% of these crashes. About 82% of multi-vehicle fatal crashes at traffic signals occurred on urban roadways. Conversely, about 57% of multi-vehicle fatal crashes at stop signs occurred on rural roadways. The majority or 80% of stop sign crashes occurred on two-lane roadways. On the other hand, half the traffic signal crashes (50%) happened on two-lane roadways.

No major difference was found between the single vehicle, two-vehicle, and multi-vehicle crash categories regarding the infrastructure where these fatal crashes occurred. In contract, the major contributing factors for each crash category provided valuable insight into the unique issues associated with these particular crashes. Single vehicle crashes were almost three times as likely to involve alcohol than two-vehicle or multi-vehicle crashes. Alcohol was involved in 37% of all single vehicle fatal crashes involving a light vehicle violating the traffic signal or the stop sign. Furthermore, single vehicle crashes had the highest rate of speeding and inattention, 33% and 14% respectively. Inattention or distraction was reported for about 11.0% of all violating light vehicles in two-vehicle fatal crossing path crashes. Alcohol was linked to 14% of all violating light vehicles in two-vehicle fatal crossing path crashes. Furthermore, alcohol involvement was more prevalent in failure to obey than in failure to yield crashes. Speeding or racing, including police chase, was related to 10% of all violating light vehicles in multi-vehicle fatal crashes in 1999 and 2000. This factor was 4 times more prevalent in traffic signal crashes than in stop sign crashes. Inattention or distraction was the second most reported factor representing about 7% of all violating light vehicles in multi-vehicle fatal crashes. Alcohol was linked to 13% of all violating light vehicles in multi-vehicle crashes. The relative frequency of alcohol exceeded speeding as the most dominant contributing factor.

Finally, fatal crashes involving a light vehicle violating the traffic signal or stop sign occurred in similar locations regardless if they were single vehicle, two-vehicle, or multi-vehicle crashes. Additionally, alcohol, speeding, and inattention were the three most common contributing factors of fatal crashes at traffic signals and stop signs.

1.0 Introduction

This report provides an in-depth analysis of fatal collisions involving a light vehicle (passenger car, sport utility vehicle, van, or pickup truck) violating a stop sign or traffic signal. This analysis examines the violation of these traffic control devices in terms of the driver's "failure to obey" and "failure to yield". Crash contributing factors and circumstances are provided for each violating vehicle. Crash data were obtained from the 1999-2000 Fatality Analysis Reporting System (FARS). The FARS contains files for all qualifying fatal crashes which occurred within the 50 states, the District of Columbia, and Puerto Rico since 1975. For a crash to be included in the FARS database: (A) the collision must have involved a motor vehicle traveling on a public trafficway and (B) the collision must have resulted in the death of an occupant or non-motorist within 30 days of the impact (*1*). Through the use of the FARS database, analysts have been able to conduct crash and vehicle research on the most severe crashes occurring in the United States (U.S.).

This report was produced in support of the U.S. Department of Transportation's (DOT) Intelligent Transportation System (ITS)/Intelligent Vehicle Initiative (IVI). The focus of the IVI program is the continued development and deployment of advanced-technology crash avoidance systems to help avoid and reduce the severity of collisions on the nation's highways (*2*). Research conducted under the IVI program involves the following areas: rear-end collisions, off-roadway collisions, lane change collisions, crossing path collisions, driver impairment monitoring, vision enhancement, vehicle stability, and the safety impact of in-vehicle information systems. This analysis supports the National Highway Traffic Safety Administration (NHTSA) in developing performance specifications for stop sign/traffic signal violations and insufficient gap warning systems (e.g., left turn across path).

Current NHTSA work involves the development of performance guidelines for crash countermeasure systems that would provide an in-vehicle violation warning to drivers who are at risk of running a red light or stop sign. The goal of these systems is to reduce the frequency of intersection crashes associated with unintentional violations of traffic signals and stop signs. This report complements the work conducted by the Virginia Tech Transportation Institute (VTTI) in their Task Order entitled "Vehicle-Based Countermeasures for Signal and Stop Sign Violations", and addresses the first task, "Intersection Control Violation Crash Analyses" (*3*).

This analysis of fatal crashes is concerned with understanding the pre-crash scenarios, and concomitant circumstances, associated with traffic signal/stop sign violations in order to evaluate proposed countermeasure designs, or to offer insight to countermeasure development. This report provides answers to seven definitive questions:

1. What are the rates of traffic control device violation involvement in fatal crashes?
2. What are the involvement rates of light vehicles in crashes due to failure to obey or failure to yield at traffic signals and stop signs?
3. What are the distributions in terms of the number of light vehicles involved in crashes due to failure to obey or failure to yield at traffic signals and stop signs?
4. What are the types of crashes occurring in single, two-vehicle, and multi-vehicle crashes by the violating light vehicle?
5. What is the breakdown of light vehicle maneuvers prior to the critical event?
6. What are the crash contributing factors in each of the crash types?
7. What are the infrastructure characteristics for each crash type?

The analysis began with all fatal crashes that occurred in 1999 and 2000. Two years of data were used to obtain a larger sample of crashes that will provide a better understanding of crash dynamics and factors, and to provide enough information to address the seven questions. Next, the fatal crashes were broken down by whether they occurred at a traffic signal, stop sign, or at no traffic control device. The crashes were then examined to see if the driver violated the traffic signal or stop sign. Additionally, the type of violation was noted, whether the driver failed to obey or failed to yield at the sign/signal. The failure to obey and failure to yield violations were then examined to ensure that the violating vehicle was a light vehicle. The analysis was restricted to light vehicles to support ongoing work at NHTSA in developing light vehicle countermeasure systems for crashes that involved violation of the traffic control device. After the crashes involving light vehicles violating the traffic signal/stop sign were identified, these crashes were then examined to identify the number of vehicles involved in the crash (single vehicle, two-vehicle, or multi-vehicle crash). This was followed by a detailed analysis of the contributing factors and infrastructure characteristics in single vehicle, two-vehicle, and multi-vehicle crashes.

2.0 Traffic Signal/Stop Sign Fatal Crashes

This section determines the involvement rates of traffic control device violations in fatal crashes using 1999 and 2000 FARS. It also identifies the involvement rates of light vehicles in crashes due to failure to obey or failure to yield at traffic signals and stop signs. Moreover, this section separates these crashes into three categories including single, two-vehicle, and multi-vehicle (≥ 3 vehicles) crashes.

2.1 Breakdown of Fatal Crashes By Traffic Control Device

The *Traffic Control Device* variable, located in the FARS "Accident File", indicates the presence and type of traffic control device. Since the work involves developing performance guidelines for traffic control device violation warning systems, particular attention was paid towards crash locations controlled by traffic signals or stop signs. The following element values from the *Traffic Control Device* variable were used (*4*):

Traffic Signal:
- Code 01: Traffic Control Signal (on colors) Without Pedestrian Signal
- Code 02: Traffic Control Signal (on colors) With Pedestrian Signal
- Code 03: Traffic Control Signal (on colors) Not Known Whether or Not Pedestrian Signal

Stop Sign:
- Code 20: Stop Sign

The *Traffic Control Device* variable is coded on the accident level in FARS, not the vehicle level. Therefore, an intersection may have different types of traffic control devices for the various legs; in this case, the control device with the lowest code number was used.

Table 1 provides the total number of fatal crashes, number of vehicles involved, and the number of fatalities in 1999 and 2000 broken out by type of traffic control device. A total of 74,549 fatal crashes occurred between 1999 and 2000. There was a yearly average of 37,275 fatal motor vehicle crashes on U.S. roadways in the two years, resulting in a yearly average of 41,769 fatalities. Approximately 6.9% of these crashes occurred at traffic signals and 9.5% at stop signs. About 5.4% of these crashes happened at other types of traffic control devices including school zones, warning signs, railroad crossings, etc. The remaining 78.2% occurred at sites with no traffic control devices.

Figure 1 shows the relative frequencies of traffic control device involvement rates in fatal crashes. It is noteworthy that the relative frequencies and the total number of crashes remained relatively consistent from 1999 to 2000. Most of fatal crashes occurred predominately at sites with no traffic control device, including all fatal crashes regardless of where they occurred on or off the trafficway.

Table 1: Fatal Crashes by Traffic Control Device.

	Traffic Signal	Stop Sign	Other Controls	No Controls	Total
1999 FARS					
No. of Fatal Crashes	2,571	3,636	2,005	28,928	37,140
No. of Vehicles Involved	4,941	7,069	2,955	41,855	56,820
No. of Fatalities	2,764	4,113	2,316	32,524	41,717
2000 FARS					
No. of Fatal Crashes	2,583	3,424	2,037	29,365	37,409
No. of Vehicles Involved	5,010	6,558	3,011	42,824	57,403
No. of Fatalities	2,780	3,884	2,339	32,818	41,821

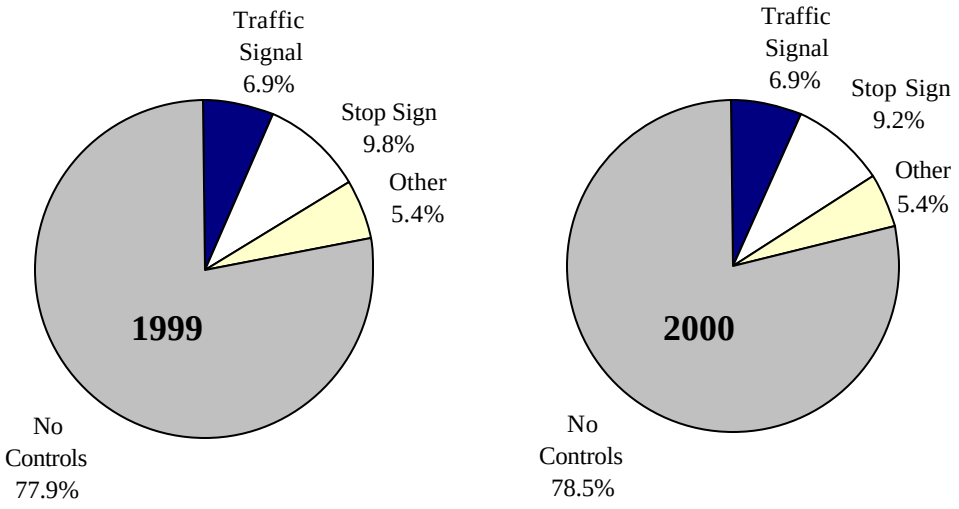


Figure 1: Distribution of Fatal Crashes by Traffic Control Device.

Figure 2 presents the number of fatalities per crash broken down by the type of traffic control device. On average, there were 1.12 fatalities per fatal crash in 1999 and 2000. Traffic signals had 1.08 fatalities per crash, slightly less than 1.13 fatalities per crash reported at stop signs. It should be noted that the highest number of fatalities per crash occurred at locations controlled by other types of traffic control devices.

Figure 3 provides the number of vehicles per fatal crash by the type of traffic control device. An average of 1.53 vehicles per fatal crash was reported in 1999 and 2000. Fatal crashes at traffic signals and stop signs had an equal average of 1.93 vehicles per crash. Traffic signal crashes had the lowest rate of fatalities per crash and one of the highest number of vehicles per crash.

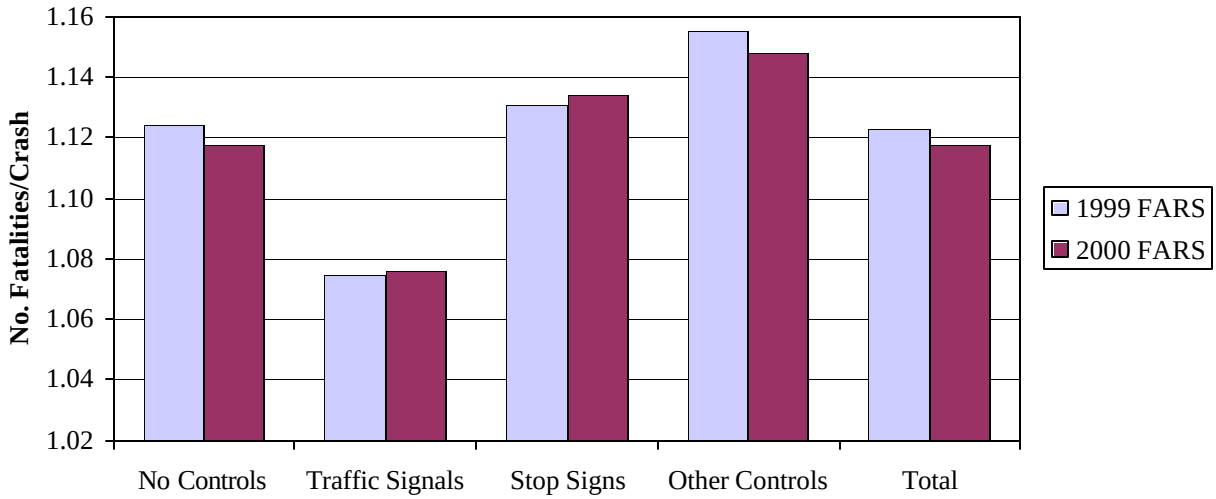


Figure 2: Number of Fatalities per Crash by Traffic Control Device.

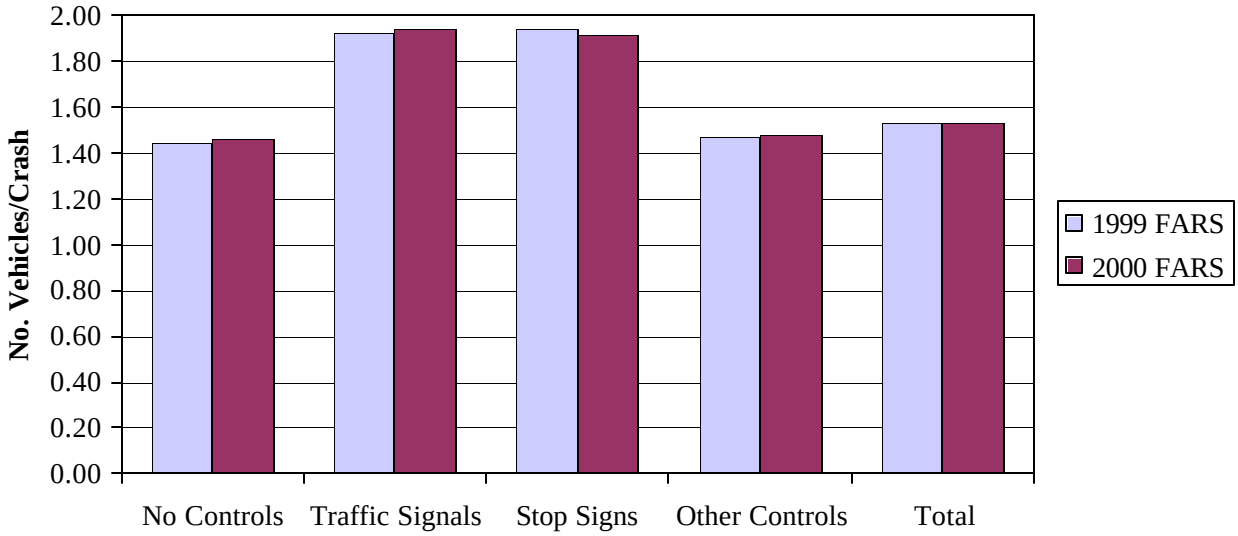


Figure 3: Number of Vehicles per Crash by Traffic Control Device.

Based on the statistics of the General Estimates System (GES), approximately 6,389,000 police-reported (PR) motor vehicle crashes occurred on U.S. roadways in 2000. Given the number of fatal crashes in 2000, the probability of a fatal crash given that a PR crash has occurred can be estimated at 0.0059 – about 5.9 fatal crashes per 1,000 PR crashes. Also in 2000, about 1,357,000 PR crashes and 699,000 PR crashes were reported at locations controlled respectively by traffic signals and stop signs (*4*). Using the data in Table 1, the probability of a fatal crash given that a PR crash has occurred in the presence of a traffic signal is about 0.0019 (1.9 fatal crashes per 1,000 PR crashes). Similarly, the probability of a fatal crash given that a PR crash has occurred in the presence of a stop sign is 0.0049 (4.9 fatal crashes per 1,000 PR crashes), which is about 2.5 times higher than at traffic signals.

Tables 2 and 3 provide statistics about fatal crashes in terms of traffic control device versus relation to junction in 1999 and 2000, respectively. The majority of fatal crashes happened at non-junctions with a yearly average of 26,732 or 71.7% of fatal crashes in 1999 and 2000. On the other hand, intersections were cited at a yearly average of 7,232 or 19.4% of all fatal crashes over those two years. A yearly average of 2,107 fatal crashes or 81.7% of all traffic signal fatal crashes occurred at intersections in 1999 and 2000. On the other hand, intersections controlled by stop signs experienced a higher yearly average of 3,049 fatal crashes than at intersections with traffic signals, or 86.4% of all stop sign fatal crashes. Figure 4 illustrates statistics about the number of fatal crashes per 1,000 PR crashes in 2000 at different roadway locations. Intersections were ranked fourth in 2000 with 4.7 fatal crashes per 1,000 PR crashes behind "other" locations, non-junctions, and rail grade crossings. The probability of a fatal crash given that a PR crash has occurred at an intersection controlled by traffic signals was 0.0031 in 2000 (3.1 fatal crashes per 1,000 PR crashes). In contrast, this probability at stop sign-controlled intersections was almost two times higher than at traffic signals with 0.0061 (6.1 fatal crashes per 1,000 PR crashes).

Table 2: 1999 FARS Relation to Junction by Traffic Control Device.

	Traffic Signal	Stop Sign	Other Controls	No Controls	Total	
NON-INTERCHANGE						
Non-Junction	15	191	1,167	25,234	26,607	71.6%
Intersection	2,022	2,997	329	1,512	6,860	18.5%
Intersection Related	400	197	59	575	1,231	3.3%
Driveway, Alley Access, etc.	7	27	18	554	606	1.6%
Entrance/Exit Ramp Related	11	8	17	164	200	0.5%
Rail Grade Crossing		1	264	4	269	0.7%
In Crossover		9	10	42	61	0.2%
Unknown Non-Interchange	1	1	50	11	63	0.2%
INTERCHANGE						
Intersection	88	173	26	139	426	1.1%
Intersection Related	14	5	2	16	37	0.1%
Driveway Access	1	3		4	8	0.0%
Entrance/Exit Ramp Related	12	23	34	260	329	0.9%
In crossover		1	1	4	6	0.0%
Other Location in Interchange			20	372	392	1.1%
Unknown, Interchange Area			6	32	38	0.1%
Unknown			2	5	7	0.0%
Total	2,571	3,636	2,005	28,928	37,140	100.0%

Table 3: 2000 FARS Relation to Junction by Traffic Control Device.

	Traffic Signal	Stop Sign	Other Controls	No Controls	Total	
NON-INTERCHANGE						
Non-Junction	12	209	1,041	25,594	26,856	71.8%
Intersection	1,967	2,703	288	1,659	6,617	17.7%
Intersection Related	412	218	58	542	1,230	3.3%
Driveway, Alley Access, etc.	8	25	9	458	500	1.3%
Entrance/Exit Ramp Related	10	9	16	157	192	0.5%
Rail Grade Crossing			280	4	284	0.8%
In Crossover		10	3	22	35	0.1%
Unknown Non-Interchange	1	1	34	14	50	0.1%
INTERCHANGE						
Intersection	136	225	37	163	561	1.5%
Intersection Related	25	5	4	32	66	0.2%
Driveway Access		1		19	20	0.1%
Entrance/Exit Ramp Related	7	15	27	306	355	0.9%
In crossover	1	1	1	5	8	0.0%
Other Location in Interchange	3	2	14	342	361	1.0%
Unknown, Interchange Area			4	37	41	0.1%
Unknown	1		221	11	233	0.6%
Total	2,583	3,424	2,037	29,365	37,409	100.0%

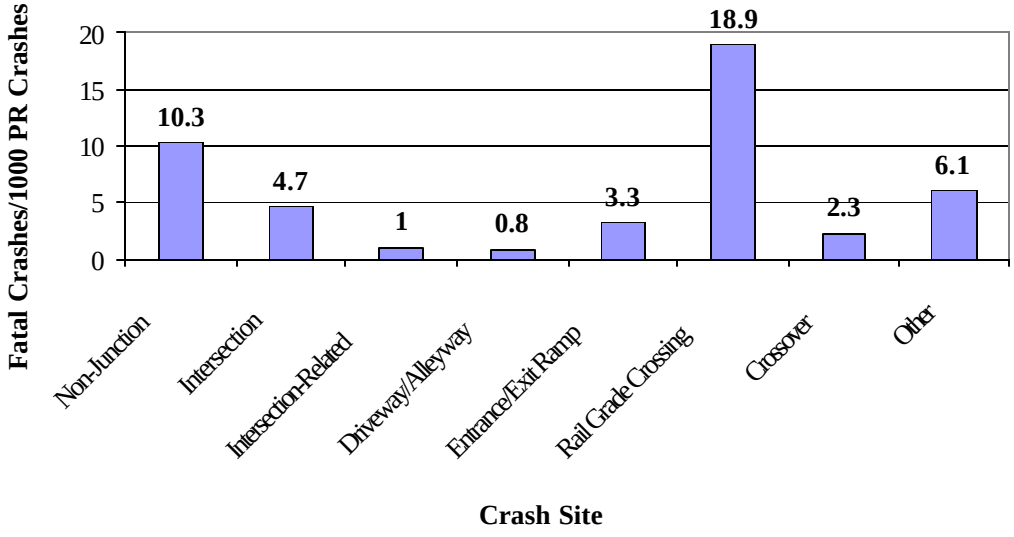


Figure 4: Rate of Fatal Crashes per 1,000 Police-Reported Crashes by Relation to Junction in 2000.

2.2 Fatal Crashes with Violations

After the crashes were broken down by traffic control device, they were examined to see if the crash included any violations. Violations were examined through the *Violations Charged* variable in the FARS "Driver File". This variable reports up to three violations that the driver was cited with as noted on the police accident report. The *Violations Charged* variable only reports violations that the driver was actually cited for, not the factors that the officer noted existed at the time.

In this step, all types of violations were examined, including but not limited to: impairment, speeding, hit and run, homicide, recklessness or carelessness, rules of the road, and traffic sign and signal violations. The *Violations Charged* variable from the FARS database was used to determine (*4*):

Violations Cited: Codes 01-98
No Violations: Code 00
Unknown if Violations: Code 99

Figures 5 and 6 illustrate the breakdown of 1999 and 2000 fatal crashes by violations cited, respectively. In 1999 and 2000, the police cited violations in approximately 25.8% of the fatal crashes at traffic signals and 21.4% of the fatal crashes at stop signs. The total number of fatal stop sign crashes cited with a violation decreased by 13%, and the number of traffic signal crashes cited with a violation increased slightly by 2% from 1999 to 2000. Appendix A provides additional information on the number of vehicles and fatalities associated with these crashes.

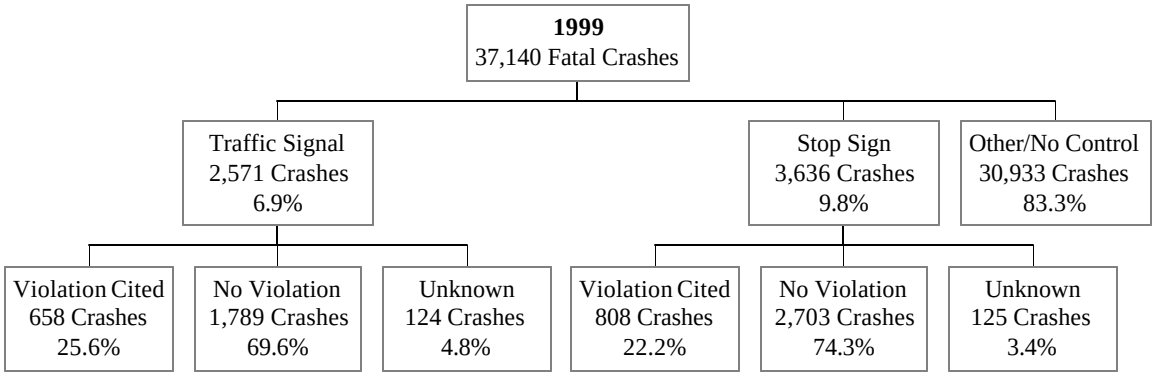


Figure 5: Breakdown of 1999 Fatal Crashes with Violations.

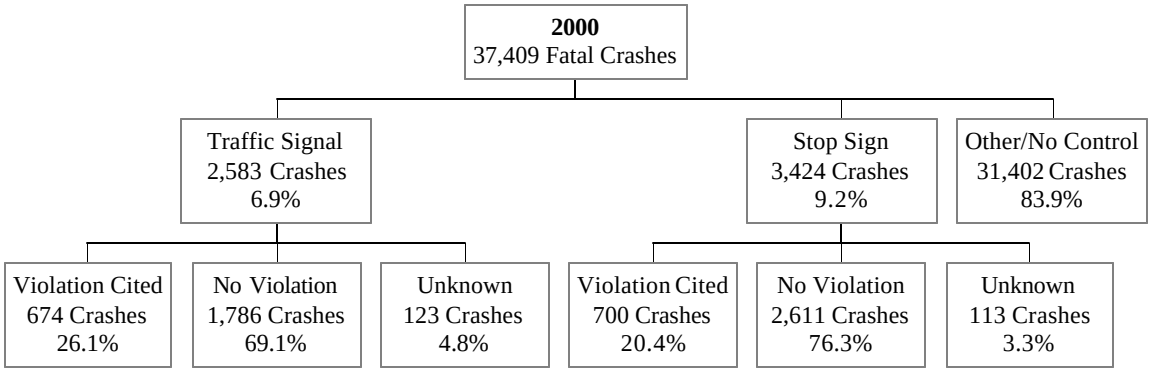


Figure 6: Breakdown of 2000 Fatal Crashes with Violations.

2.3 Traffic Control Device Violations

The previous sub-section examined all fatal crashes that were cited with any type of violation. This sub-section will take the analysis a step further and look strictly at traffic control device violations. Two methods were used to identify traffic control device violations from the crash data: (1) police reported violations and (2) reported crash factors. The *Violations Charged* variable was used to identify police reported violations, and the *Related Factors-Driver Level* variable was used to determine crash related factors. Using both variables, the full spectrum of traffic control device violation crashes was identified.

Traffic control device violations were classified into two violation categories: failure to obey and failure to yield. "Failure to obey" crashes primarily represent crashes in which the driver ran the stop sign or traffic signal. These crashes correspond to a definite violation of the sign/signal. "Failure to yield" crashes don't necessarily refer to a violation by definition; however, some police accident reports (PAR's) stated failure to yield as a crash factor. Moreover, failure to yield is sometimes used synonymously with failure to obey in PAR's, and thus may indicate a possible violation of the sign/signal.

Due to the distinct difference between traffic signals and stop signs, the violating vehicles were identified separately for each device. Traffic signal violations were identified based on the following codes from the *Violations Charged* and *Related Factors-Driver Level* variables (*4*):

Fail to Obey:

Violations Charged:

Code 31: Fail to Stop for Red Signal
Code 32: Fail to Stop for Flashing Red
Code 33: Violation of Turn on Red (Fail to Stop & Yield, Yield to Pedestrian Before Turning)
Code 34: Fail to Obey Flashing Signal (Yellow or Red)
Code 35: Fail to Obey Signal, Generally
Code 38: Fail to Obey Yield Sign
Code 39: Fail to Obey Traffic Control Device

Related Factors-Driver Level:

Code 39: Failure to Obey Actual Traffic Sign, Traffic Control Devices of Traffic Officers

Fail to Yield:

Related Factors-Driver Level:

Code 38: Failure to Yield Right-of-Way

Stop sign violations were identified using the following *Violations Charged* and *Related Factors-Driver Level* variable codes (*4*):

Fail to Obey:

Violations Charged:

Code 38: Fail to Obey Stop Sign

Code 39: Fail to Obey Traffic Control Device

Related Factors-Driver Level:

Code 39: Failure to Obey Actual Traffic Sign, Traffic Control Devices of Traffic Officers

Fail to Yield:

Related Factors-Driver Level:

Code 38: Failure to Yield Right-of-Way

In the case that a crash was coded as both codes 38 and 39 for the *Related Factors-Driver Level* variable, it was classified as a failure to obey crash.

A distinction was made between a vehicle that "entered the intersection without stopping" and a vehicle that "stopped first and then proceeded against crossing traffic" in stop sign crashes. Only vehicles that "entered the intersection without stopping" entail a true violation. Cases where the driver ran the stop sign were coded as *Failure to Obey;* drivers that stopped first and then proceeded against crossing traffic were generally coded as *Failure to Yield*.

The vehicle-based warning system currently under investigation by VTTI would only provide a warning for drivers who are about to run a stop sign, not for drivers who stop first and then proceed against traffic. However, it is still important to analyze both the *Failure to Obey* and *Failure to Yield* cases since drivers that violated the stop sign may have been coded as *Failure to Yield*. It should also be noted that the failure to yield crashes are potential target crashes to insufficient gap warning systems.

Traffic Signal Violations

Section 2.2 examined fatal crashes with any type of police reported violation. From this point onward, the analysis will switch to the vehicle level and identify the vehicles that failed to obey or failed to yield at the traffic signal or stop sign. The breakdown of fatal crashes shown in Figures 5 and 6 is continued in this sub-section, however at the vehicle level. Figures 7 and 8 illustrate the breakdown of the "fail to obey" and "fail to yield" vehicles involved in traffic signal crashes respectively in 1999 and 2000.

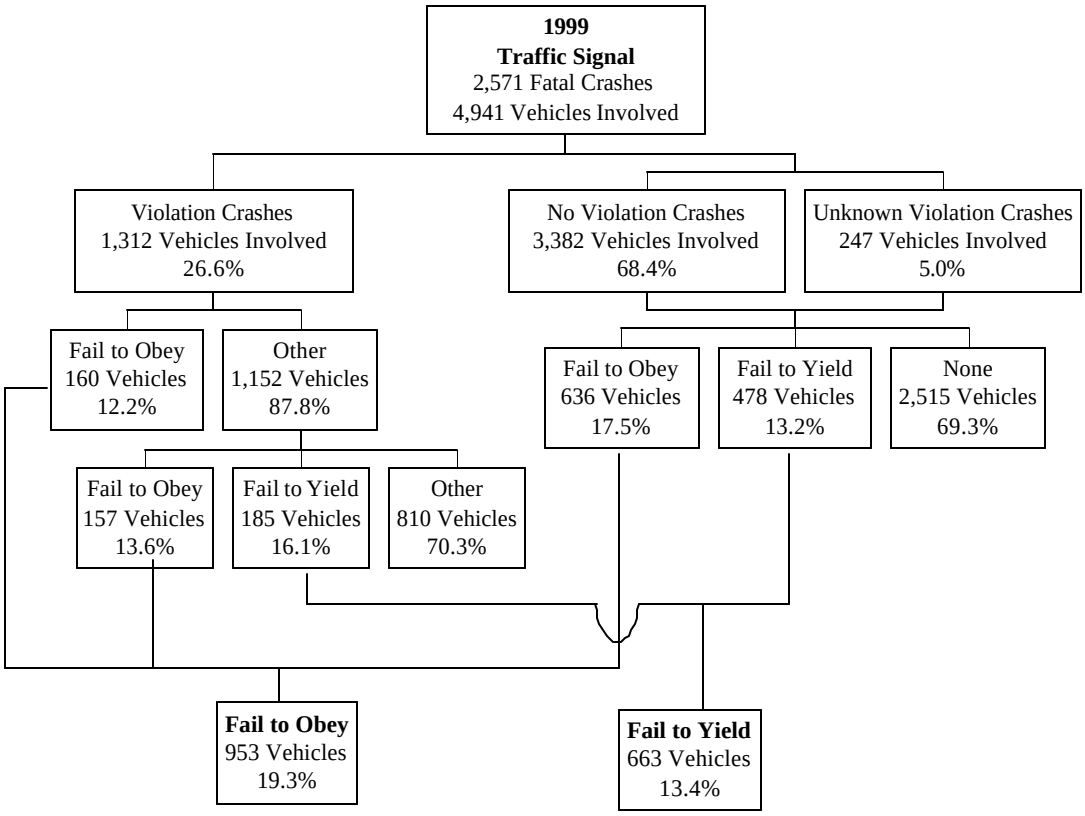


Figure 7: 1999 Traffic Signal Fail to Obey/Yield Breakdown.

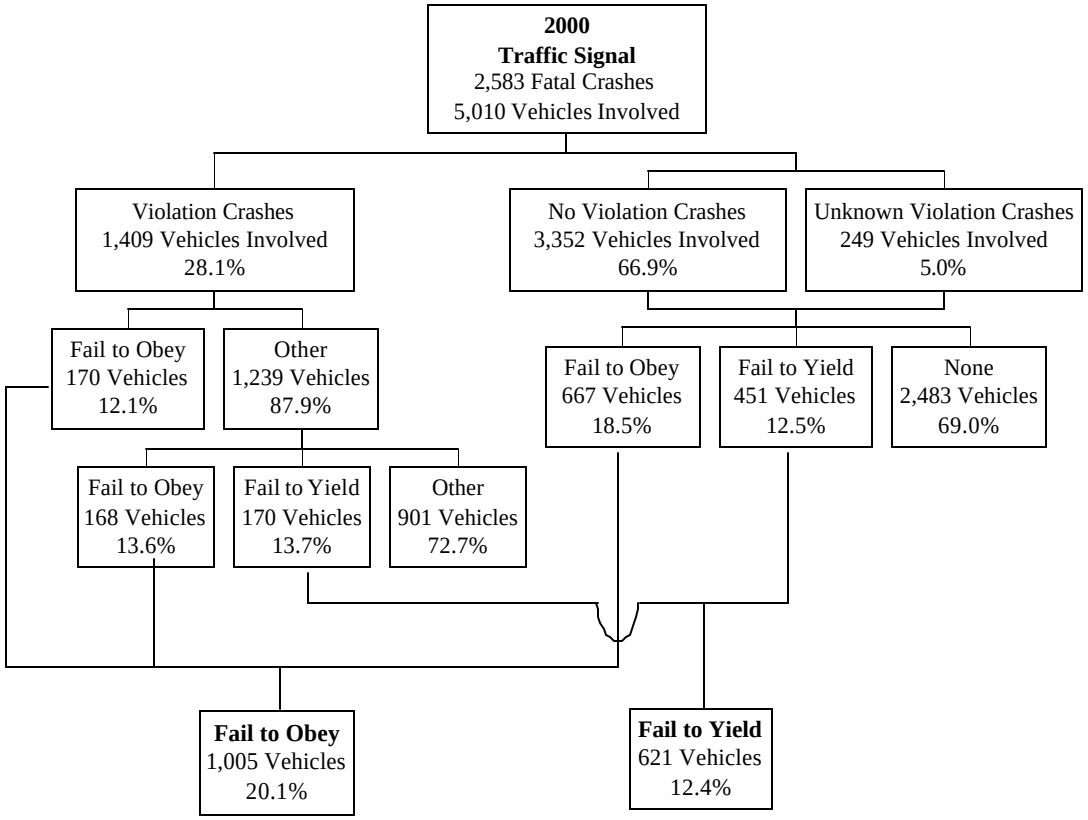


Figure 8: 2000 Traffic Signal Fail to Obey/Yield Breakdown.

The 1999 fatal traffic signal crashes were first split by whether or not at least one vehicle in the crash was cited with a violation using the FARS *Violations Charged* variable (solid bold line shown in Figure 9). The vehicles in crashes with violations cited were then examined to identify any "fail to obey" traffic signal violations, also using the FARS *Violations Charged* variable. The analysis then switched over to the *Related Factors-Driver Level* variable (dashed bold line in Figure 9) to examine "fail to obey" and "fail to yield" crash related factors. The "other" branch of the vehicles with "violation crashes" were split into "fail to obey", "fail to yield", and "other" crash related factors. Furthermore, the "no violation crashes" and "unknown violation crashes" branches were combined together and examined using the *Related Factors-Driver Level* variable to identify "fail to obey", "fail to yield", and "none" crash related factors. After all the groups were identified, the three "fail to obey" and the two "fail to yield" groups were combined to extract all vehicles that failed to obey or failed to yield at the traffic signal.

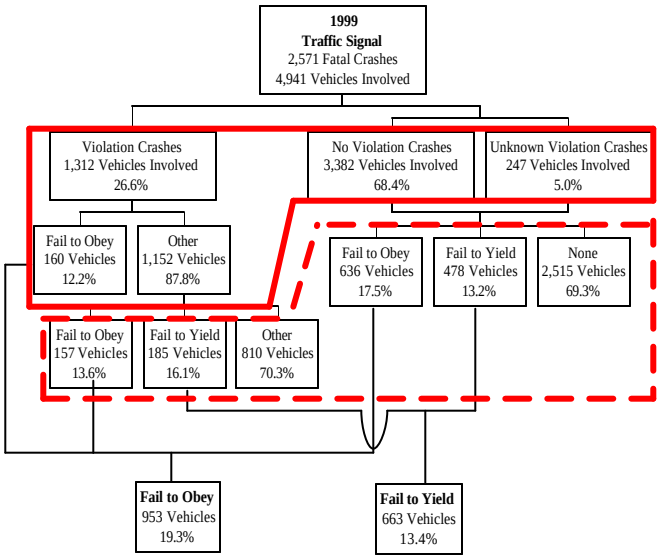


Figure 9: Illustration of Fail to Obey/Yield Vehicle Breakdown.

In 1999, 4,941 vehicles were involved in 2,571 fatal crashes at locations controlled by traffic signals. Of these vehicles, 19.3% failed to obey the signal and 13.4% failed to yield the right-of-way. Similarly in 2000, about 20% and 12.4% of the 5,010 vehicles involved in the 2,583 fatal crashes at traffic signals respectively failed to obey the signal and failed to yield the right-of-way. These violation percentages at traffic signals have remained fairly consistent between 1999 and 2000. Overall in 1999 and 2000, 19.7% and 12.9% of the 9,951 vehicles involved in fatal crashes at traffic signals failed to obey the signal and failed to yield the right-of-way, respectively.

Stop Sign Violations

Figures 10 and 11 show the breakdown of the 1999 and 2000 stop sign "fail to obey" and "fail to yield" vehicles, respectively. In 1999, 7,069 vehicles were involved in 3,636 fatal crashes at locations controlled by stop signs. Of these vehicles, 20.5% failed to obey the stop sign and 23.2% failed to yield the right-of-way. In 2000, 21.4% and 22.8% of the 6,558 vehicles involved in the 3,424 fatal crashes at stop signs respectively failed to obey the stop sign and failed to yield the right-of-way. Similar to traffic signals, these stop sign violation percentages have remained somewhat consistent between 1999 and 2000. Overall in 1999 and 2000, 21.0% and 23.0% of the 13,627 vehicles involved in fatal crashes at stop signs failed to obey the sign and failed to yield the right-of-way, respectively.

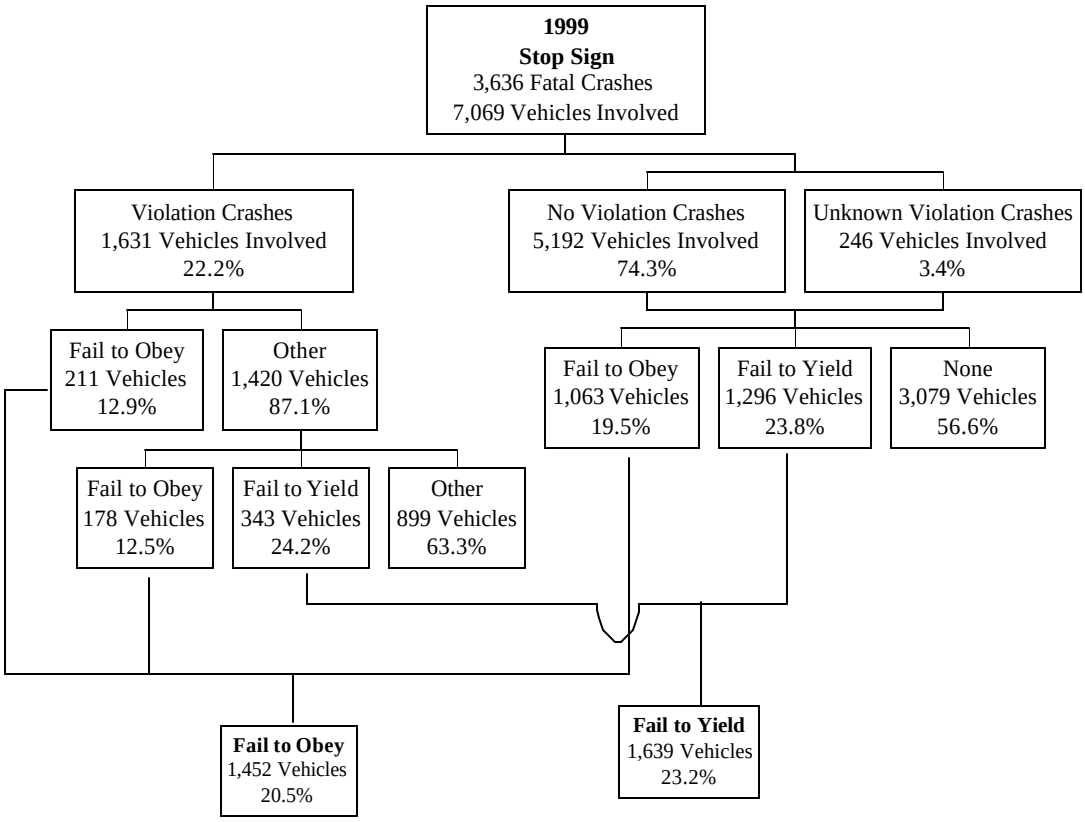


Figure 10: 1999 Stop Sign Fail to Obey/Yield Breakdown.

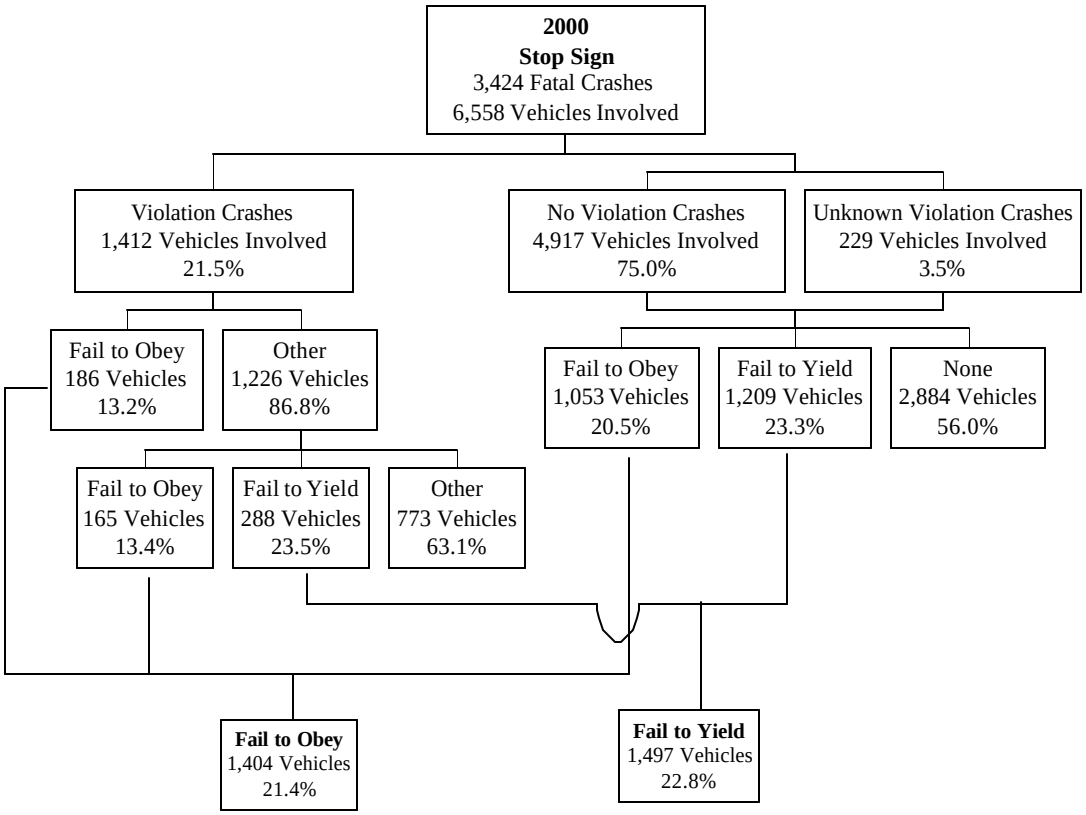


Figure 11: 2000 Stop Sign Fail to Obey/Yield Breakdown.

Table 4 summarizes the results presented in this section. Approximately, one traffic control device violation occurred for every three vehicles involved in a fatal crash at a traffic signal. On the other hand, one violation occurred for every 2.3 vehicles involved in a fatal crash at a stop sign. The overall percentage of vehicles that violated the traffic signal or stop sign has remained consistent from 1999 to 2000. The violations of failure to obey were 6.2% higher at stop signs than at traffic signals over these two years. In contrast, violations of failure to yield were 43.9% higher at stop signs than at traffic signals over the same period. The higher rate of failure to yield at stop signs is mostly due to a larger number of vehicles that stop first and then proceed against crossing traffic at stop signs than at traffic signals.

Table 4: Frequency of Fail to Obey/Yield Violations by Traffic Control Device.

	Traffic Signal		Stop Sign	
	1999 FARS	**2000 FARS**	**1999 FARS**	**2000 FARS**
Total No. of Fatal Crashes	2,571	2,583	3,636	3,424
Total No. of Vehicles Involved	4,941	5,010	7,069	6,558
No. of Fail to Obey Vehicles	953	1,005	1,452	1,404
% Fail to Obey	19.3%	20.1%	20.5%	21.4%
No. of Fail to Yield Vehicles	663	621	1,639	1,497
% Fail to Yield	13.4%	12.4%	23.2%	22.8%
Total % Violation	32.7%	32.5%	43.7%	44.2%

2.4 Light Vehicle Fail to Obey/Yield Violations

Vehicles that violated the traffic signal or stop sign were examined to separate light vehicles (passenger car, sport utility vehicle, van, or pickup truck) from other vehicle types. The light vehicle population was segregated to support ongoing work at NHTSA in developing light vehicle countermeasure systems for intersection control violation crashes.

Light vehicles were identified by selecting codes 01-12, 14-22, 28-41, 45, or 48-49 from the *Body Type* variable and code 0 from the *Special Use* variable located is the FARS "Vehicle File." The following are the relevant codes of the *Body Type* variable (*4*):

Codes 01-09: Automobiles
Codes 10-12: Automobile Derivatives
Codes 14-19: Utility vehicles
Codes 20-22, 28-29: Van Based Light Trucks (Gross Vehicle Weight Ratio less than or equal to 10,000 lbs.)
Codes 30-39: Light Conventional Trucks (Pickup-style cab, Gross Vehicle Weight Ratio less than or equal to 10,000 lbs.)
Codes 40-41, 45, 48-49: Other Light Conventional Trucks (Gross Vehicle Weight Ratio less than or equal to 10,000 lbs.)

The relevant code from the *Special Use* variable is (*4*):

Code 0: No Special Use

Table 5 indicates the involvement rate of light vehicles in failure to obey and failure to yield violation crashes. Between 1999 and 2000, light vehicles constituted 88.8% and 90.5% of all the involved vehicles that respectively failed to obey and failed to yield at traffic signals. Similarly at stop signs, light vehicles accounted for 92.5% and 94.5% of all the involved vehicles that respectively failed to obey and failed to yield. These light vehicle violation rates are comparable between traffic signal and stop sign crashes (within 4%) in 1999 and 2000.

Table 5: Vehicle Frequency of Fail to Obey/Yield Light Vehicle Violations by Traffic Control Device.

	Traffic Signal		Stop Sign	
	1999 FARS	**2000 FARS**	**1999 FARS**	**2000 FARS**
Fail to Obey				
No. of Vehicles	953	1,005	1,452	1,404
No. of Light Vehicles	843	896	1,349	1,294
% Light Vehicles	88.5%	89.2%	92.9%	92.2%
Fail to Yield				
No. of Vehicles	663	621	1,639	1,497
No. of Light Vehicles	599	563	1,553	1,411
% Light Vehicles	90.3%	90.7%	94.8%	94.3%
Total % Light Vehicles	89.2%	89.7%	93.9%	93.2%

Table 6 shows the number of crashes in which a light vehicle violated the traffic signal or stop sign. The number of crashes is less than the number of violating light vehicles, indicating that more than one light vehicle violated the traffic control device in some crashes.

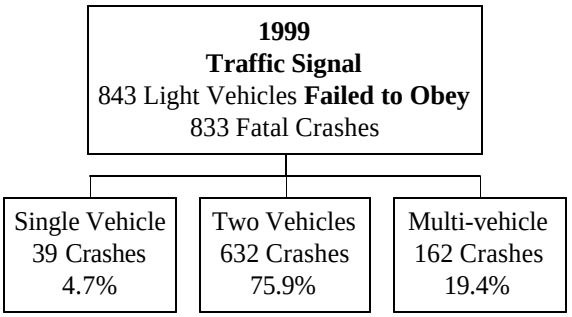
Table 6: Crash Frequency of Fail to Obey/Yield Light Vehicle Violations.

	Traffic Signal		Stop Sign	
	1999 FARS	2000 FARS	1999 FARS	2000 FARS
Fail to Obey				
No. of Light Vehicles	843	896	1,349	1,294
No. of Crashes	883	884	1,344	1,283
Fail to Yield				
No. of Light Vehicles	599	563	1,553	1,411
No. of Crashes	588	553	1,547	1,405

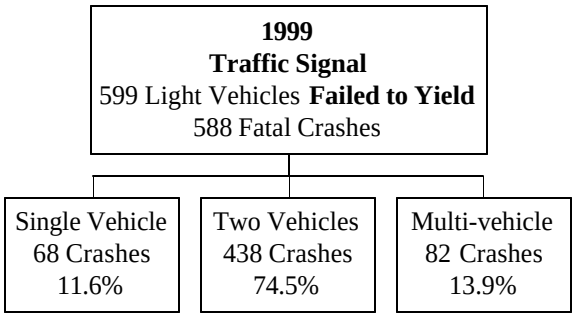
In 1999 and 2000, a light vehicle failed to obey the traffic signal in 1,717 fatal crashes, that represents 2.3% of the total fatal crash population and 33.3% of all fatal crashes at traffic signals. A light vehicle's failure to yield at the traffic signal comprised of 1,141 crashes or 1.5% of the total fatal crash population and 22.1 % of all fatal crashes at traffic signals. Over the same two years, a light vehicle failed to obey the stop sign in 2,627 fatal crashes, accounting for 3.5% of the total fatal crash population and 37.2% of all fatal crashes at stop signs. On the other hand, a light vehicle failed to yield at a stop sign in 2,952 fatal crashes representing 4.0% of the total fatal crash population and 41.8% of all fatal crashes at stop signs. Fatal crashes associated with failure to obey by the light vehicle were 1.5 times higher at stop signs than at traffic signals in 1999 and 2000. In contrast, the "failure to yield" fatal crashes by the light vehicle were 2.6 times higher at stop signs than at traffic signals over the same period.

2.5 Vehicle Involvement

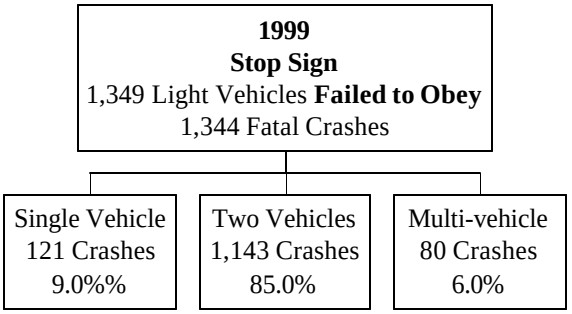
Light vehicle violation fatal crashes were examined to determine the number of vehicles that were involved in the crash. Crashes were separated into the following three categories using the *Vehicle Forms Submitted* FARS variable: single vehicle, two-vehicle, and multi-vehicle crashes. Multi-vehicle crashes were defined as those that involved three or more vehicles. Figure 12 graphically displays the results. Overall, two-vehicle crashes were the majority of fatal crashes, regardless of the type of violation or traffic control device, which accounted for 74.6% and 87.4% of light vehicle violation fatal crashes respectively at traffic signals and stop signs in 1999 and 2000. Multi-vehicle crashes ranked second with 17.9% at traffic signals and 6.8% at stop signs. Single vehicle crashes represented only 7.5% and 5.8% of all light vehicle violation fatal crashes at traffic signals and stop signs, respectively. Figure 13 presents the distribution of light vehicle violation fatal crash categories by traffic control device and violation type. Failure to obey the stop sign was the most dominant in single vehicle crashes. On the other hand, failure to yield at the stop sign was the most prevalent in the two-vehicle crashes. Finally, failure to obey the traffic signal was the most frequent in multi-vehicle crashes.



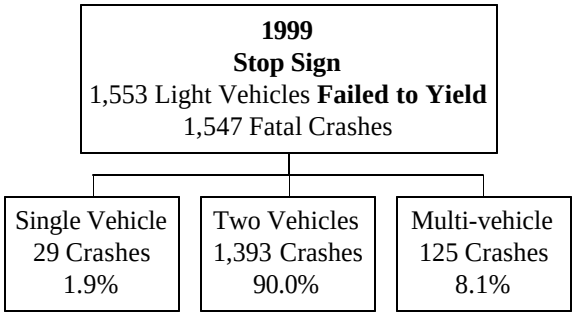
A: 1999 Traffic Signal Fail to Obey.



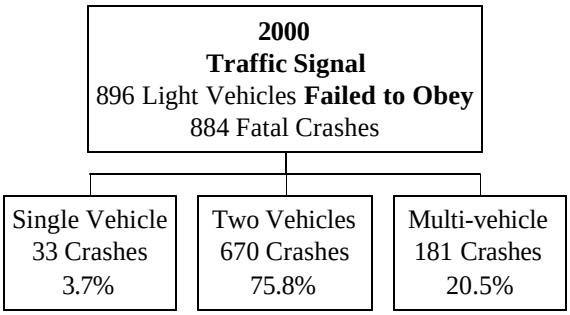
B: 1999 Traffic Signal Fail to Yield.



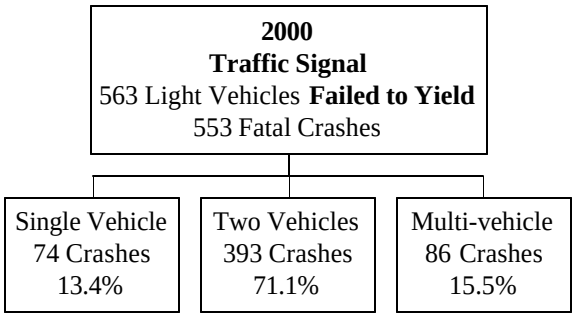
C: 1999 Stop Sign Fail to Obey.



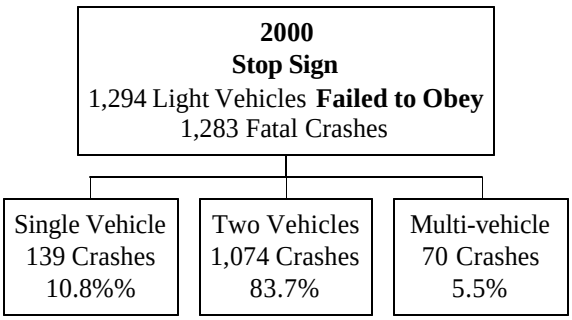
D: 1999 Stop Sign Fail to Yield.



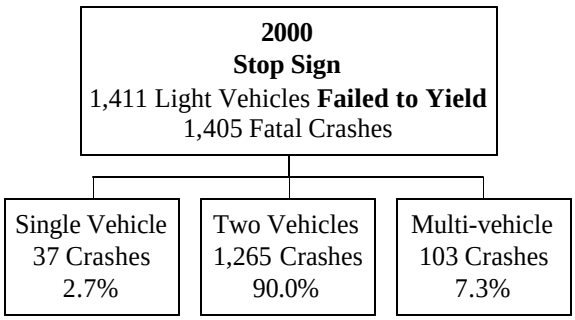
E: 2000 Traffic Signal Fail to Obey.



F: 2000 Traffic Signal Fail to Yield.



G: 2000 Stop Sign Fail to Obey.



H: 2000 Stop Sign Fail to Yield.

Figure 12: Vehicle Involvement in Light Vehicle Violations at Traffic Signals and Stop Signs.

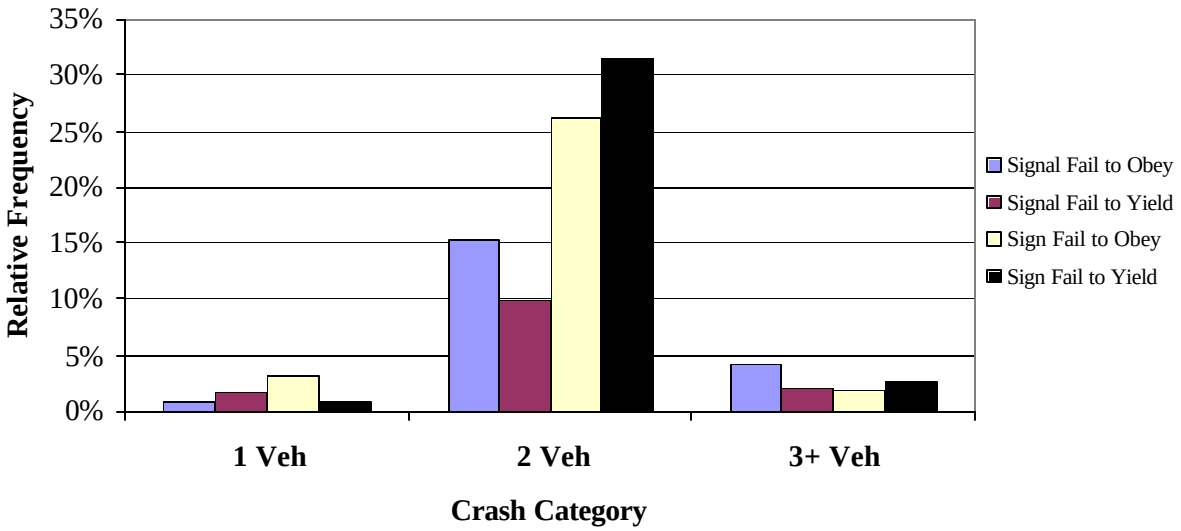


Figure 13: Distribution of Light Vehicle Violation Fatal Crashes by Crash Category Based on 1999 and 2000 FARS.

2.6 Summary of Traffic Signal/Stop Sign Fatal Crashes

Major observations were as follows:

- Between 1999 and 2000 there was a yearly average of 37,275 fatal motor vehicle crashes on U.S. roadway, 6.9% of these crashes occurred at traffic signals and 9.5% at stop signs.
- The probability of a fatal crash given that a PR crash has occurred in the presence of a traffic signal is about 0.0019. Similarly, the probability of a fatal crash given that a PR crash has occurred in the presence of a stop sign is 0.0049, which is about 2.5 times higher than at traffic signals.
- Intersections were cited at a yearly average of 7,232 or 19.4% of all fatal crashes in 1999 and 2000.
- The probability of a fatal crash given that a PR crash has occurred at an intersection controlled by traffic signals was 0.0031 in 2000. In contrast, the probability at stop sign-controlled intersections was almost two times higher than at traffic signals with 0.0061.
- Overall in 1999 and 2000, 19.7% and 12.9% of the 9,951 vehicles involved in fatal crashes at traffic signals failed to obey the signal and failed to yield the right-of-way, respectively.
- Approximately 21% and 23% of the 13,627 vehicles involved in fatal crashes at stop signs failed to obey the sign and failed to yield the right-of-way, respectively.
- Light vehicles constituted 88.8% and 90.5% of all the involved vehicles that respectively failed to obey and failed to yield at traffic signals.
- At stop signs, light vehicles accounted for 92.5% and 94.5% of all involved vehicles that respectively failed to obey and failed to yield.
- Fatal crashes associated with failure to obey by the light vehicle were 1.5 times higher at stop signs than at traffic signals in 1999 and 2000. In contrast, the "failure to yield" fatal crashes by the light vehicle were 2.6 times higher at stop signs than at traffic signals over the same period.
- Two-vehicle crashes accounted for 74.6% and 87.4% of light vehicle violation fatal crashes respectively at traffic signals and stop signs. Multi-vehicle crashes represented 17.9% at traffic signals and 6.8% at stop signs.

3.0 Single Light Vehicle Crashes

This section identifies the single vehicle fatal crash types that the violating light vehicle was involved in, as well as the maneuvers that the light vehicle was conducting prior to the critical event of the crash. In addition, this section statistically describes the contributing factors and infrastructure characteristics associated with these single vehicle fatal crashes.

3.1 Crash Types

Single vehicle crashes were classified into crash types using the *Person Type* variable. Four predominant crash types were identified: pedestrian, cyclist, pedestrian and cyclist, and other crashes. The following element values from the *Person Type* variable were used (*4*):

Pedestrian:
- Code 05: Pedestrian
- Code 08: Other Pedestrian

Cyclist:
- Code 06: Bicyclist
- Code 07: Other Cyclist

The *Person Type* variable is coded on the person level and identifies the "type" of person, either a motorist or non-motorist who was involved in the crash. The pedestrian code is used for all pedestrians except those who are on/in pedestrian conveyances or in buildings. Pedestrian conveyances include skateboards, wheelchairs, roller skates, mobility scooters, etc. These pedestrians are coded as "other pedestrians". The bicyclist code is used only for a two-wheeled non-motorized cycle. Unicycles and tricycles are included in the "other cyclist" category.

Table 7 provides the breakdown of fatal single, violating light vehicle crashes by crash type. Pedestrian crashes were the majority of these crashes, expect for those in which the vehicle failed to obey the stop sign. Between 1999 and 2000, pedestrian crashes accounted for 63.9% and 95.1% of the single vehicle fatal crashes in which a light vehicle respectively failed to obey and failed to yield at traffic signals. On the other hand, pedestrian crashes accounted for 75.8% of the single vehicle fatal crashes that involved a light vehicle failing to yield at stop signs; while "other" crashes accounted for 95.4% of the fatal single vehicle crashes in which the light vehicle failed to obey the stop sign. Other crashes encompassed run-off-road and parked-vehicle crashes.

Table 7: Breakdown of Fatal Single Light Vehicle Crashes by Crash Type.

	Pedestrian	Cyclist	Pedestrian & Cyclist	Other	Total
1999 FARS					
Fail to Obey Traffic Signal (39)	64.1%	7.7%		28.2%	100%
Fail to Yield Traffic Signal (68)	95.6%	1.5%	2.9%		100%
Fail to Obey Stop Sign (121)	0.8%	1.7%		97.5%	100%
Fail to Yield Stop Sign (29)	62.1%	27.6%		10.3%	100%
2000 FARS					
Fail to Obey Traffic Signal (33)	63.6%	6.1%		30.3%	100%
Fail to Yield Traffic Signal (74)	94.6%	5.4%			100%
Fail to Obey Stop Sign (139)	5.0%	1.5%		93.5%	100%
Fail to Yield Stop Sign (37)	86.5%	5.4%		8.1%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Parentheses refer to actual crash counts.

The crash types were then examined to determine the vehicle's maneuver prior to the critical event of the crash. The following element values from the *Vehicle Maneuver* variable were used (*4*):

Code 01: Going Straight
Code 02: Slowing or Stopping in Traffic Lane
Code 03: Starting in Traffic Lane
Code 04: Stopped in Traffic Lane
Code 05: Passing or Overtaking Another Vehicle
Code 06: Leaving a Parked Position
Code 07: Parked
Code 08: Entering a Parked Position
Code 09: Maneuvering to Avoid
Code 10: Turning Right: Right Turn on Red Permitted
Code 11: Turning Right: Right Turn on Red Not Permitted
Code 12: Turning Right: Right Turn on Red Not Applicable or Not Known if Permitted
Code 13: Turning Left
Code 14: Making a U-Turn
Code 15: Baking Up
Code 16: Changing Lances or Merging
Code 17: Negotiating a Curve
Code 98: Other
Code 99: Unknown

Tables 8 through 11 provide results for the light vehicle's maneuver prior to the critical event of the crash. In 1999 and 2000, vehicles were going straight in 91.3% of the pedestrian crashes at traffic signals in which the driver failed to obey the signal. In contrast, vehicles were turning left in 43.7%, going straight in 40.0%, and turning right in 13.3% of the pedestrian crashes at traffic signals in which the driver failed to yield the right-of-way. On the other hand, vehicles were going straight in 64.0%, turning left in 24.0%, and turning right in 10.0% of the pedestrian

crashes at stop signs in which the driver failed to yield the right-of-way. "Other" single light vehicle fatal crashes were dominant at stop signs in which the driver failed to obey the sign. In these crashes, approximately 89.5% of the vehicles were going straight.

Table 8: Breakdown of Light Vehicle Maneuvers Prior to the Critical Event by Crash Type for 1999 Fatal Single Vehicle Crashes at Traffic Signals.

Vehicle Maneuver	Crash Type			
	Pedestrian	Cyclist	Pedestrian & Cyclist	Other
Fail to Obey	(25)	(3)		(11)
Going Straight	88.0%	100.0%		81.8%
Controlled Maneuver to Avoid	4.0%			18.2%
Turning Left	4.0%			
Changing Lanes/Merging	4.0%			
Total	100%	100%		100%
Fail to Yield	(65)	(1)	(2)	
Going Straight	32.3%	100.0%	50.0%	
Turning Right	16.9%			
Turning Left	49.2%		50.0%	
Negotiating a Curve	1.5%			
Total	100%	100%	100%	

- Empty cells refer to scenarios that had no crashes in the 1999 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 9: Breakdown of Light Vehicle Maneuvers Prior to the Critical Event by Crash Type for 2000 Fatal Single Vehicle Crashes at Traffic Signals.

Vehicle Maneuver	Crash Type		
	Pedestrian	Cyclist	Other
Fail to Obey	(21)	(2)	(10)
Going Straight	95.2%	100.0%	60.0%
Passing/Overtaking	4.8%		10.0%
Controlled Maneuver to Avoid			10.0%
Turning Left			10.0%
Negotiating a Curve			10.0%
Total	100%	100%	100%
Fail to Yield	(70)	(4)	
Going Straight	47.1%	75.0%	
Starting in Traffic Lane	2.9%		
Passing/Overtaking	1.4%		
Turning Right	10.0%		
Turning Left	38.6%	25.0%	
Total	100%	100%	

- Empty cells refer to scenarios that had no crashes in the 2000 FARS.
- Parentheses refer to actual crash counts.

Table 10: Breakdown of Light Vehicle Maneuvers Prior to the Critical Event by Crash Type for 1999 Fatal Single Vehicle Crashes at Stop Signs.

Vehicle Maneuver	Crash Type		
	Pedestrian	Cyclist	Other
Fail to Obey	(1)	(2)	(118)
Going Straight	100.0%	100.0%	89.0%
Turning Right			2.5%
Turning Left			5.1%
U-Turn			0.8%
Negotiating a Curve			2.5%
Total	100%	100%	100%
Fail to Yield	(18)	(8)	(3)
Going Straight	83.3%	50.0%	100.0%
Starting in Traffic Lane		25.0%	
Turning Right		12.5%	
Turning Left	16.7%	12.5%	
Total	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 11: Breakdown of Light Vehicle Maneuvers Prior to the Critical Event by Crash Type for 2000 Fatal Single Vehicle Crashes at Stop Signs.

Vehicle Maneuver	Crash Type		
	Pedestrian	Cyclist	Other
Fail to Obey	(7)	(2)	(130)
Going Straight	85.7%	100.0%	90.0%
Turning Right			2.3%
Turning Left			3.1%
U-Turn			
Negotiating a Curve			3.1%
Other	14.3%		0.8%
Unknown			0.8%
Total	100%	100%	100%
Fail to Yield	(32)	(2)	(3)
Going Straight	53.2%	50.0%	66.7%
Starting in Traffic Lane		50.0%	33.3%
Passing/Overtaking	3.1%		
Turning Right	15.6%		
Turning Left	28.1%		
Total	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

3.2 Crash Contributing Factors

Crash contributing factors were determined for the driver of all violating light vehicles and for the pedestrian or cyclist involved in the fatal crash. An in-depth examination of the 1999 and 2000 FARS databases was conducted using the *Related Factors - Driver Level* and *Related Factors - Person Level* variables. Results from the analysis are provided in Figures 14-24. It should be noted that up to four factors for the *Related Factors - Driver Level* variable and up to three factors for the *Related Factors - Person Level* variable might be coded for each crash. Figures 14-24 show the number of times that each factor was reported, recognizing that one crash may have four reported driver factors and another may have none.

Driver Factors

Speeding was the dominant factor in 33.3% of all the single light vehicle fatal crashes in which the driver violated the traffic signal/stop sign. Inattention ranked second with 13.9% of all these crashes. Hit and run and vision obscured accounted respectively for 8.9% and 5.9% of all these crashes. About 2.0% of these crashes involved high-speed police chases. Figure 25 presents the relative frequency statistics of major driver factors for each of the four most common single vehicle crash types. Speeding accounted for 54.0% of all "other" crashes in which the driver failed to obey the stop sign. Hit and run crashes were reported in 39.1% of all pedestrian crashes in which the driver failed to obey the traffic signal. Vision obscured was cited in 18.0% of all pedestrian crashes in which the driver failed to yield at stop signs. Inattention was the contributing factor in 17.0% of all pedestrian crashes in which the driver failed to yield at traffic signals.

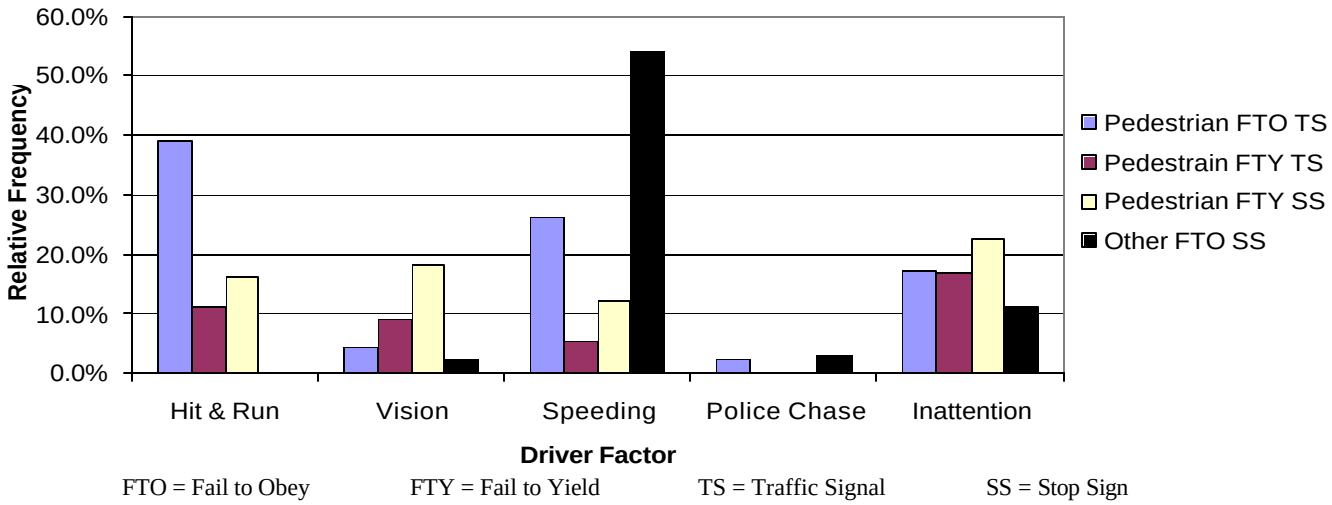


Figure 25: Relative Frequency Statistics for Major Single Vehicle Driver Factors.

Person Factors

Improper crossing was the dominant pedestrian factor in 7.9% of all pedestrian crashes. This was followed by walking against traffic in 5.4% of these crashes. Darting onto the road and failing to obey the traffic signal accounted respectively for 4.2% and 3.3% of all pedestrian crashes. Improper crossing and riding against traffic were equally cited at 16.7% of all cyclist crashes.

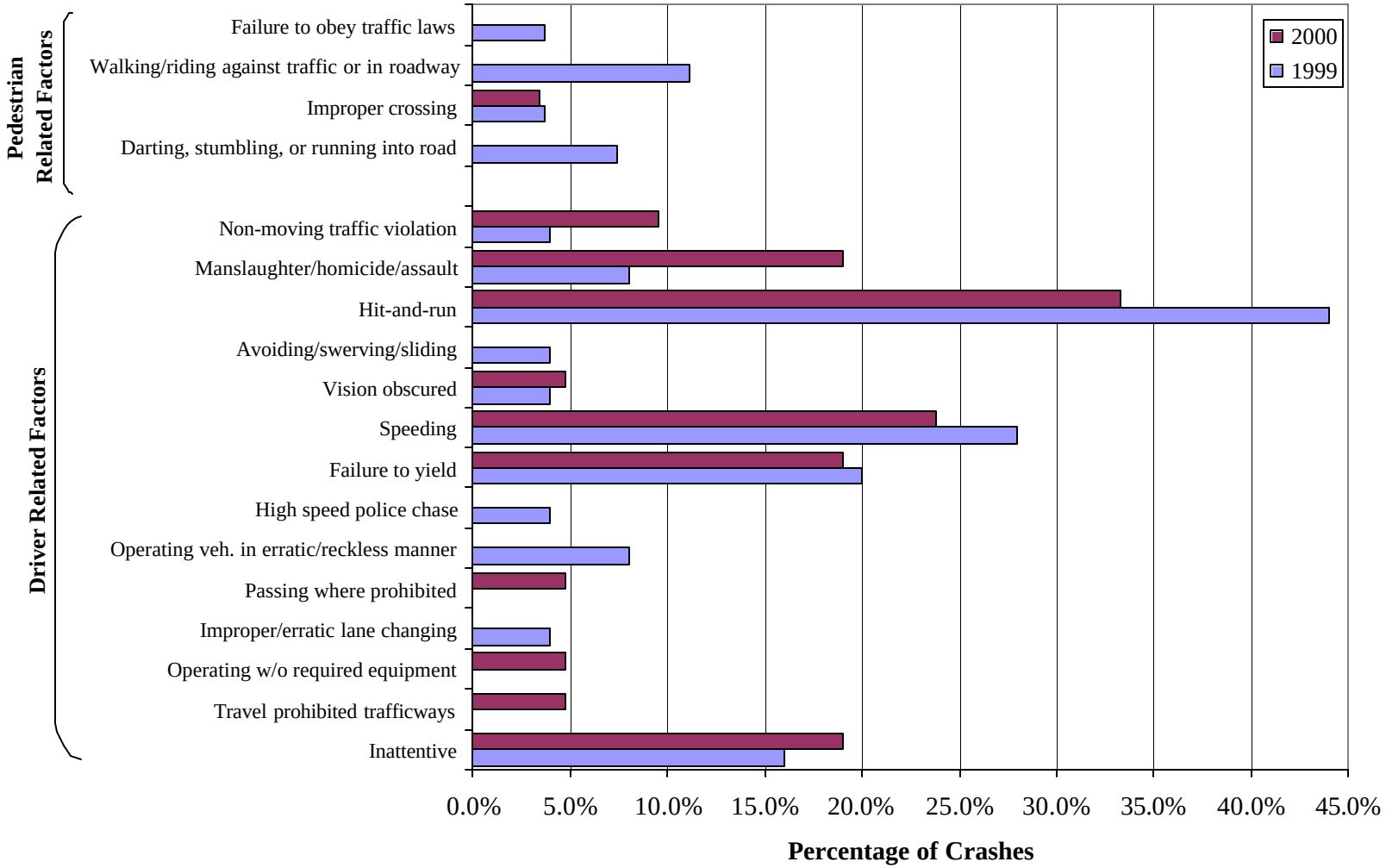


Figure 14: Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Pedestrian Crashes at Traffic Signals.

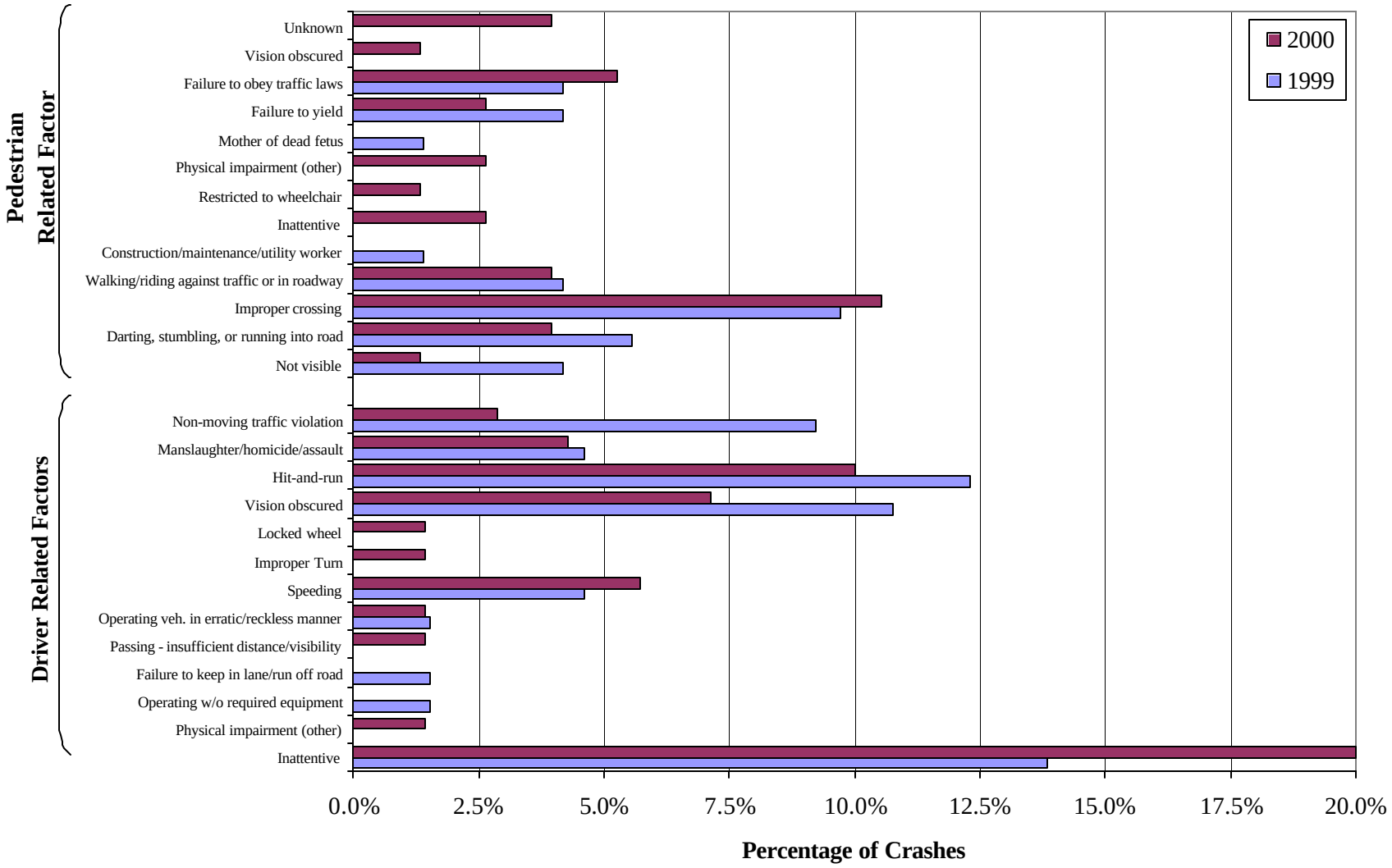


Figure 15: Breakdown of Fatal Crash Related Factors for Failure to Yield Single Vehicle Pedestrian Crashes at Traffic Signals.

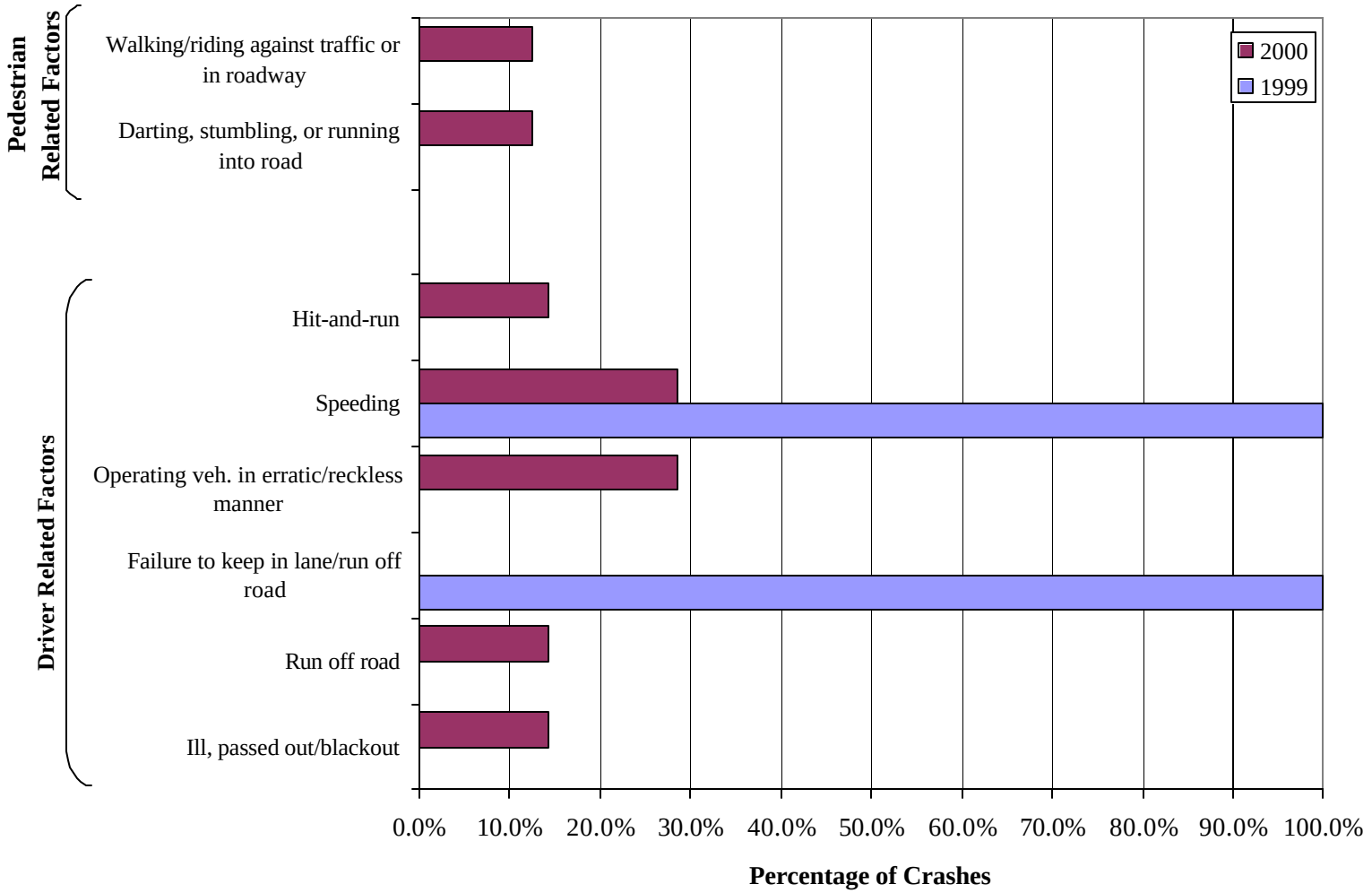


Figure 16: Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Pedestrian Crashes at Stop Signs.

Note: Low Crash Frequency (1999 – 1 crash, 2000 – 7 crashes).

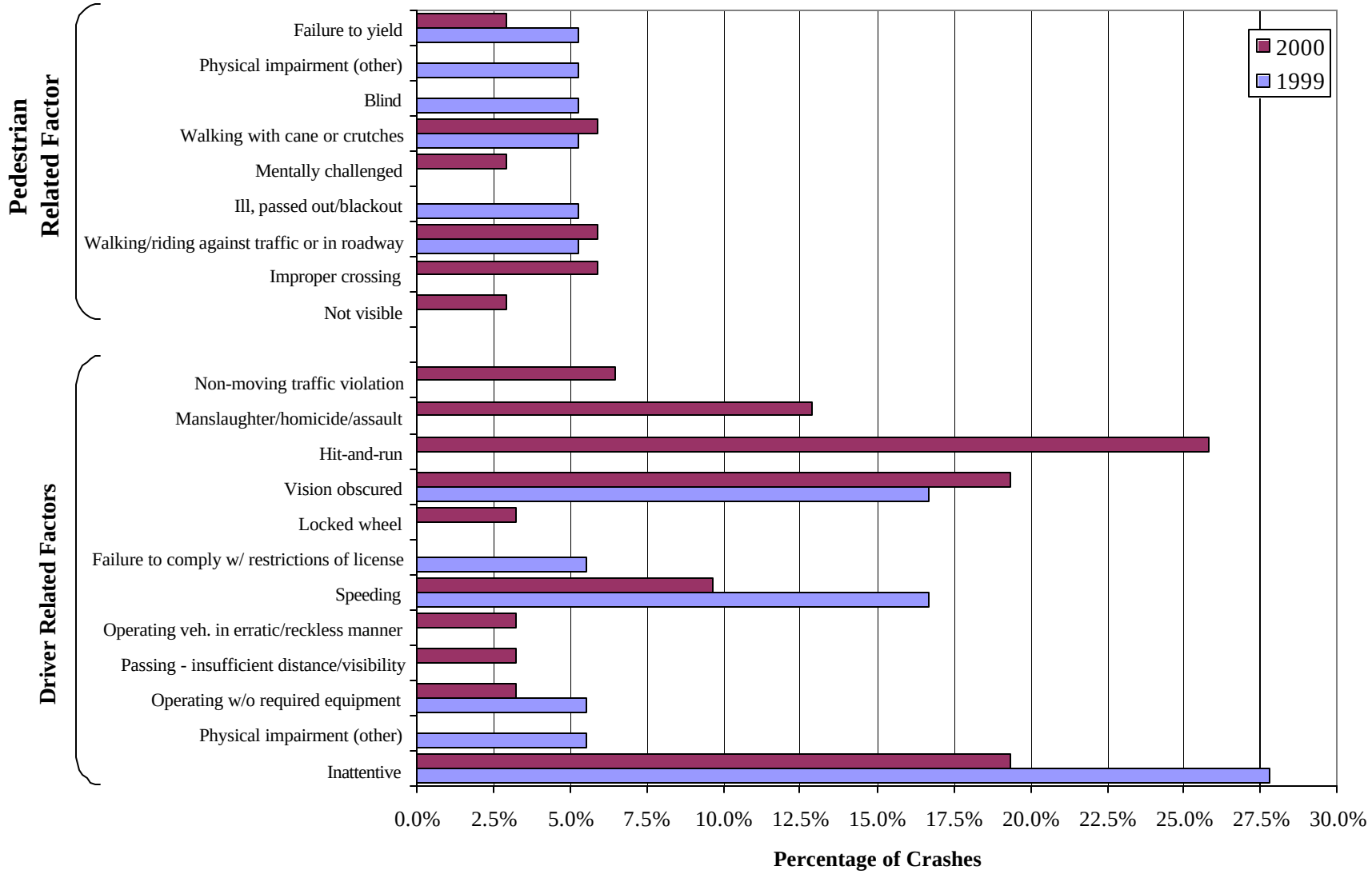


Figure 17: Breakdown of Fatal Crash Related Factors for Failure to Yield Single Vehicle Pedestrian Crashes at Stop Signs.

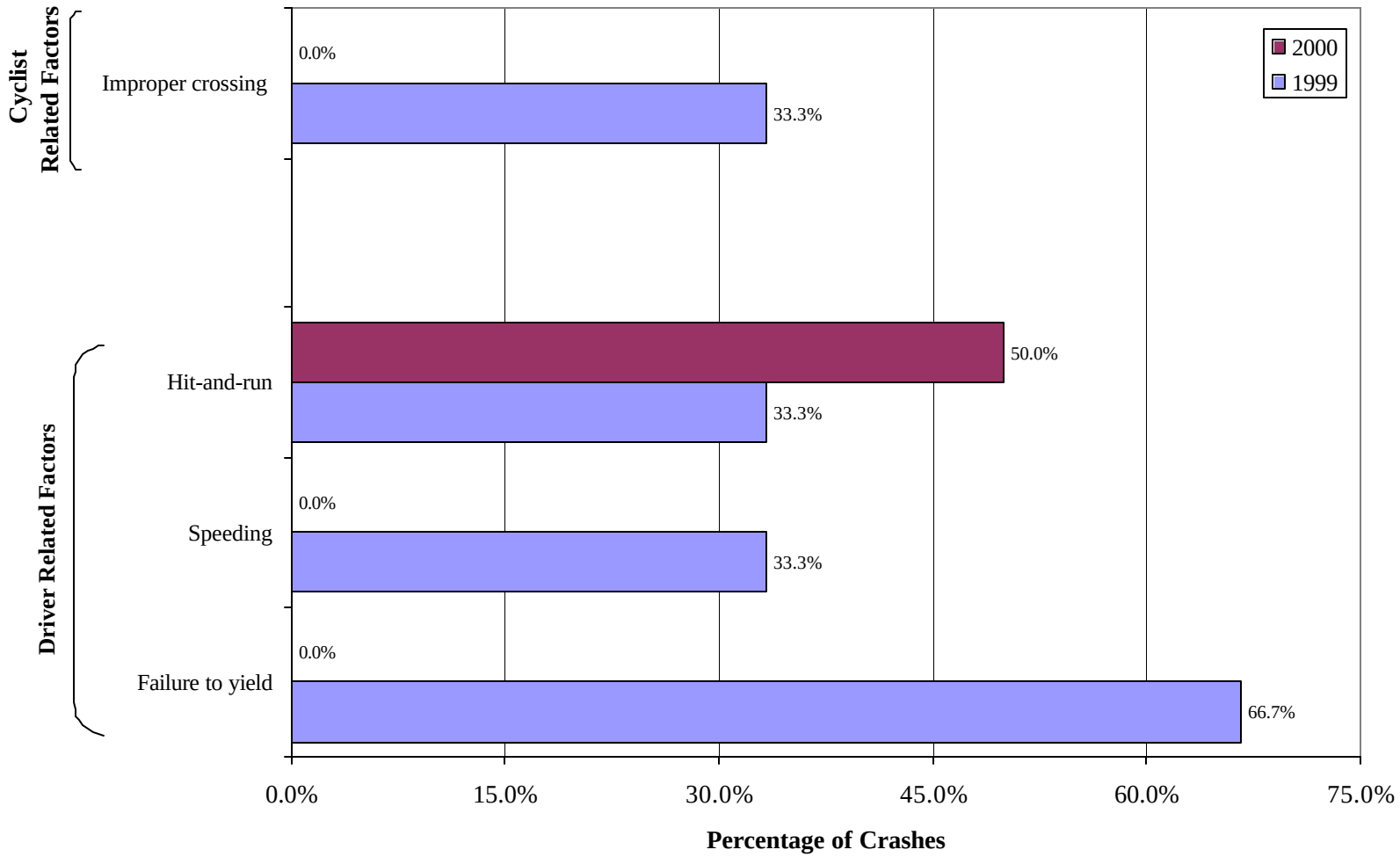


Figure 18: Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Cyclist Crashes at Traffic Signals.

Note: Low Crash Frequency (1999 – 3 crashes, 2000 – 2 crashes).

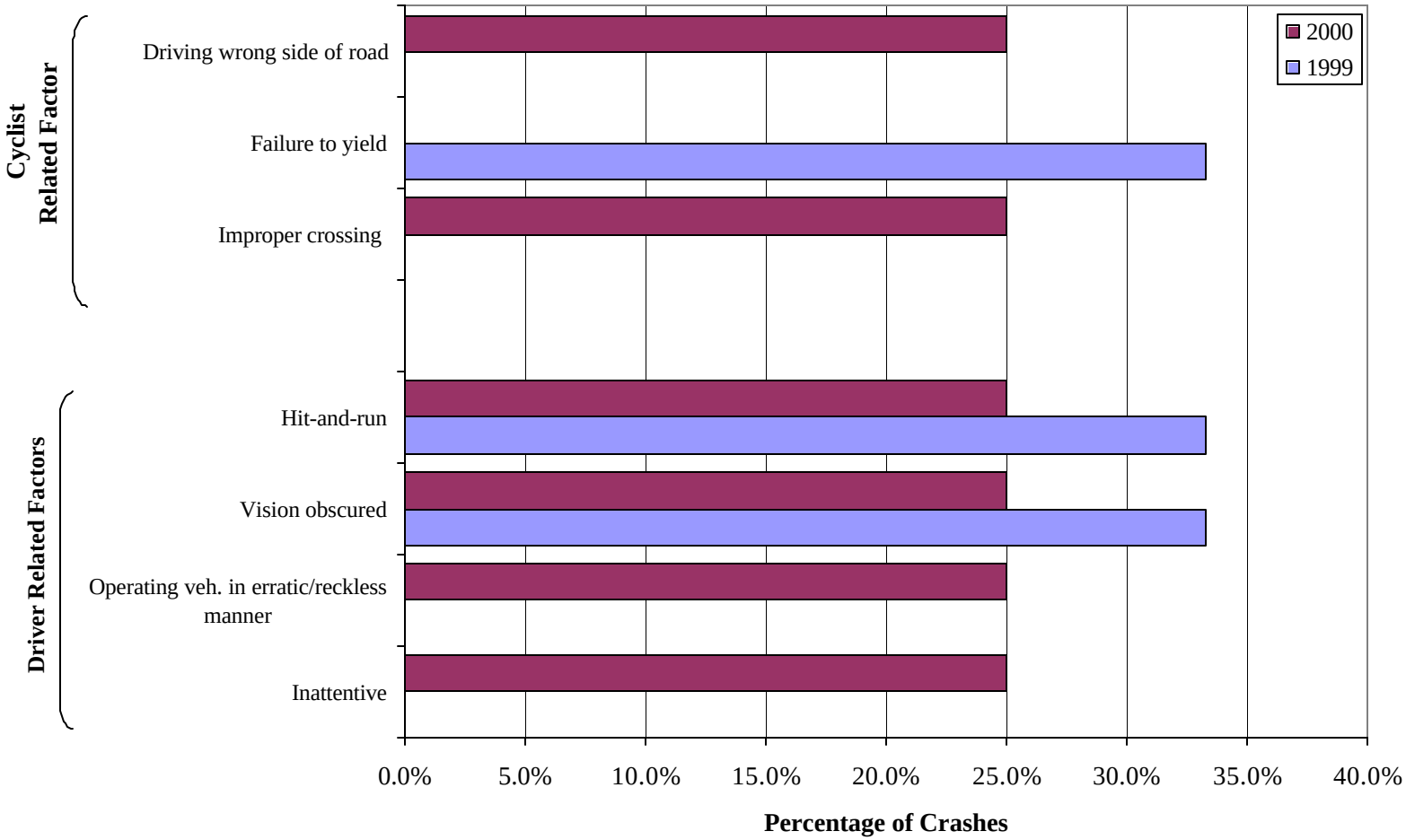


Figure 19: Breakdown of Fatal Crash Related Factors for Failure to Yield Single Vehicle Cyclist Crashes at Traffic Signals.

Note: Low Crash Frequency (1999 – 3 crashes, 2000 – 4 crashes).

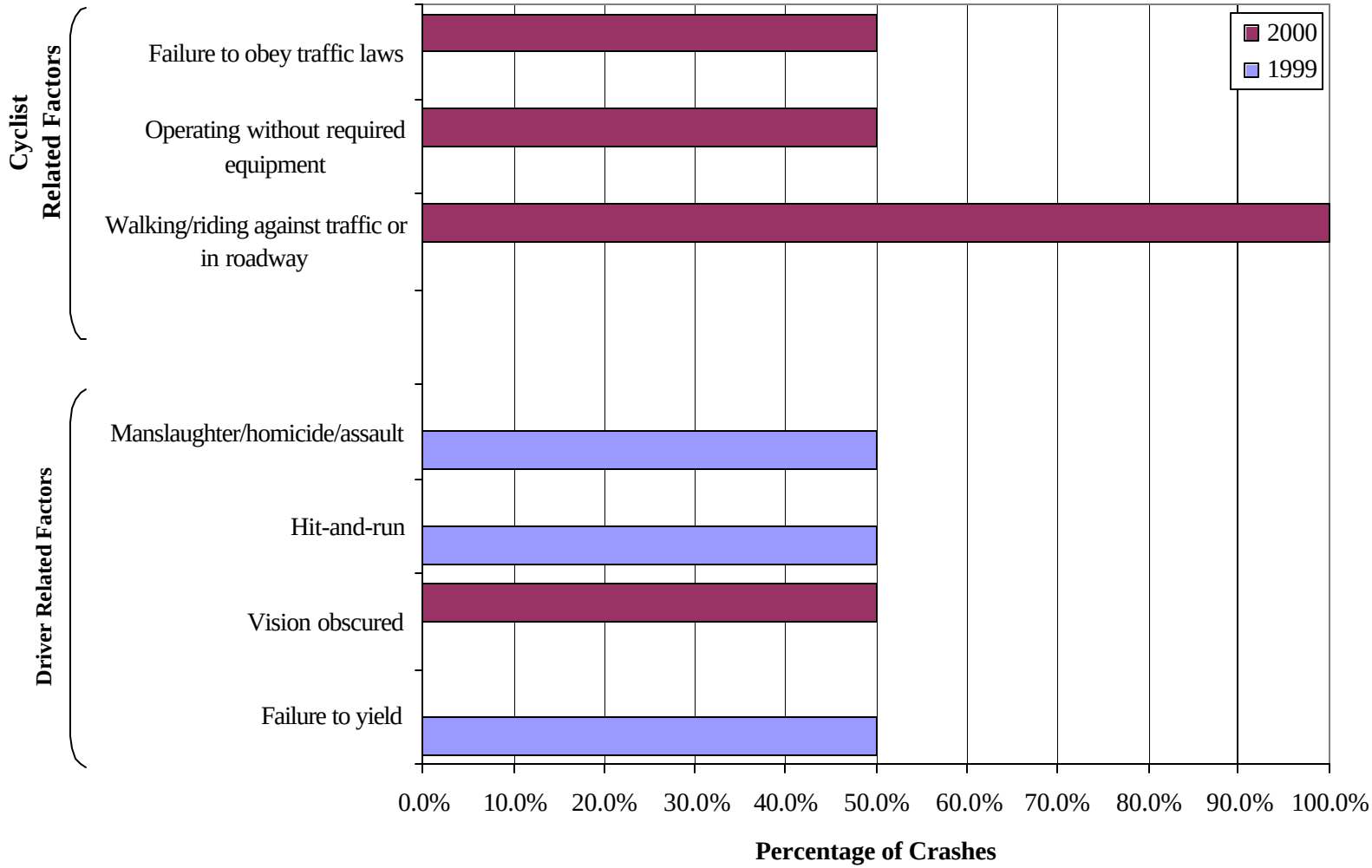


Figure 20. Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Cyclist Crashes at Stop Signs.

Note: Low Crash Frequency (1999 – 2 crashes, 2000 – 2 crashes).

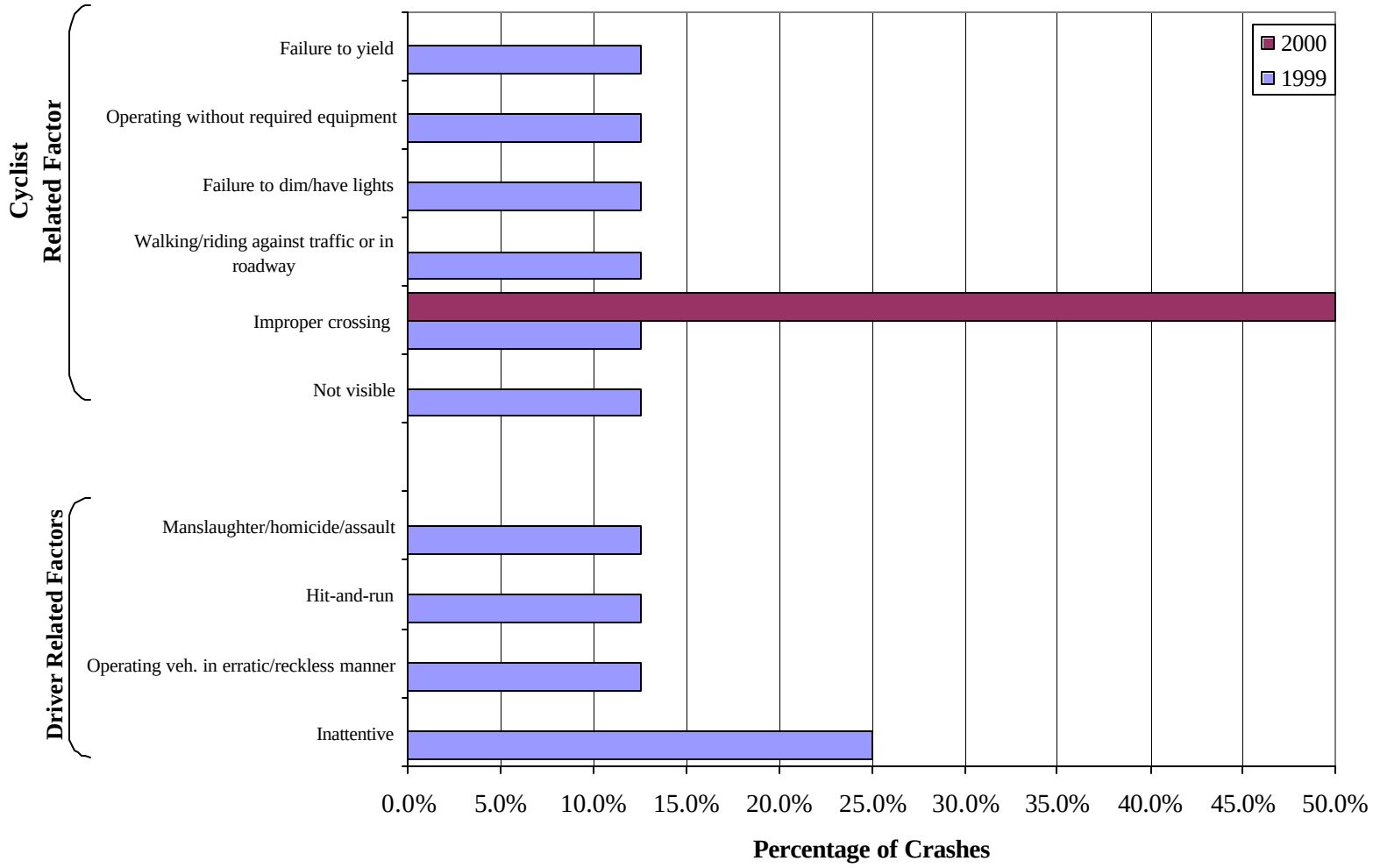


Figure 21: Breakdown of Fatal Crash Related Factors for Failure to Yield Single Vehicle Cyclist Crashes at Stop Signs.

Note: Low Crash Frequency (1999 – 8 crashes, 2000 – 2 crashes).

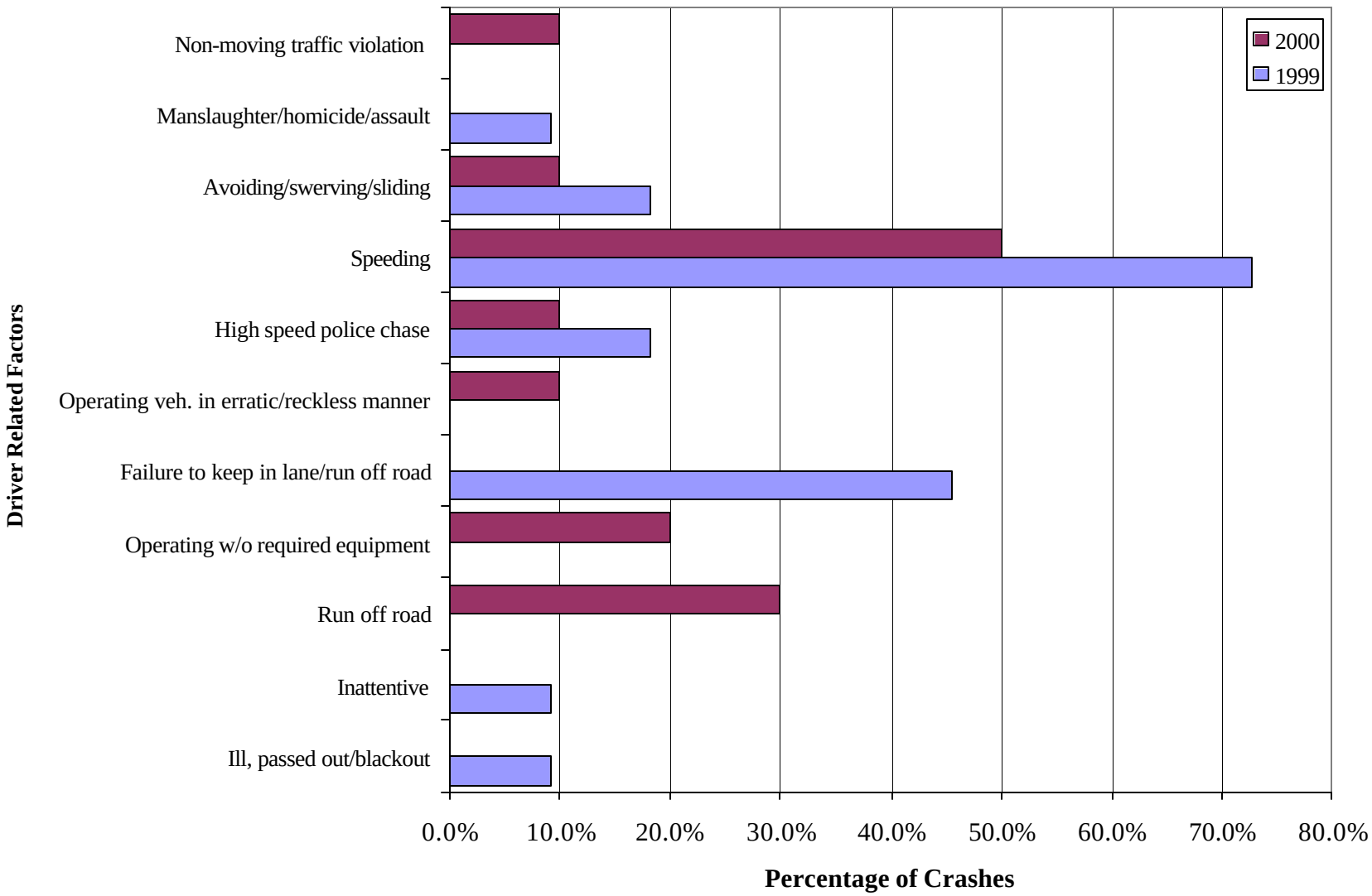


Figure 22: Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Other Crashes at Traffic Signals.

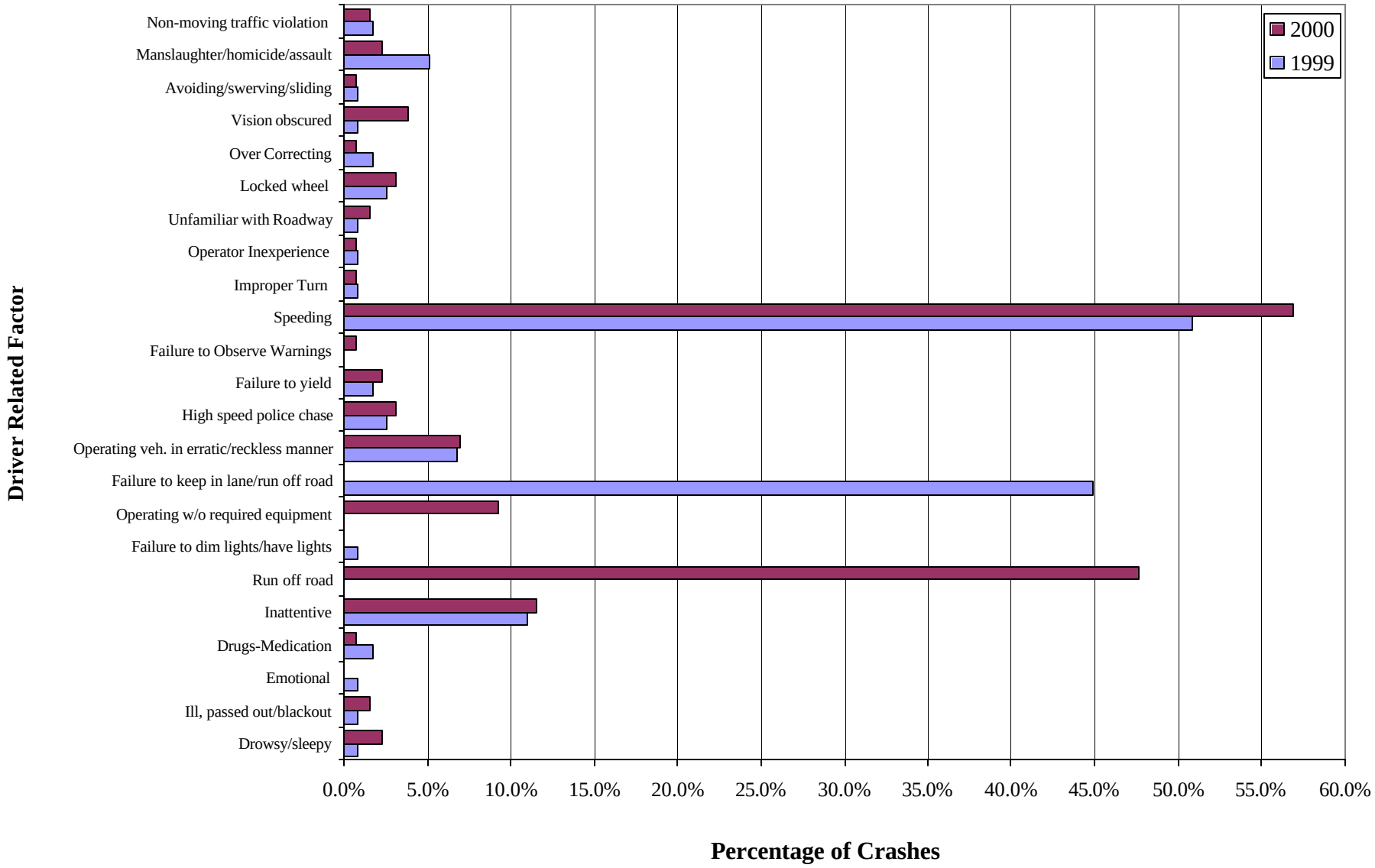


Figure 23: Breakdown of Fatal Crash Related Factors for Failure to Obey Single Vehicle Other Crashes at Stop Signs.

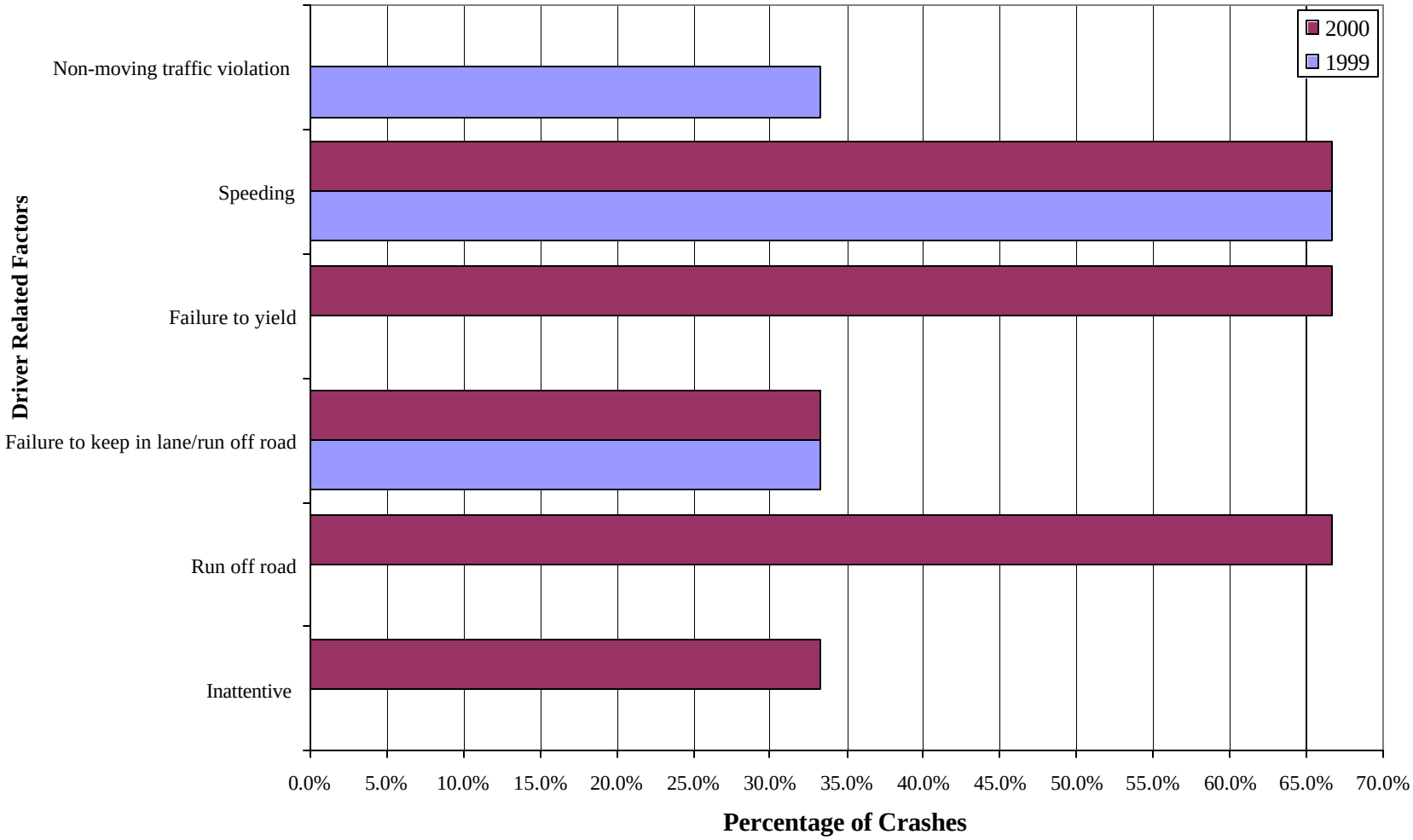


Figure 24: Breakdown of Fatal Crash Related Factors for Failure to Yield Single Vehicle Other Crashes at Stop Signs.

Note: Low Crash Frequency (1999 – 3 crashes, 2000 – 3 crashes).

3.3 Alcohol Involvement

The single light vehicle fatal crash types were examined to determine if alcohol was involved in the crash using the *Drinking* variable. The *Drinking* variable provides information on police reported alcohol involvement. The following element values from the *Drinking* variable were used (*4*):

Code 0: No (Alcohol Not Involved)
Code 1: Yes (Alcohol Involved)
Code 8: Not Reported
Code 9: Unknown (Police Reported)

The variable is only coded as "Yes (Alcohol Involved)" if the police report explicitly states or implies that alcohol is involved. If no indication of alcohol involvement is noted on the police report, then the variable is coded as "Not Reported." If the police report explicitly states that it is unknown whether or not alcohol is involved then the variable is coded as "Unknown."

Table 12 provides the frequency of fatal crashes that involved alcohol. It should be noted that alcohol involvement was only examined for the driver of the light vehicle. Alcohol was involved in 37.1% of all single vehicle fatal crashes involving a light vehicle violating a traffic signal or stop sign. Furthermore, 56% of the failure to obey violations involved alcohol. Alcohol involvement was reported in 31.9% of all single vehicle crashes in which the driver failed to obey the traffic signal, as opposed to 62.3% of the failure to obey the stop sign. The highest rate of alcohol involvement was reported in 62.9% of all "other" crashes. These were mostly run-off-road crashes that have been known to high alcohol involvement (*5*).

Table 12: Breakdown of Police Reported Alcohol Involvement in Fatal Single Vehicle Crashes.

	Pedestrian	Cyclist	Pedestrian & Cyclist	Other
1999 FARS				
Fail to Obey Traffic Signal	24.0% (25)	0.0% (3)		54.5% (11)
Fail to Yield Traffic Signal	1.5% (65)	0.0% (1)	0.0% (2)	
Fail to Obey Stop Sign	0.0% (1)	0.0% (2)		65.3% (118)
Fail to Yield Stop Sign	11.1% (18)	0.0% (8)		66.7% (3)
2000 FARS				
Fail to Obey Traffic Signal	33.3% (21)	0.0% (2)		40.0% (10)
Fail to Yield Traffic Signal	7.1% (70)	0.0% (4)		
Fail to Obey Stop Sign	42.9% (7)	0.0% (2)		63.1% (130)
Fail to Yield Stop Sign	6.5% (32)	0.0% (2)		66.7% (3)

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Parentheses refer to actual crash counts.

3.4 Infrastructure Characteristics

Three characteristics of the infrastructure were examined for single light vehicle fatal crashes: roadway functional class, number of lanes, and posted speed limit.

Roadway Functional Class

The FARS *Roadway Functional Class* variable was used to obtain the functional class of the roadway on which the vehicle was traveling. For an intersection crash, the highest functional class of the intersecting trafficways was coded. Additional information on the criteria used for the classification of roadways is provided in Appendix B.

Table 13 provides the breakdown of roadway classification for single light vehicle fatal crashes. At traffic signals, 90.7% and 7.5% of these crashes occurred respectively in urban and rural areas. In contrast, 42.3% and 57.1% of these crashes occurred respectively in urban and rural areas at stop signs. An urban area is defined as a locality set by the responsible State and local officials having a population of 5,000 or more (*6*). About 86.4% of the crashes in which the driver failed to yield at the stop sign occurred at urban locations, while 68.5% of the crashes in which the driver failed to obey the stop sign happened in rural areas.

The "urban principal arterial" had the highest rates of single light vehicle fatal crashes at traffic signals, accounting for 44.4% and 46.5% of the crashes in which the driver respectively failed to obey the signal and failed to yield the right-of-way. On the other hand, the "rural local road/street" was the most common roadway at 23.1% of the crashes in which the driver failed to obey the stop sign. Conversely, the "urban local road/street" had 33.3% of the crashes in which the driver failed to yield at the stop sign.

Table 13: Breakdown of Roadway Classification for Fatal Single Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(39)	(68)	(121)	(29)
Rural Principal Arterial-Interstate			0.8%	
Rural Principal Arterial-Other		5.9%	6.6%	
Rural Minor Arterial		2.9%	12.4%	3.4%
Rural Major Collector		1.5%	21.5%	3.4%
Rural Minor Collector			5.8%	3.4%
Rural Local Road/Street	2.6%	1.5%	22.3%	6.9%
Urban Principal Arterial-Interstate	2.6%		2.5%	
Urban Principal Arterial-Other Freeway	5.1%	1.5%		3.4%
Urban Principal Arterial	35.9%	48.5%	1.7%	13.8%
Urban Minor Collector	20.5%	17.6%	3.3%	13.8%
Urban Collector	2.6%	4.4%	8.3%	20.7%
Urban Local Road/Street	28.2%	16.2%	14.0%	31.0%
Urban Unknown	2.6%		0.8%	
Total	100%	100%	100%	100%
2000 FARS	(33)	(74)	(139)	(37)
Rural Principal Arterial-Interstate			1.4%	
Rural Principal Arterial-Other		1.4%	3.6%	
Rural Minor Arterial			6.5%	2.7%
Rural Major Collector		1.4%	18.7%	
Rural Minor Collector		1.4%	9.4%	
Rural Local Road/Street	3.0%	2.7%	23.7%	5.4%
Rural Unknown		1.4%	4.3%	
Urban Principal Arterial-Interstate		1.4%	1.4%	
Urban Principal Arterial-Other Freeway		2.7%	0.7%	
Urban Principal Arterial	54.5%	44.6%	2.9%	24.3%
Urban Minor Collector	18.2%	18.9%	4.3%	24.3%
Urban Collector		8.1%	7.9%	5.4%
Urban Local Road/Street	18.2%	10.8%	13.7%	35.1%
Urban Unknown	3.0%	1.4%	0.7%	
Unknown	3.0%	4.1%	0.7%	2.7%
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Number of Travel Lanes

The FARS *Number of Travel Lanes* variable was used to obtain information about the number of lanes of travel. The variable indicates the number of all travel lanes, regardless of their direction if the roadway is not divided; however, if the roadway is divided the variable only indicates the number of travel lanes in the direction of travel. It is noteworthy that unlike the GES, only lanes open for travel are counted; turn lanes are excluded. Table 14 presents data on the number of travel lanes for single light vehicle fatal crashes. The majority of the failure to obey crashes occurred on two-lane roadways, 91.9% of stop sign crashes and 52.8% of traffic signal crashes.

Similarly, most failure to yield crashes also occurred on two-lane roadways, 77.3% of stop sign crashes and 52.1% of crashes at traffic signals. A large number of failure to yield crashes at signals also occurred on three- and four-lane roadways. Crash statistics on the number of travel lanes are important for the design of the signal violation warning system since the system will need to track the vehicle's position within the roadway boundaries.

Table 14: Breakdown of Number of Travel Lanes for Fatal Single Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(39)	(68)	(121)	(29)
1 Lane		1.5%		
2 Lanes	48.7%	54.4%	90.9%	79.3%
3 Lanes	17.9%	17.6%	2.5%	
4 Lanes	23.1%	23.5%	4.1%	17.2%
6 Lanes	7.7%			
Unknown	2.6%	2.9%	2.5%	3.4%
Total	100%	100%	100%	100%
2000 FARS	(33)	(74)	(139)	(37)
1 Lane	3.0%			8.1%
2 Lanes	57.6%	50.0%	92.8%	75.7%
3 Lanes	6.1%	12.2%	1.4%	
4 Lanes	18.2%	31.1%	2.9%	5.4%
5 Lanes		2.7%		
6 Lanes	6.1%	2.7%		5.4%
7 or More Lanes	3.0%	1.4%	0.7%	
Unknown	6.1%		2.2%	5.4%
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Speed Limit

Table 15 shows the distribution of fatal single vehicle crashes by traffic control device, violation type, and posted speed limit based on the 1999 and 2000 FARS. The posted speed limit is coded on the accident level in the *Speed Limit* variable. Since the variable is coded on the accident level, only one posted speed limit is coded for each crash regardless of whether the intersecting roadways have different posted speeds. For the case of intersecting roadways with different speed limits, the speed limit for the roadway where the unstabilizing situation began was coded. The posted speed limit is coded in actual or statutory miles per hour except for the following cases (*4*):

Code 00: No Statutory Limit
Code 99: Unknown

Regardless of the type of violation, most (31.3%) fatal single vehicle crashes at traffic signals occurred at locations with a 35 mph posted speed limit. For fatal crashes at stop signs, 32.7% of the failure to obey crashes occurred at locations with a 55 mph speed limit and 39.4% of the

failure to yield crashes occurred at locations with a posted speed limit of 25 mph. The majority of failure to obey and failure to yield crashes at traffic signals occurred at locations with a speed limit of 35 mph or less. The majority of failure to yield crashes at stop signs also occurred at speed limits of 35 mph or less, conversely the majority of failure to obey crashes at stop signs occurred at locations with a speed limit of 40 mph or greater.

Table 15: Speed Limit Breakdown for Fatal Single Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(39)	(68)	(121)	(29)
15 mph			0.8%	
20 mph		1.5%	0.8%	
25 mph	12.8%	19.1%	11.6%	44.8%
30 mph	30.8%	23.5%	8.3%	10.3%
35 mph	25.6%	32.4%	9.1%	27.6%
40 mph	7.7%	8.8%	5.0%	
45 mph	10.3%	5.9%	9.9%	6.9%
50 mph	5.1%	2.9%	5.0%	
55 mph	7.7%	2.9%	38.0%	3.4%
60 mph			0.8%	
65 mph			5.8%	
70 mph			0.8%	
Unknown		2.9%	4.1%	6.9%
Total	100%	100%	100%	100%
2000 FARS	(33)	(74)	(139)	(37)
20 mph			0.7%	
25 mph	21.2%	16.2%	15.8%	35.1%
30 mph	18.2%	24.3%	10.8%	21.6%
35 mph	30.3%	33.8%	12.9%	18.9%
40 mph	9.1%	10.8%	6.5%	5.4%
45 mph	9.1%	8.1%	10.1%	5.4%
50 mph	9.1%		5.0%	
55 mph		2.7%	28.1%	8.1%
60 mph			2.2%	
65 mph		1.4%	5.0%	
70 mph			0.7%	
Unknown	3.0%	2.7%	2.2%	5.4%
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

3.5 Summary of Single Light Vehicle Crashes

Major observations were as follows:

- Pedestrian crashes accounted for 63.9% and 95.1% of the single vehicle fatal crashes in which a light vehicle respectively failed to obey and failed to yield at traffic signals.
- Pedestrian crashes accounted for 75.8% of the single vehicle fatal crashes that involved a light vehicle failing to yie ld at stop signs.
- Vehicles were traveling straight in 91.3% of the pedestrian crashes at traffic signals in which the driver failed to obey the signal.
- Vehicles were turning left in 43.7%, going straight in 40.0%, and turning right in 13.3% of the pedestrian crashes at traffic signals in which the driver failed to yield the right-of-way.
- The driver field to yield the right-of-way at stop sign crashes while traveling straight in 64%, turning left in 24%, and turning right in 10% of the crashes.
- Speeding was the dominant factor in 33.3% of all single light vehicle fatal crashes in which the driver violated the traffic signal/stop sign. Inattention ranked second with 13.9% of all crashes.
- Hit and run crashes were reported in 39.1% of all pedestrian crashes in which the driver failed to obey the traffic signal.
- Vision obscured was cited in 18.0% of all pedestrian crashes in which the driver failed to yield at stop signs.
- Inattention was a contributing factor in 17.0% of all pedestrian crashes in which the driver failed to yield at traffic signals.
- Improper crossing was the dominant pedestrian factor in 7.9% of all pedestrian crashes. Followed by walking against traffic in 5.4% of these crashes.
- Alcohol was involved in 37.1% of all single vehicle fatal crashes involving a light vehicle violating a traffic signal or stop sign.
- Fifty-six percent of the failure to obey violations involved alcohol: 31.9% at traffic signals and 62.3% at stop signs.
- At traffic signals, 90.7% of the fatal single vehicle crashes occurred in urban areas. In contrast, 57.1% occurred in rural areas at stop signs.
- About 86.4% of the crashes in which the driver failed to yield at the stop sign occurred at urban locations, while 68.5% of the crashes in which the driver failed to obey the stop sign happened in rural areas.
- The “urban principal arterial” accounted for 44.4% and 46.5% of the crashes in which the driver respectively failed to obey the signal and failed to yield the right-of-way. “ Rural local road/street” was the most common roadway at 23.1% of the crashes in which the driver failed to obey the stop sign. Conversely, the “urban local road/street” had 33.3% of the crashes in which the driver failed to yield at the stop sign.
- The majority of the failure to obey crashes occurred on two-lane roadways, 91.9% of stop sign crashes and 52.8% of traffic signal crashes. Failure to yield crashes also occurred on two-lane roadways, 77.3% of stop sign crashes and 52.1% of crashes at traffic signals.
- The majority of failure to obey and failure to yield crashes at traffic signals occurred at locations with a speed limit of 35 mph or less. The majority of failure to yield crashes at stop signs also occurred at speed limits of 35 mph or less, conversely the majority of failure to obey crashes at stop signs occurred at locations with a speed limit of 40 mph or greater.

4.0 Two-Vehicle Crashes

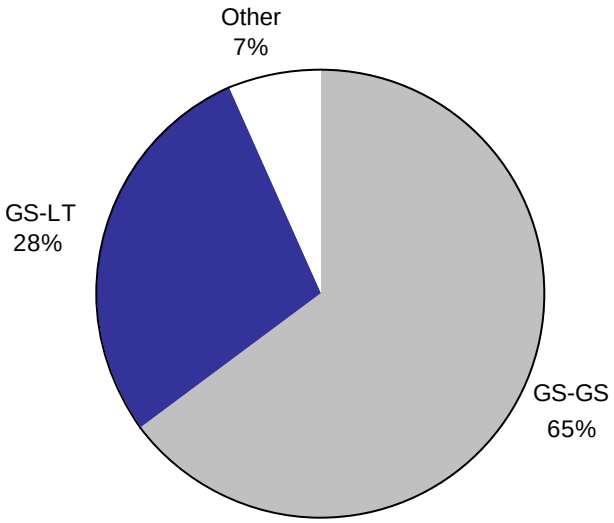
This section identifies the two-vehicle fatal crash types that the violating light vehicle was involved in, as well as the maneuvers that the vehicles were conducting prior to the critical event of the crash. The crossing path crash type was selected as the focus of this section since it is the most dominant crash at intersections. In addition, this section statistically describes the contributing factors and infrastructure characteristics associated with these two-vehicle fatal crashes.

4.1 Two-Vehicle Crash Types

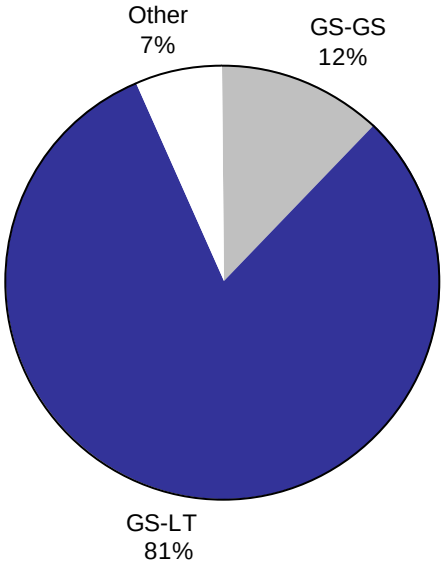
Two-vehicle crash types were categorized by the combinations of each vehicle maneuver prior to the critical event of the crash. The following element values from the *Vehicle Maneuver* variable were used (*4*):

Code 01: Going Straight
Code 02: Slowing or Stopping in Traffic Lane
Code 03: Starting in Traffic Lane
Code 04: Stopped in Traffic Lane
Code 05: Passing or Overtaking Another Vehicle
Code 06: Leaving a Parked Position
Code 07: Parked
Code 08: Entering a Parked Position
Code 09: Maneuvering to Avoid
Code 10: Turning Right: Right Turn on Red Permitted
Code 11: Turning Right: Right Turn on Red Not Permitted
Code 12: Turning Right: Right Turn on Red Not Applicable or Not Known if Permitted
Code 13: Turning Left
Code 14: Making a U-Turn
Code 15: Baking Up
Code 16: Changing Lances or Merging
Code 17: Negotiating a Curve
Code 98: Other
Code 99: Unknown

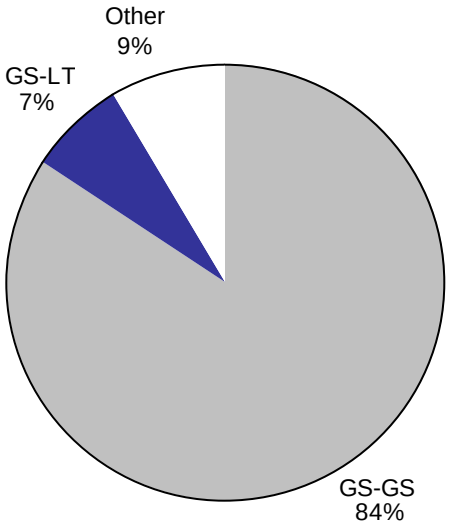
Appendix C provides the matrices of pre-crash maneuvers that were conducted by each of the two vehicles involved in traffic signal and stop sign crashes in 1999 and 2000. Three major scenarios emerged from fatal crashes in which the driver failed to obey or yield at the traffic signal, and from crashes in which the driver failed to obey the stop sign: going straight-going straight (GS-GS), going straight-left turn (GS-LT), and other. The "other" scenario includes combinations of maneuvers such as going straight and slowing in traffic lane, starting in traffic lane, stopped in traffic lane, maneuvering to avoid an obstacle, turning right, making U-turn, changing lanes, or other maneuver. On the other hand, four most common scenarios were identified from fatal crashes in which the driver failed to yield the right-of-way at stop signs: going straight-going straight, going straight- left turn, going straight-starting in traffic lane (GS-ST), and other. Figures 26 and 27 provide the relative frequencies of the crash scenarios by year and type of violation.



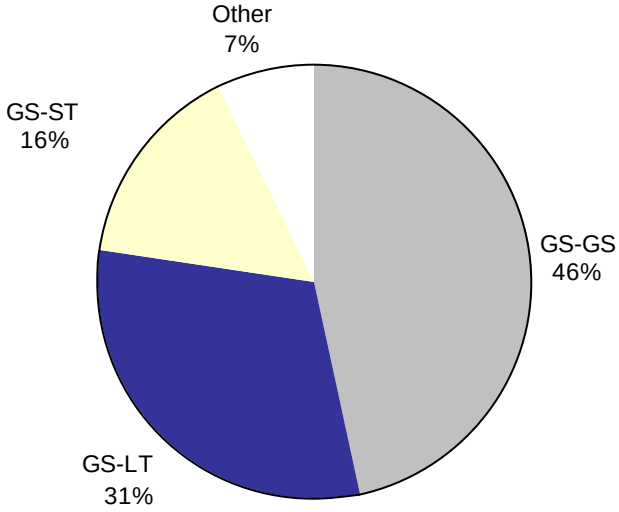
A: 1999 Traffic Signal Fail to Obey (632).



B: 1999 Traffic Signal Fail to Yield (438).



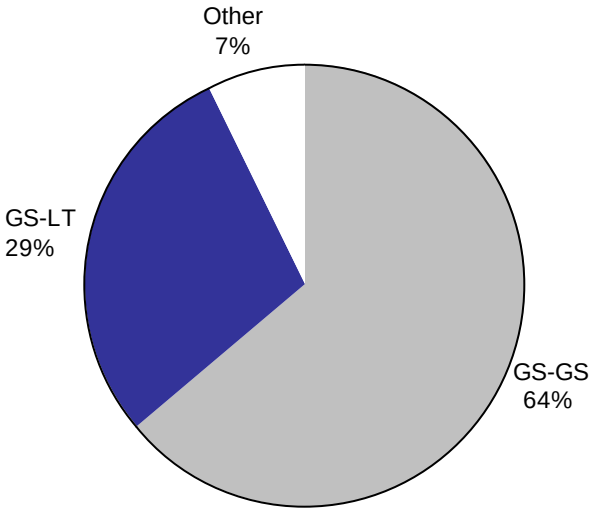
C: 1999 Stop Sign Fail to Obey (1143).



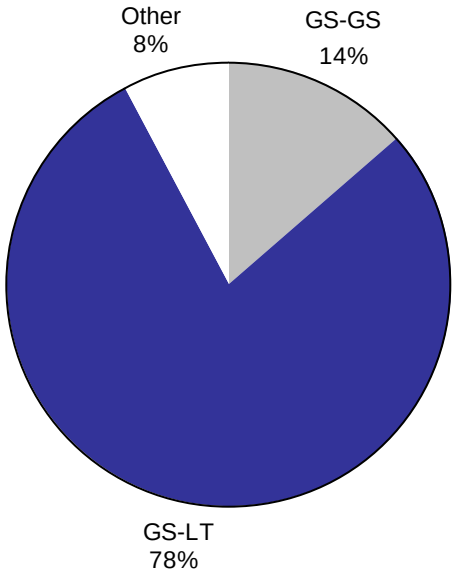
D: 1999 Stop Sign Fail to Yield (1393).

GS = Going Straight ST = Starting in Traffic Lane LT = Left Turn

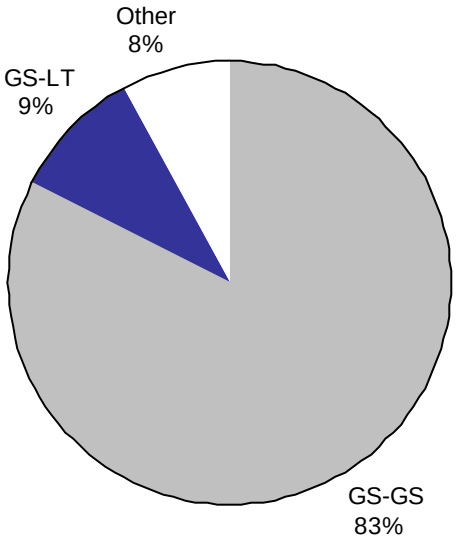
Figure 26: 1999 Fatal Two-Vehicle Crash Scenarios.



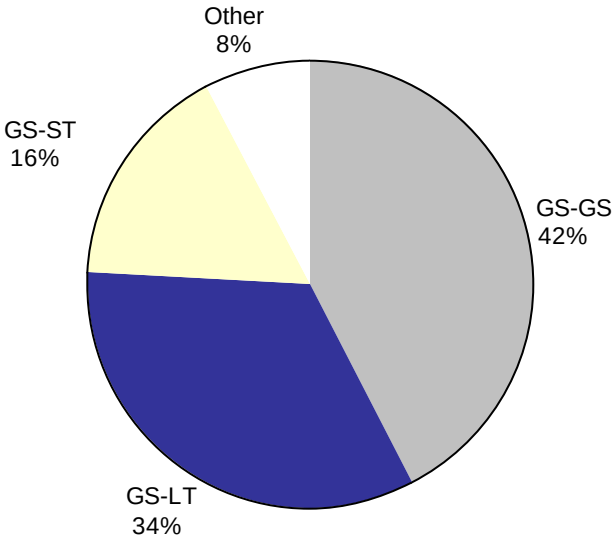
A: 2000 Traffic Signal Fail to Obey (670).



B: 2000 Traffic Signal Fail to Yield (393).



C: 2000 Stop Sign Fail to Obey (1074).



D: 2000 Stop Sign Fail to Yield (1265).

GS = Going Straight ST = Starting in Traffic Lane LT = Left Turn

Figure 27: 2000 Fatal Two-Vehicle Crash Scenarios.

Table 16: Frequency of Two-Vehicle Fatal Crash Scenarios.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS				
Going Straight-Going Straight	409	53	961	649
Going Straight-Turning Left	180	356	84	426
Going Straight-Starting in Traffic Lane				218
Other	43	29	98	100
2000 FARS				
Going Straight-Going Straight	428	54	885	536
Going Straight-Turning Left	194	308	101	424
Going Straight-Starting in Traffic Lane				208
Other	48	31	88	97

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.

Table 16 provides the total number of crashes for each scenario. The GS-GS, GS-LT, and GS-ST scenarios accounted for 92.4% of all two-vehicle fatal crashes. The relative frequencies of the GS-GS and GS-LT scenarios were respectively 64.3% and 28.7% of all failure to obey traffic signal crashes in 1999 and 2000 (GS-GS scenario 2.24 × higher than GS-LT). Conversely, the relative frequencies of the GS-GS and GS-LT scenarios were respectively 12.9% and 79.9% of all failure to yield crashes at traffic signals (GS-LT scenario 6.21 × higher than GS-GS). On the other hand, the relative frequencies of the GS-GS and GS-LT scenarios were respectively 83.3% and 8.3% of all failure to obey stop sign crashes in 1999 and 2000 (GS-GS scenario 9.98 × higher than GS-LT). The GS-GS, GS-LT, and GS-ST scenarios respectively comprised 44.6%, 32.0%, and 16.0% of all failure to yield crashes at stop signs.

4.2 Crossing Path Crash Types

The analysis of two-vehicle crashes focused on crossing path crashes that are generally the most frequent at intersections. Prior research has determined six dominant pre-crash scenarios for crossing path crashes (*7*):

1. Left Turn Across Path – Opposite Direction (LTAP/OD)
2. Left Turn Across Path – Lateral Direction (LTAP/LD)
3. Left Turn Into Path – Merge (LTIP)
4. Right Turn Into Path – Merge (RTIP)
5. Straight Crossing Paths (SCP)
6. Right Turn Across Path – Lateral Direction (RTAP/LD)

Graphical representations of the crossing path crash scenarios are provided below in Figure 28. For all cases except for the SCP crashes, one of the vehicles is traveling straight and the other vehicle is turning. In the case of the SCP crashes, both vehicles are traveling straight. Additionally, Figure 28 depicts a four-way perpendicular intersection, this is not always the case; crashes in the database include three-way, greater than four-way, and skewed angle intersections

and junctions. For this analysis, the only restriction on the crossing area was that it was controlled by a stop sign or traffic signal. All crossings were examined regardless if they were an intersection or junction.

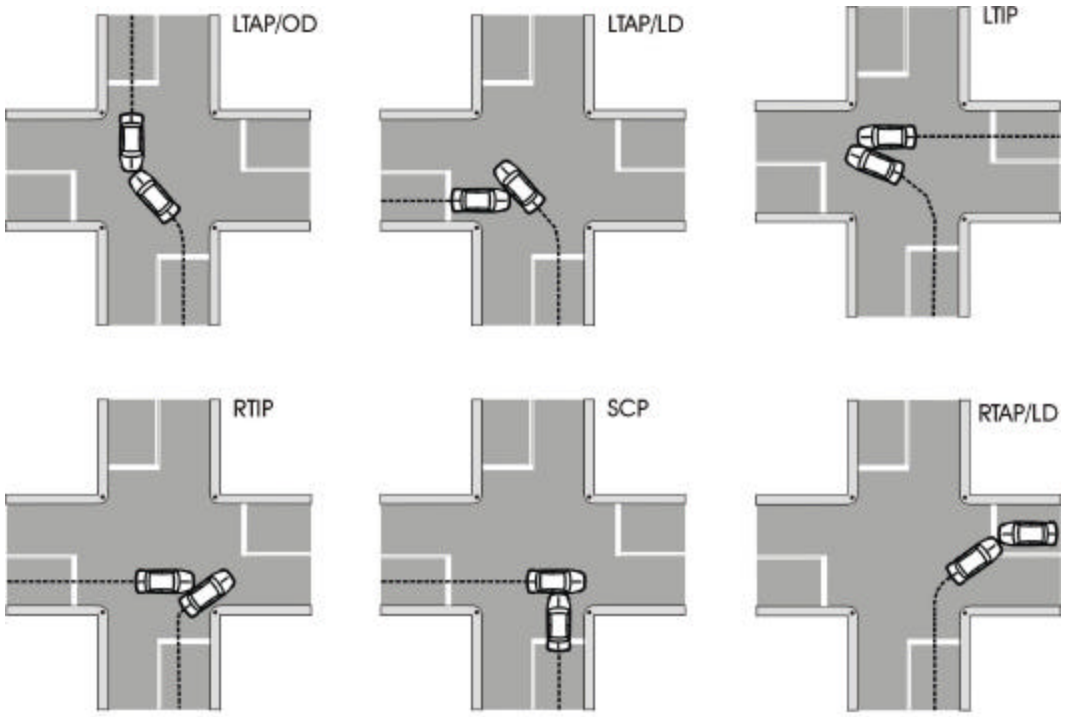


Figure 28: Schematics of Common Crossing Path Crash Scenarios (*7*).

In prior research, the *Accident Type* variable from the "Vehicle/Driver File" within the GES crash database was used to define crossing path crash types (*7*). For the FARS, however, the *Accident Type* or a similar variable does not exist. Crossing path crash scenarios were identified using the FARS *Vehicle Maneuver* variable. It should be noted that without a variable similar to *Accident Type*, the LTAP/OD, LTAP/LD, and LTIP crossing paths were unable to be segregated past the category: Left Turn Crossing Path (LTCP). Similarity, RTIP and RTAP/LD were unable to be segregated past the category: Right Turn Crossing Path (RTCP). Table 17 defines the crossing path crash scenarios in FARS using the vehicle maneuver and the manner of collision.

Table 17: Definition of Crossing Path Crashes by *Vehicle Maneuver*.

Scenario	**Maneuver Coding**	**Vehicle Maneuver**	
		Vehicle 1	**Vehicle 2**
Straight Crossing Paths (SCP)	GS-GS	Going Straight	Going Straight
Left Turn Crossing Path (LTCP)	GS-LT	Going Straight	Turning Left
Straight/Starting	GS-ST	Going Straight	Starting in Traffic Lane
Other	Other	*All Remaining Codes*	*All Remaining Codes*

The two-vehicle scenarios based on the vehicle maneuver were further examined using the *Manner of Collision* variable. The *Manner of Collision* variable is located in the "Accident File" and is based entirely on the directions of travel of the vehicles involved. The following element values for the *Manner of Collision* variable was used (*4*):

Code 0: Not Collision with Motor Vehicle in Transport
Code 1: Rear-End
Code 2: Head-On
Code 3: Rear-to-Rear
Code 4: Angle
Code 5: Sideswipe, Same Direction
Code 6: Sideswipe, Opposite Direction
Code 9: Unknown

Tables 18 and 19 provide the breakdown of the crash scenarios by the *Manner of Collision* variable at traffic signals and stop signs, respectively. Crashes coded as “not collision with motor vehicle in transport” and “rear-end” were excluded from further analysis. Collisions with motor vehicles not in transport were excluded to ensure the collision occurred with a vehicle on the trafficway and not a parked vehicle. Furthermore, rear-end collisions were excluded to make sure that the vehicles in the scenarios were not from the same approach/lane. About 93.9% of all two-vehicle traffic signal fatal crashes and 97.9% of all two-vehicle stop sign fatal crashes were angle crashes. Angle crashes were dominant at 96.4% and 89.9% respectively of all the failure to obey and failure to yield crashes at traffic signals. The failure to yield crashes at traffic signals had slightly less angle crashes than the failure to obey crashes, and more head-on crashes due perhaps to higher frequency of LTAP/OD scenario crashes. In contrast, stop sign crashes had equal number of angle crashes at 98% in failure to obey and failure to yield crashes.

Table 18: Breakdown of Manner of Collision by Crash Scenario for Fatal Two-Vehicle Crashes at Traffic Signals.

	Fail to Obey			Fail to Yield		
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Other**
1999 FARS	(409)	(180)	(43)	(53)	(356)	(29)
Not Collision with Motor Vehicle in Transport			2.3%	5.7%		
Rear-End		1.7%	4.7%	1.9%	0.3%	13.8%
Head-On	0.2%	5.6%	2.3%	1.9%	8.4%	
Angle	99.8%	92.8%	90.7%	90.6%	90.2%	82.8%
Unknown					1.1%	3.4%
Total	100%	100%	100%	100%	100%	100%
2000 FARS	(428)	(194)	(48)	(54)	(308)	(31)
Not Collision with Motor Vehicle in Transport	0.5%				0.3%	
Rear-End	0.5%		14.6%	3.7%		12.9%
Head-On	0.9%	4.6%	2.1%	7.4%	8.1%	3.2%
Rear-to-Rear	0.2%					
Angle	97.7%	95.4%	79.2%	88.9%	91.2%	80.6%
Sideswipe, Same Direction			4.2%			3.2%
Unknown	0.2%				0.3%	
Total	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 19: Breakdown of Manner of Collision by Crash Scenario for Fatal Two-Vehicle Crashes at Stop Signs.

	Fail to Obey			Fail to Yield			
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Straight/ Starting**	**Other**
1999 FARS	(961)	(84)	(98)	(649)	(426)	(218)	(100)
Not Collision with Motor Vehicle in Transport					0.5%	0.5%	2.0%
Rear-End	0.1%			0.2%			
Head-On	0.8%	4.8%	3.1%	0.5%	3.1%		4.0%
Rear-to-Rear			1.0%				
Angle	99.1%	95.2%	95.9%	98.9%	96.5%	99.5%	93.0%
Sideswipe, Same Direction				0.2%			
Sideswipe, Opposite Direction				0.3%			1.0%
Total	100%	100%	100%	100%	100%	100%	100%
2000 FARS	(885)	(101)	(88)	(536)	(424)	(208)	(97)
Not Collision with Motor Vehicle in Transport		1.0%	2.3%	0.4%	1.2%		1.0%
Rear-End		1.0%	2.3%				1.0%
Head-On	1.6%	5.9%	3.4%	0.2%	1.7%	0.5%	2.1%
Rear-to-Rear							
Angle	98.2%	92.1%	92.0%	99.4%	96.9%	99.0%	94.8%
Sideswipe, Same Direction	0.1%						
Unknown	0.1%				0.2%	0.5%	1.0%
Total	100%	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

The number of violating light vehicles in two-vehicle fatal crossing path crashes amounted to 2,148 and 4,887 vehicles respectively at traffic signals and stop signs in 1999 and 2000. At traffic signals, 61.5% of vehicles failed to obey the signal as opposed to 38.5% of vehicles that failed to yield the right-of-way. The number of violating light vehicles was 103 and 101 per 100 two-vehicle traffic signal crashes in which the driver failed to obey and failed to yield, respectively. On the other hand, 45.7% and 54.3% of vehicles respectively failed to obey the sign and failed to yield the right-of-way at stop signs. The number of violating light vehicles was 101 and 100 per 100 two-vehicle stop sign crashes in which the driver failed to obey and failed to yield, respectively. Figure 29 shows the distribution of violating light vehicles per scenario and vehicle maneuver at traffic signals and stop signs in both failure to obey and failure to yield crashes, in 1999 and 2000. The number of violating vehicles that were turning left was higher than the number of violating vehicles that were going straight in LTCP crashes with failure to yield at traffic signals, failure to obey the stop sign, and failure to yield at stop signs with respective ratios of 3.25, 2.60, and 3.14. Conversely, the number of violating vehicles that were going straight was 1.38 times higher than the number of violating vehicles that were turning left in LTCP crashes

with failure to obey at traffic signals. Finally, the number of violating vehicles that were starting in traffic was 2.98 times higher than the vehicles that were going straight in the going straight-starting scenario of the failure to yield crashes at stop signs.

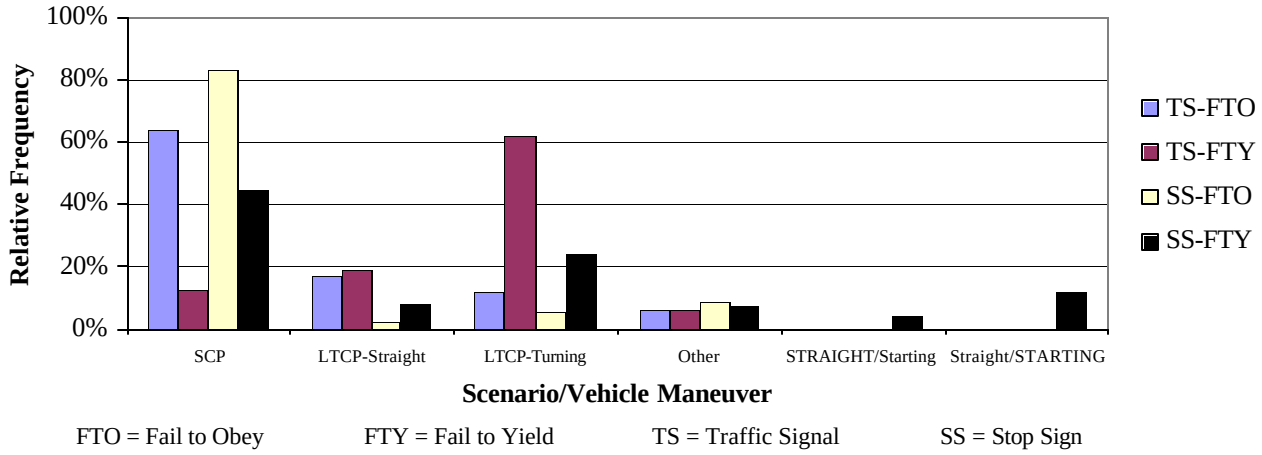


Figure 29: Distribution of Violating Light Vehicles per Scenario and Vehicle Maneuver.

4.3 Crash Contributing Factors

Figure 30 presents the distribution of driver-related factors reported in all two-vehicle violation crashes at traffic signals and stop signs in 1999 and 2000 FARS. Figures 31-34 provide detailed distributions of driver-related factors by failure to obey and failure to yield violations at stop signs and traffic signals, separated by crash scenario and vehicle maneuver. Four most common factors dominated in 1999 and 2000 FARS: inattention, reckless driving, speeding, and vision obscured.

Inattention or distraction was reported for about 11.0% of all violating light vehicles in two-vehicle fatal crossing path crashes. Specifically, this factor was associated with:

- 10.0% of light vehicle drivers who failed to obey the traffic signal, mostly in SCP crashes.
- 8.9% of light vehicle drivers who failed to yield the right-of-way at traffic signals, mostly by left-turning vehicles in LTCP crashes.
- 11.6% of light vehicle drivers who failed to obey the stop sign, mostly in SCP crashes.
- 11.5% of light vehicle drivers who failed to yield the right-of-way at stop signs, mostly in SCP crashes.

Operating vehicle in erratic or reckless manner was cited to about 3.8% of all violating light vehicles in two-vehicle fatal crossing path crashes. Specifically, reckless driving was linked to:

- 5.2% of light vehicle drivers who failed to obey the traffic signal.
- 2.8% of light vehicle drivers who failed to yield at traffic signals.
- 4.7% of light vehicle drivers who failed to obey the stop sign.
- 2.6% of light vehicle drivers who failed to yield at stop signs.

Speeding or racing, including police chase, was related to 6.4% of all violating light vehicles in two-vehicle fatal crossing path crashes. Specifically, speeding was mostly dominant in the SCP crash scenario and was cited to:

- 15.1% of light vehicle drivers who failed to obey the traffic signal.
- 2.1% of light vehicle drivers who failed to yield at traffic signals.
- 9.3% of light vehicle drivers who failed to obey the stop sign.
- 1.0% of light vehicle drivers who failed to yield at stop signs.

As indicated above, speeding was mostly associated with failure to obey violations at traffic signals or stop signs. Vision obscured was reported in 3.0% of all violating light vehicles in two-vehicle fatal crossing path crashes:

- 1.4% of light vehicle drivers who failed to obey the traffic signal.
- 2.1% of light vehicle drivers who failed to yield at traffic signals.
- 2.5% of light vehicle drivers who failed to obey the stop sign.
- 4.5% of light vehicle drivers who failed to yield at stop signs.

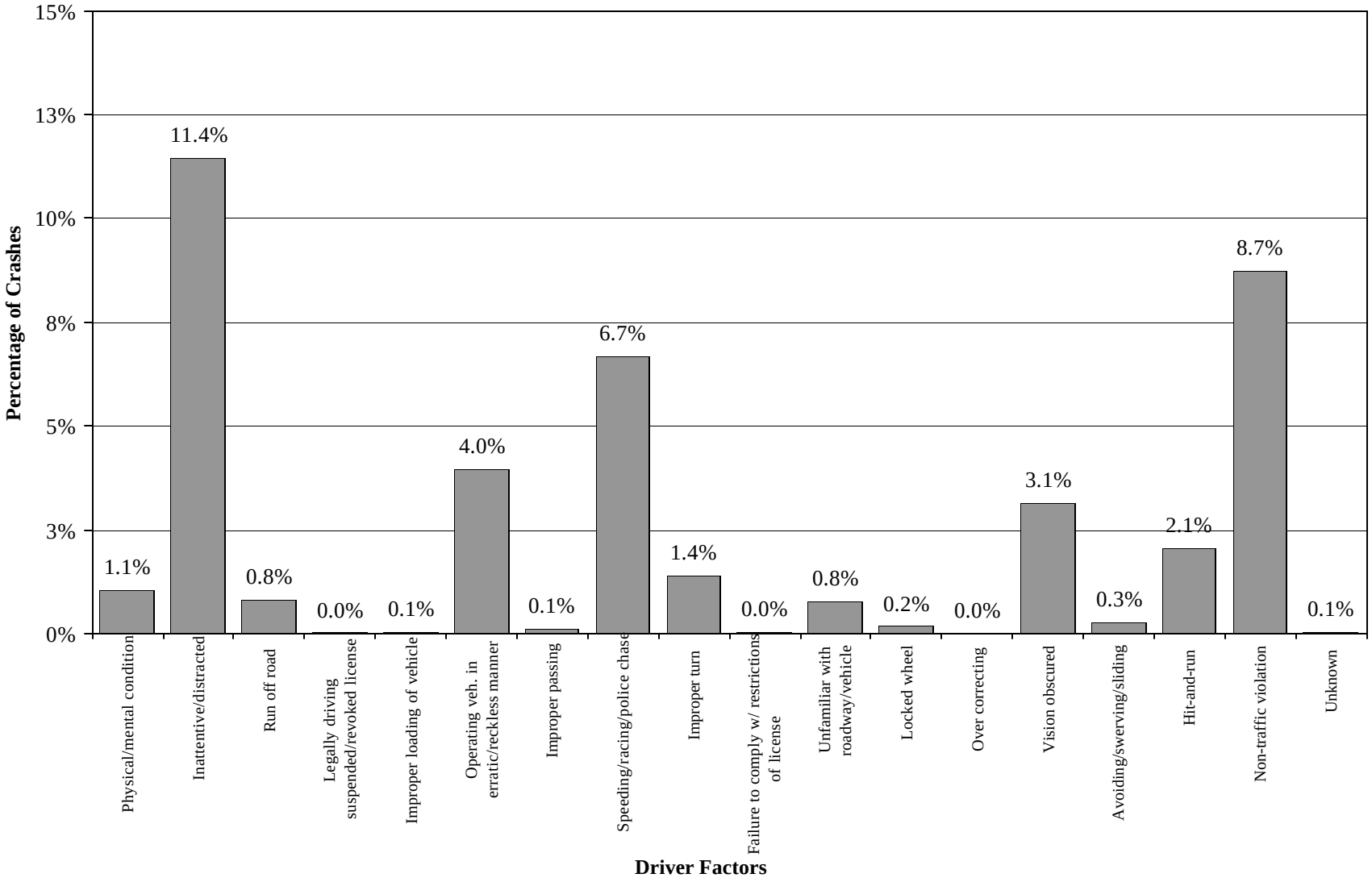


Figure 30: Breakdown of Driver Related Factors for All Fatal Two-Vehicle Crashes Involving at Least One Light Vehicle that Violated the Traffic Signal or Stop Sign.

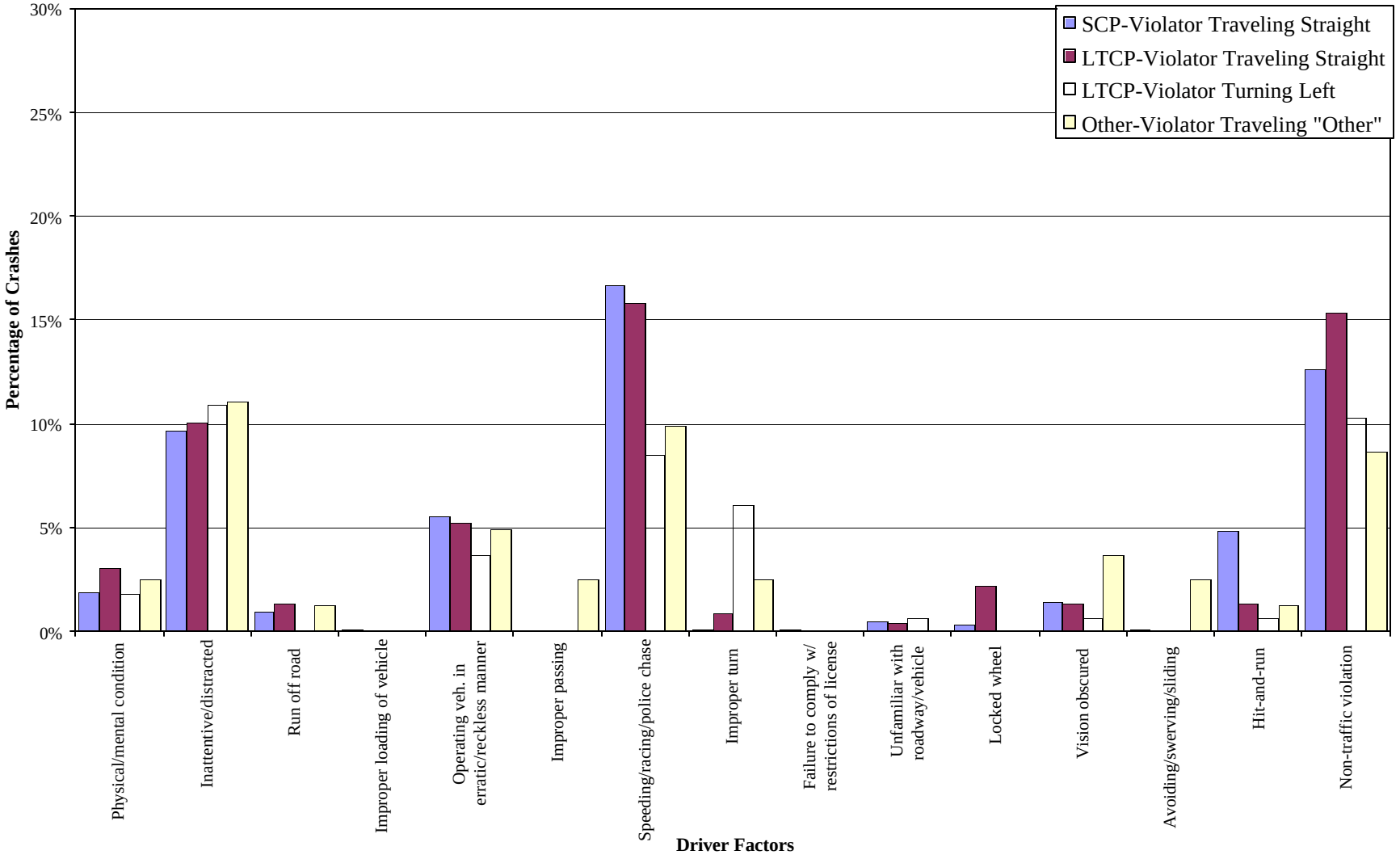


Figure 31: Breakdown of Driver Related Factors for Fatal Two-Vehicle Crashes at Traffic Signals in which the Driver Failed to Obey.

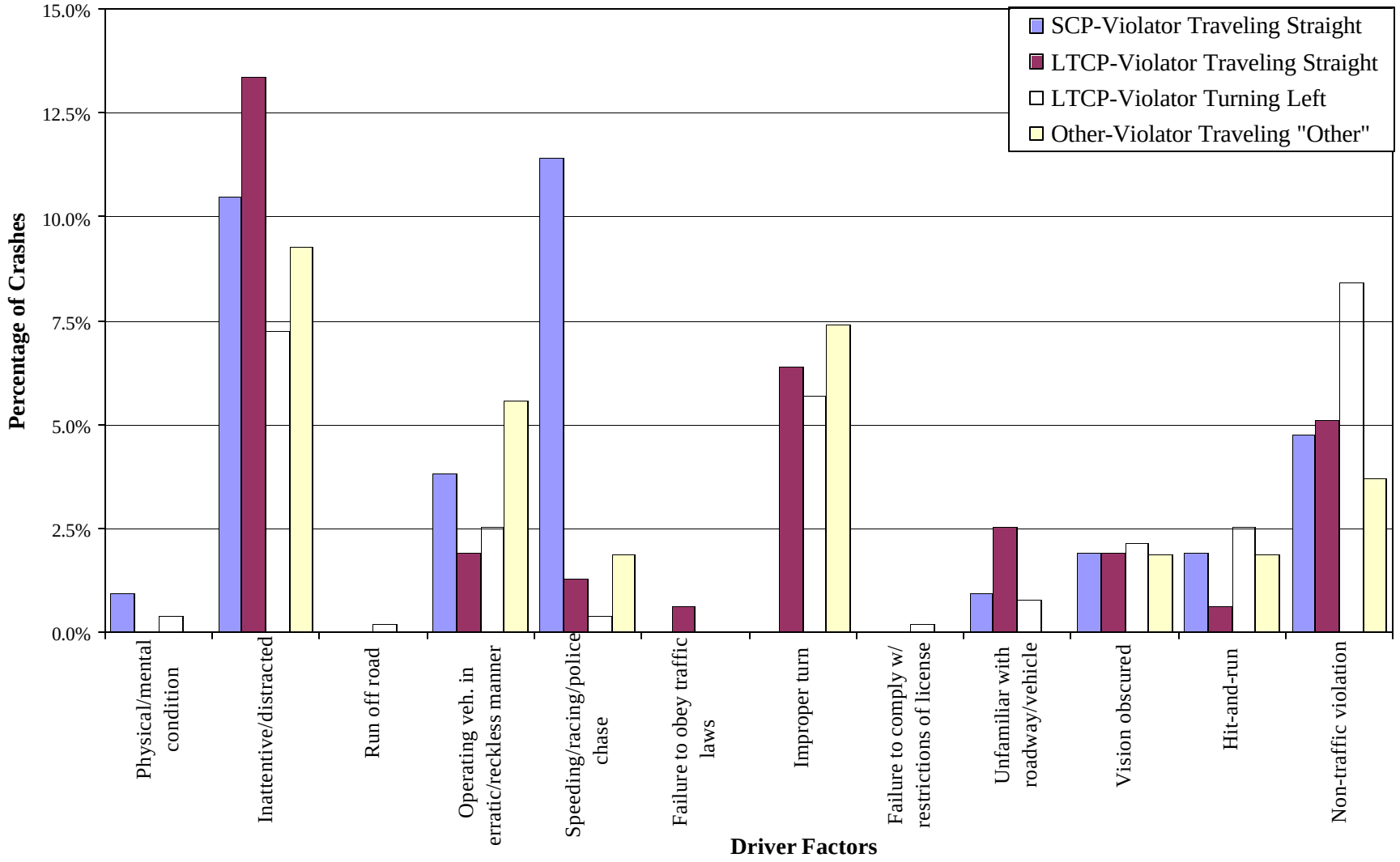


Figure 32: Breakdown of Driver Related Factors for Fatal Two-Vehicle Crashes at Traffic Signals in which the Driver Failed to Yield.

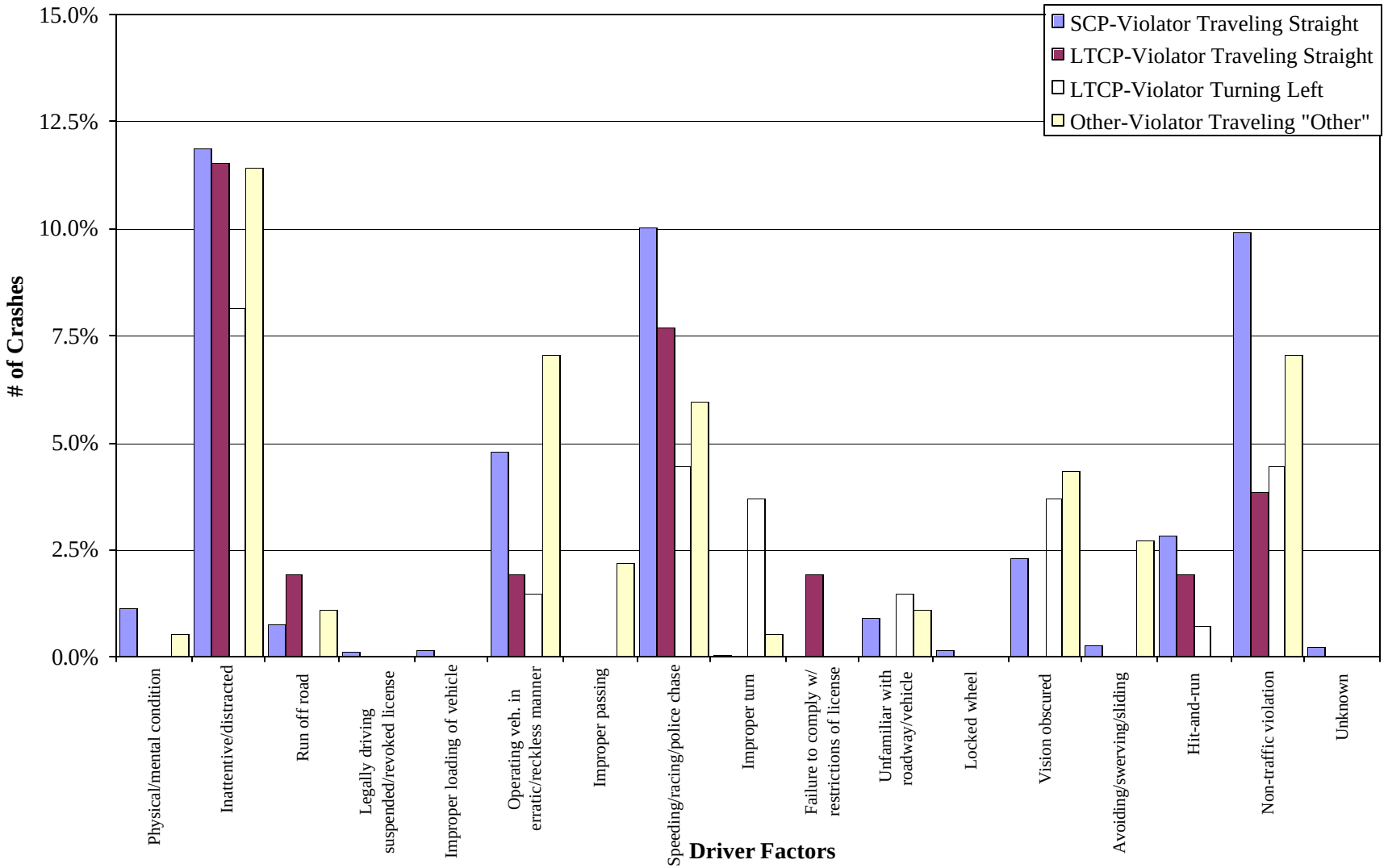


Figure 33: Breakdown of Driver Related Factors for Fatal Two-Vehicle Crashes at Stop Signs in which the Driver Failed to Obey.

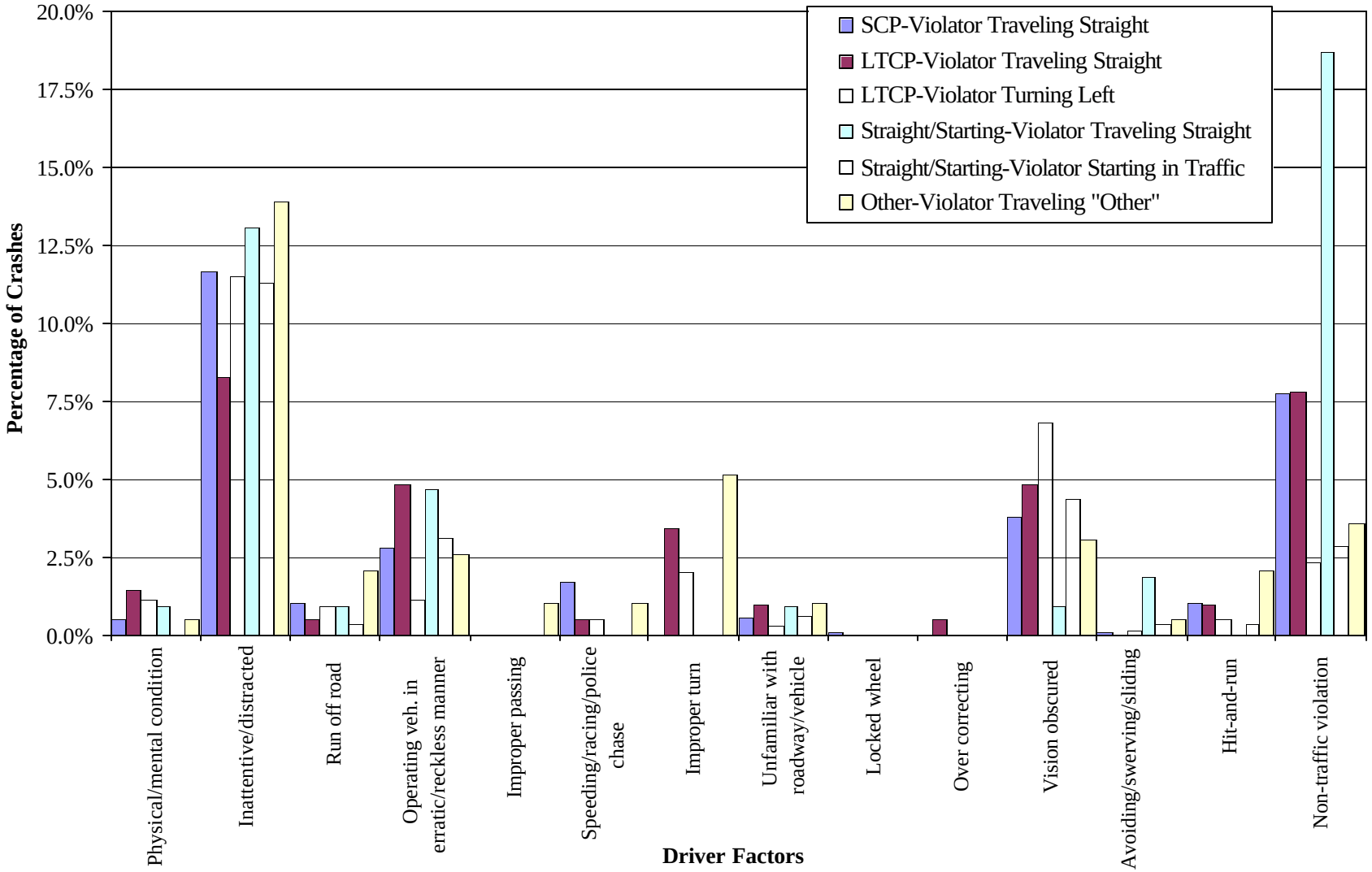


Figure 34: Breakdown of Driver Related Factors for Fatal Two-Vehicle Crashes at Stop Signs in which the Driver Failed to Yield.

4.4 Alcohol Involvement

Table 20 lists the statistics of alcohol involvement for violating light vehicle drivers by violation type, traffic control device, crash scenario, and vehicle maneuver separately in 1999 and 2000. Overall, alcohol was linked to 14.0% of all violating light vehicles in two-vehicle fatal crossing path crashes. Thus, the relative frequency of this factor exceeded inattention as the most dominant contributing factor in these crashes. Specifically, the percentages of violating light vehicle drivers who were charged with alcohol involvement were broken down as follows:

- 20.7% of drivers in failure to obey crashes at traffic signals.
- 11.5% of drivers in failure to yield crashes at traffic signals.
- 17.8% of drivers in failure to obey crashes at stop signs.
- 8.3% of drivers in failure to yield crashes at stop signs.

Clearly, alcohol involvement was more prevalent in failure to obey than in failure to yield crashes.

Table 20: Breakdown of Police Reported Alcohol Involvement in Fatal Two-Vehicle Crashes.

	SCP	LTCP (Traveling Straight)	LTCP (Turning Left)	Straight/ Starting (Straight)	Straight/ Starting (Starting)	Other
1999 FARS						
Fail to Obey Traffic Signal	20.6% (418)	19.5% (113)	12.2% (74)			15.0% (40)
Fail to Yield Traffic Signal	19.6% (51)	8.6% (81)	11.9% (277)			0.0% (25)
Fail to Obey Stop Sign	19.0% (965)	28.6% (21)	15.4% (65)			5.1% (99)
Fail to Yield Stop Sign	8.6% (649)	6.0% (100)	8.3% (327)	7.5% (53)	7.3% (164)	8.2% (98)
2000 FARS						
Fail to Obey Traffic Signal	24.7% (429)	20.0% (115)	15.4% (91)			17.1% (41)
Fail to Yield Traffic Signal	18.5% (54)	13.2% (76)	8.5% (234)			17.2% (29)
Fail to Obey Stop Sign	19.1% (897)	9.7% (31)	7.1% (70)			16.5% (85)
Fail to Yield Stop Sign	11.6% (536)	5.7% (105)	8.5% (317)	3.7% (54)	3.2% (155)	6.3% (96)

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Parentheses refer to actual crash counts.

4.5 Infrastructure Characteristics

The majority of two-vehicle fatal crossing path crashes at traffic signals happened on urban roadways, accounting for 77.9% of these crashes. In contrast, the majority of two-vehicle fatal crossing path crashes at stop signs occurred on rural roadways, accounting for 63.9% of these crashes. About 69.1% and 59.6% of stop sign crashes in which the driver failed to obey and failed to yield, respectively, happened on rural roadways. The number of urban roadway crashes at traffic signals was equally distributed at about 78% for failure to obey and failure to yield violations. The SCP crash scenario in failure to yield crashes at traffic signals was relatively more frequent on rural roadways than the LTCP scenario. Conversely, these two crash scenarios had equivalent rates on rural roadways in failure to obey at traffic signals. On the other hand, the LTCP crash scenario in failure to obey and failure to yield crashes at stop signs was relatively more frequent on urban roadways than the SCP scenario.

Roadway Functional Class

Tables 21 and 22 provide the distributions of two-vehicle fatal crossing path crashes by roadway class in 1999 and 2000 for traffic signals and stop signs, respectively. The urban principal arterial was the most reported roadway in traffic signal crashes among other roadway functional classes, accounting for 41.2% of these crashes. About 39.3% and 44.3% of traffic signal crashes in which the driver failed to obey and failed to yield, respectively, happened on the urban principal arterial. Approximately 48.2% of the LTCP crashes in which the driver failed to obey the traffic signal occurred on this roadway class as compared to 36.6% of the SCP crashes. Similarly, this roadway class was also reported in 46.4% of the LTCP crashes and 32.7% of the SCP crashes in which the driver failed to yield at traffic signals. On the other hand, the rural major collector was the most reported roadway class at 21.9% of the failure to obey crashes at stop signs in 1999 and 2000. This roadway class was also the most prevalent in SCP and LTCP scenarios of these crashes. The failure to yield crashes at stop signs were mostly reported on rural principal arterial-other with 19.9% of these crashes. This roadway class was most prevalent in SCP and straight-starting crash scenarios with 22.4% and 20.5% of their respective failure to yield crashes at stop signs. In contrast, the urban principal arterial ranked first at 18.4% of the LTCP crashes with failure to yield at stop signs, followed by the rural principal arterial-other with 16.5% of these crashes.

Table 21: Breakdown of Roadway Classification for Fatal Two-Vehicle Crashes at Traffic Signals.

	Fail to Obey			Fail to Yield		
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Other**
1999 FARS	(409)	(177)	(40)	(49)	(355)	(25)
Rural Principal Arterial-Interstate	0.2%				0.3%	
Rural Principal Arterial-Other	7.3%	4.5%	27.5%	8.2%	5.6%	12.0%
Rural Minor Arterial	3.4%	4.0%	2.5%	6.1%	3.9%	20.0%
Rural Major Collector	2.7%	4.0%	5.0%		2.3%	4.0%
Rural Minor Collector	0.7%	0.6%			0.6%	
Rural Local Road/Street	3.2%	5.6%	2.5%	8.2%	4.2%	
Rural Unknown	0.5%				0.8%	
Urban Principal Arterial-Interstate	1.2%	1.1%			0.8%	
Urban Principal Arterial-Other Freeway	4.6%	4.5%	2.5%		2.5%	
Urban Principal Arterial	40.3%	48.0%	27.5%	44.9%	48.7%	24.0%
Urban Minor Collector	18.8%	16.4%	15.0%	18.4%	20.6%	20.0%
Urban Collector	5.4%	4.0%	2.5%	4.1%	2.8%	8.0%
Urban Local Road/Street	11.0%	7.3%	15.0%	10.2%	6.5%	12.0%
Unknown	0.5%				0.3%	
Total	100%	100%	100%	100%	100%	100%
2000 FARS	(424)	(194)	(41)	(52)	(307)	(27)
Rural Principal Arterial-Interstate	0.9%					
Rural Principal Arterial-Other	5.4%	6.7%	9.8%	7.7%	7.2%	3.7%
Rural Minor Arterial	4.0%	4.1%		5.8%	3.6%	3.7%
Rural Major Collector	3.5%	1.5%	7.3%	3.8%	2.6%	7.4%
Rural Minor Collector	0.7%	0.5%	2.4%	1.9%	1.0%	
Rural Local Road/Street	2.8%	2.6%	4.9%	17.3%	2.0%	3.7%
Rural Unknown	2.1%	1.0%		3.8%	1.6%	3.7%
Urban Principal Arterial-Interstate	1.7%	3.1%			1.3%	
Urban Principal Arterial-Other Freeway	3.8%	5.7%	7.3%	3.8%	2.6%	
Urban Principal Arterial	33.0%	48.5%	24.4%	21.2%	43.6%	55.6%
Urban Minor Collector	17.9%	10.3%	19.5%	13.5%	20.5%	18.5%
Urban Collector	3.8%			3.8%	2.0%	
Urban Local Road/Street	13.4%	10.3%	14.6%	11.5%	8.5%	3.7%
Urban Unknown	1.4%	2.1%			0.3%	
Unknown	5.4%	3.6%	9.8%	5.8%	3.3%	
Total	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 22: Breakdown of Roadway Classification for Fatal Two-Vehicle Crashes at Stop Signs.

	Fail to Obey			Fail to Yield			
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Straight/ Starting**	**Other**
1999 FARS	(960)	(84)	(98)	(648)	(424)	(217)	(98)
Rural Principal Arterial-Interstate		1.2%	1.0%	0.9%	0.2%	0.9%	
Rural Principal Arterial-Other	15.4%	15.5%	20.4%	22.7%	15.8%	19.4%	20.4%
Rural Minor Arterial	11.4%	7.1%	13.3%	11.7%	11.8%	17.1%	13.3%
Rural Major Collector	23.1%	21.4%	17.3%	17.3%	15.1%	14.7%	15.3%
Rural Minor Collector	7.3%	7.1%	11.2%	4.6%	1.7%	4.1%	5.1%
Rural Local Road/Street	13.2%	7.1%	6.1%	9.0%	5.9%	9.2%	9.2%
Rural Unknown	0.9%	1.2%		1.4%	0.7%	0.5%	
Urban Principal Arterial-Interstate	0.4%			0.8%	0.5%		
Urban Principal Arterial-Other Freeway	0.7%		2.0%	1.1%	1.4%	0.9%	1.0%
Urban Principal Arterial	6.0%	15.5%	8.2%	13.3%	19.3%	17.1%	13.3%
Urban Minor Collector	7.4%	13.1%	6.1%	6.9%	14.6%	5.1%	12.2%
Urban Collector	3.6%	1.2%	4.1%	1.7%	4.5%	3.7%	4.1%
Urban Local Road/Street	9.9%	9.5%	9.2%	7.4%	8.0%	6.5%	5.1%
Urban Unknown	0.2%		1.0%	0.6%	0.5%		
Unknown	0.3%			0.6%		0.9%	1.0%
Total	100%	100%	100%	100%	100%	100%	100%
2000 FARS	(885)	(99)	(84)	(534)	(419)	(208)	(95)
Rural Principal Arterial-Interstate	0.3%		1.2%	0.4%	0.7%		
Rural Principal Arterial-Other	11.4%	14.1%	11.9%	22.1%	17.2%	21.6%	14.7%
Rural Minor Arterial	12.9%	6.1%	13.1%	13.3%	12.6%	9.6%	15.8%
Rural Major Collector	21.0%	19.2%	25.0%	15.0%	11.0%	17.8%	15.8%
Rural Minor Collector	7.3%	3.0%	3.6%	5.6%	2.6%	5.3%	2.1%
Rural Local Road/Street	10.6%	12.1%	10.7%	6.2%	3.3%	5.3%	1.1%
Rural Unknown	5.2%	4.0%	2.4%	1.3%	0.5%	0.5%	1.1%
Urban Principal Arterial-Interstate	0.3%	2.0%				1.4%	1.1%
Urban Principal Arterial-Other Freeway	0.6%	5.1%	1.2%	2.1%	1.7%	1.4%	2.1%
Urban Principal Arterial	6.1%	11.1%	3.6%	13.1%	17.4%	15.4%	15.8%
Urban Minor Collector	6.7%	10.1%	8.3%	8.2%	17.4%	8.7%	11.6%
Urban Collector	3.5%	3.0%	3.6%	1.7%	6.0%	2.4%	5.3%
Urban Local Road/Street	8.8%	6.1%	11.9%	6.9%	4.8%	8.2%	7.4%
Urban Unknown	0.6%	1.0%	1.2%	0.7%	0.2%		
Unknown	4.6%	3.0%	2.4%	3.4%	4.5%	2.4%	6.3%
Total	100%	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Number of Travel Lanes

Tables 23 and 24 provide the distributions of two-vehicle fatal crossing path crashes by number of travel lanes in 1999 and 2000 for traffic signals and stop signs, respectively. Two-lane roadways experienced the most two-vehicle fatal crossing path crashes at traffic signals, accounting for 52.3% of these crashes. Four-lane roadways followed with 23.5% of these crashes. On the other hand, 83.0% of the two-vehicle fatal crossing path crashes at stop signs occurred on two-lane roadways, followed by 10.8% on four-lane roadways. About 53.7%, 15.6%, and 22.1% of traffic signal crashes in which the driver failed to obey the signal happened respectively on two-lane, three-lane, and four-lane roadways. Similarly, 50.2%, 13.1%, and 25.8% of traffic signal crashes in which the driver failed to yield the right-of-way occurred respectively on two-lane, three-lane, and four-lane roadways. Moreover, there were relatively more LTCP crashes than SCP crashes on four-lane roadways in failure to yield violations at traffic signals. About 84.7% and 9.7% of stop sign crashes in which the driver failed to obey the sign occurred respectively on two-lane and four-lane roadways. Similarly, 81.5% and 11.8% of stop sign crashes in which the driver failed to yield the right-of-way happened respectively on two-lane and four-lane roadways. LTCP crashes at stop signs had relatively higher percentage than SCP crashes on four-lane roadways.

Table 23: Breakdown of Number of Travel Lanes for Fatal Two-Vehicle Crashes at Traffic Signals.

	Fail to Obey			**Fail to Yield**		
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Other**
1999 FARS	(409)	(177)	(40)	(49)	(355)	(25)
1 Lane	0.5%				1.1%	4.0%
2 Lanes	53.3%	53.7%	55.0%	53.1%	49.0%	72.0%
3 Lanes	16.9%	16.9%	5.0%	14.3%	13.0%	16.0%
4 Lanes	22.0%	22.6%	27.5%	26.5%	27.9%	8.0%
5 Lanes	2.0%	0.6%	10.0%		0.8%	
6 Lanes	2.0%	3.4%		4.1%	5.6%	
7 or More Lanes	0.7%	0.6%	2.5%	2.0%	0.3%	
Unknown	2.7%	2.3%			2.3%	
Total	100%	100%	100%	100%	100%	100%
2000 FARS	(424)	(194)	(41)	(52)	(307)	(27)
1 Lane	0.5%					
2 Lanes	54.7%	48.5%	70.7%	55.8%	48.2%	51.9%
3 Lanes	14.6%	19.1%	2.4%	9.6%	13.4%	14.8%
4 Lanes	21.7%	21.1%	24.4%	15.4%	26.7%	22.2%
5 Lanes	2.4%	1.0%	2.4%	3.8%	2.9%	3.7%
6 Lanes	3.1%	5.2%		7.7%	5.9%	7.4%
7 or More Lanes	0.5%	2.1%			0.3%	
Unknown	2.6%	3.1%		7.7%	2.6%	
Total	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 24: Breakdown of Number of Travel Lanes for Fatal Two-Vehicle Crashes at Stop Signs.

	Fail to Obey			Fail to Yield			
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Straight/ Starting**	**Other**
1999 FARS	(960)	(84)	(98)	(648)	(424)	(217)	(98)
1 Lane	0.6%	1.2%		0.2%	1.9%		1.0%
2 Lanes	84.6%	79.8%	86.7%	83.6%	75.2%	82.0%	88.8%
3 Lanes	1.5%	3.6%	1.0%	2.8%	3.8%	3.2%	1.0%
4 Lanes	10.8%	13.1%	10.2%	10.2%	15.1%	14.3%	6.1%
5 Lanes	0.1%		1.0%	0.3%	0.5%		2.0%
6 Lanes	0.1%	1.2%		0.9%	1.9%	0.5%	1.0%
7 or More Lanes				0.2%	0.2%		
Unknown	2.3%	1.2%	1.0%	1.9%	1.4%		
Total	100%	100%	100%	100%	100%	100%	100%
2000 FARS	(885)	(99)	(84)	(534)	(419)	(208)	(95)
1 Lane	0.1%			0.6%	0.7%	1.0%	1.1%
2 Lanes	86.2%	75.8%	83.3%	84.1%	76.1%	87.5%	82.1%
3 Lanes	1.9%	4.0%	2.4%	3.7%	5.0%	1.9%	4.2%
4 Lanes	7.3%	15.2%	10.7%	9.7%	15.0%	8.2%	12.6%
5 Lanes	0.1%	1.0%	1.2%	0.4%	1.0%		
6 Lanes	0.1%		1.2%		1.0%		
7 or More Lanes	0.1%					0.5%	
Unknown	4.1%	4.0%	1.2%	1.5%	1.2%	1.0%	
Total	100%	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Speed Limit

Tables 25 and 26 show crash statistics for the posted speed limit and two-vehicle fatal crossing path crash scenarios based on the 1999 and 2000 FARS. The 45-mph speed limit was the most reported in two-vehicle fatal crossing path crashes at traffic signals, accounting for 25.2% of these crashes. The 35-mph speed limit followed with 20.5% of these crashes. In contrast, about 42.6% of stop sign crashes occurred on roadways with 55-mph posted speed limit, followed by 45-mph speed limit with 14.8% of these crashes. About 29.1% of traffic signal crashes in which the driver failed to yield the right-of-way were reported on 45-mph roadways, as opposed to 22.8% in failure to obey crashes. Moreover, there were relatively more LTCP crashes than SCP crashes at traffic signals reported on 45-mph roadways. About 46.4% of stop sign crashes in which the driver failed to obey the sign were reported on 55-mph roadways, as opposed to 39.4% in failure to yield crashes. As with traffic signal crashes, there were relatively more LTCP crashes than SCP crashes at stop signs reported on 45-mph roadways in both failure to obey and failure to yield crashes.

Table 25: Speed Limit Breakdown for Fatal Two-Vehicle Crashes at Traffic Signals.

	Fail to Obey			Fail to Yield		
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Other**
1999 FARS	(409)	(177)	(40)	(49)	(355)	(25)
20 mph	0.2%					
25 mph	7.6%	1.1%		8.2%	3.4%	
30 mph	10.8%	3.4%		12.2%	5.1%	8.0%
35 mph	24.2%	18.6%	25.0%	24.5%	14.1%	16.0%
40 mph	13.2%	19.8%	7.5%	12.2%	21.7%	20.0%
45 mph	19.1%	26.0%	32.5%	14.3%	29.0%	28.0%
50 mph	8.8%	14.1%	7.5%	4.1%	8.7%	4.0%
55 mph	11.2%	14.1%	17.5%	18.4%	14.1%	16.0%
60 mph	0.7%		2.5%	2.0%	0.6%	
65 mph	0.5%	1.1%	2.5%	2.0%	0.3%	4.0%
70 mph					0.3%	
Unknown	3.7%	1.7%	5.0%	2.0%	2.8%	4.0%
Total	100%	100%	100%	100%	100%	100%
2000 FARS	(424)	(194)	(41)	(52)	(307)	(27)
20 mph		0.5%				
25 mph	5.2%	2.1%	2.4%	5.8%	2.3%	
30 mph	11.8%	4.1%	14.6%	7.7%	5.2%	7.4%
35 mph	24.5%	16.5%	24.4%	15.4%	20.2%	25.9%
40 mph	13.4%	12.9%	12.2%	17.3%	17.3%	14.8%
45 mph	20.8%	30.9%	19.5%	28.8%	31.6%	29.6%
50 mph	6.4%	10.8%	7.3%		5.5%	
55 mph	12.7%	16.5%	14.6%	21.2%	13.0%	18.5%
60 mph	0.9%	0.5%	2.4%	3.8%	0.7%	
65 mph	0.9%	2.6%			1.0%	3.7%
75 mph	0.2%					
Unknown	3.1%	2.1%	2.4%		3.3%	
Total	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Table 26: Speed Limit Breakdown for Fatal Two-Vehicle Crashes at Stop Signs.

	Fail to Obey			Fail to Yield			
	SCP	**LTCP**	**Other**	**SCP**	**LTCP**	**Straight/ Starting**	**Other**
1999 FARS	(960)	(84)	(98)	(648)	(424)	(217)	(98)
5 mph					0.2%		
15 mph				0.2%			
20 mph	0.2%			0.5%			
25 mph	6.1%	2.4%	3.1%	3.2%	2.4%	3.2%	3.1%
30 mph	6.8%	4.8%	5.1%	6.2%	6.6%	3.2%	4.1%
35 mph	7.3%	11.9%	10.2%	8.3%	9.2%	5.1%	4.1%
40 mph	4.6%	3.6%	5.1%	6.2%	9.9%	7.4%	8.2%
45 mph	11.0%	21.4%	17.3%	13.4%	23.1%	15.2%	18.4%
50 mph	5.1%	6.0%	5.1%	5.7%	6.6%	11.1%	3.1%
55 mph	46.7%	40.5%	41.8%	38.9%	32.5%	46.5%	49.0%
60 mph	2.0%	1.2%	1.0%	4.2%	2.4%	0.5%	2.0%
65 mph	6.6%	4.8%	8.2%	9.0%	5.0%	5.5%	7.1%
70 mph	2.4%	1.2%	2.0%	3.2%	1.4%	0.5%	1.0%
Unknown	0.9%	2.4%	1.0%	1.1%	0.7%	1.8%	
Total	100%	100%	100%	100%	100%	100%	100%
2000 FARS	(885)	(99)	(84)	(534)	(419)	(208)	(95)
15 mph	0.1%	1.0%					
20 mph			1.2%				1.1%
25 mph	4.9%	1.0%	2.4%	2.2%	1.7%	1.0%	5.3%
30 mph	7.8%	3.0%	8.3%	6.2%	6.0%	4.8%	5.3%
35 mph	7.5%	12.1%	6.0%	8.2%	10.7%	8.7%	9.5%
40 mph	4.1%	11.1%	3.6%	6.0%	11.5%	6.7%	9.5%
45 mph	10.2%	19.2%	17.9%	13.9%	21.5%	16.3%	21.1%
50 mph	4.6%	7.1%	8.3%	4.9%	5.3%	8.2%	9.5%
55 mph	48.7%	36.4%	41.7%	42.7%	36.0%	44.7%	31.6%
60 mph	2.6%	2.0%	1.2%	2.8%	2.1%	2.4%	3.2%
65 mph	6.1%	3.0%	8.3%	9.6%	3.3%	5.3%	2.1%
70 mph	2.7%	1.0%		3.0%	0.5%	1.0%	2.1%
Unknown	0.6%	3.0%	1.2%	0.6%	1.4%	1.0%	
Total	100%	100%	100%	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Appendix D provides an in-depth examination of crash contributing factors for fatal two-vehicle crossing path crashes at "intersections." Whereas the current analysis examines all crossings regardless of the location they occur at (the only restriction on the crossing area was that it was controlled by a stop sign or traffic signal), the results provided in Appendix D refer only to "intersection" and "intersection related" locations. Critical event dynamics, primary contributing factors, and crash circumstances of Left Turn Crossing Path (LTCP), Right Turn Crossing Path (RTCP), Straight Crossing Paths (SCP) crashes are provided. The majority of the fatal crossing path crashes were found to occur in the LTCP and SCP scenarios. SCP crashes comprised 50% of the crossing path crashes at signalized intersections, 49% were LTCP crashes. For stop sign controlled intersections, SCP and LTCP scenarios accounted respectively for 74% and 25% of the crashes.

Crash contributing factors were determined for all light vehicles that violated the signal or stop sign based on the pre-crash maneuver that the vehicle was trying to perform. Contributing factors examined include:

- Deliberate Unsafe Driving Act
- Police Pursuit
- Alcohol/Drugs
- Ill/Blackout
- Sleepy/Drowsy
- Other Driver Physical Impairments
- Vehicle Defects
- Emotion
- Inattention
- Driver's Vision Obscured
- Speeding
- Erratic Action
- Infrastructure Factor
- Unfamiliarity

Crash contributing factors, primary crash contributing factors, and multiple contributing factors were examined for LTCP, RTCP, and SCP crashes. Two distinct trends were observed in the analysis of primary crash contributing factors for the LTCP and SCP scenarios. The top primary contributing factor for vehicles with the pre-crash maneuver, turning left, was *Inattention.* For vehicles attempting to travel straight through the intersection, two primary contributing factors were observed, *Speeding* and *Inattention.* The prevalence of the contributing factor *Speeding* might be due to drivers not aware of the approaching sign/signal or drivers might have been trying to beat the amber/orange light. Furthermore, in the analysis of multiple contributing factors it was noted that alcohol/drugs and speeding often occurred together. (See Appendix D for additional information.)

4.6 Summary of Two-Vehicle Crashes

Major observations were as follows:

- At traffic signals, the GS-GS scenario accounted for 64.3% of all failure to obey crashes and the GS-LT scenario accounted for 79.9% of failure to yield crashes.
- At stop signs the GS-GS scenario accounted for 83.3% of the failure to obey and 44.6% of the failure to yield crashes.

- The number of violating vehicles that were turning left was higher than the number of violating vehicles that were going straight in LTCP crashes with failure to yield at traffic signals, failure to obey the stop sign, and failure to yield at stop signs with respective ratios of 3.25, 2.60, and 3.14. Conversely, the number of violating vehicles that were going straight was 1.38 times higher than the number of violating vehicles that were turning left in LTCP crashes with failure to obey at traffic signals. Finally, the number of violating vehicles that were starting in traffic was 2.98 times higher than the vehicles that were going straight in the going straight-starting scenario of the failure to yield crashes at stop signs.
- Inattention or distraction was reported for about 11.0% of all violating light vehicles in two-vehicle fatal crossing path crashes. Operating vehicle in erratic or reckless manner was cited to about 3.8% of all violating light vehicles.
- Speeding or racing, including police chase, was related to 6.4% of all violating light vehicles in two-vehicle fatal crossing path crashes.
- Vision obscured was reported in 3.0% of all violating light vehicles in two-vehicle fatal crossing path crashes.
- Alcohol was linked to 14.0% of all violating light vehicles. Alcohol involvement was more prevalence in failure to obey than in failure to yield crossing path crashes.
- The majority of two-vehicle fatal crossing path crashes at traffic signals occurred on urban roadways, accounting for 77.9% of these crashes. The majority of two-vehicle fatal crossing path crashes at stop signs occurred on rural roadways, accounting for 63.9% of these crashes.
- The urban principal arterial was the most reported roadway in traffic signal crashes accounting for 41.2% of the crashes. The rural major collector was the most reported roadway class at 21.9% of the failure to obey crashes at stop signs, failure to yield stop sign crashes were mostly reported on rural principal arterial/other with 19.9% of the crashes.
- Two-lane roadways experienced 52.3% and 83.0% of two-vehicle fatal crossing path crashes at traffic signals and stop signs respectively.
- About 46% of stop sign crashes in which the driver failed to obey the sign were reported on 55 mph roadways.
- The top primary contributing factor for vehicles with the pre-crash maneuver, turning left, was *Inattention*. For vehicles attempting to travel straight through the intersection, two primary contributing factors were observed, *Speeding* and *Inattention*.

5.0 Multi-Vehicle Crashes

This section describes the contributing factors of multi-vehicle (≥ 3 vehicles) fatal crashes that involved at least one light vehicle violating the traffic signal or the stop sign based on the 1999 and 2000 FARS. Moreover, this section portrays the infrastructure characteristics associated with these crashes in terms of the rural/urban area, roadway functional class, number of travel lanes, and posted speed limit. In 1999 and 2000, there were 889 fatal multi-vehicle crashes that involved violating light vehicles. Of these crashes, 57.5% happened at traffic signals while the remaining 42.5% occurred at stop signs. At traffic signals, drivers failed to obey the signal in 67.1% of the crashes and failed to yield the right-of-way in the remaining 32.9% of the crashes. In contrast, drivers failed to obey the sign in 39.7% of the stop sign crashes and failed to yield the right-of-way in 60.3% of these crashes. A total of 519 light vehicle drivers failed to obey or yield at traffic signals in multi-vehicle crashes, amounting to about 102 drivers per 100 crashes. At stop signs, 379 light vehicle drivers failed to obey or yield in multi-vehicle crashes – one violating light vehicle driver per crash.

5.1 Crash Contributing Factors

Figure 35 presents the distribution of driver-related factors reported in all multi-vehicle fatal crashes involving light vehicles that violated traffic signals or stop signs in 1999 and 2000. Figures 36-37 provide detailed distributions of driver-related factors by failure to obey and failure to yield violations at traffic signals and stop signs. As with two-vehicle fatal crashes, four most common factors dominated in 1999 and 2000 FARS: speeding, inattention, reckless driving, and vision obscured.

Speeding or racing, including police chase, was related to 10.2% of all violating light vehicles in multi-vehicle fatal crashes in 1999 and 2000. This factor was more prevalent in traffic signal crashes than in stop sign crashes, accounting for 14.3% of traffic signal crashes as opposed to 4.7% of stop sign crashes. Specifically, speeding was cited to:

- 19.7% of light vehicle drivers who failed to obey the traffic signal.
- Only 3.0% of light vehicle drivers who failed to yield at traffic signals.
- 10.0% of light vehicle drivers who failed to obey the stop sign.
- Only 1.3% of light vehicle drivers who failed to yield at stop signs.

Similar to two-vehicle crashes, speeding was mostly associated with failure to obey violations at traffic signals or stop signs. Inattention or distraction was reported for about 7.2% of all violating light vehicles in multi-vehicle fatal crashes. The relative frequency of this factor was comparable between traffic signal and stop sign crashes, accounting for 6.9% of traffic signal crashes and 7.7% of stop sign crashes. Specifically, inattention was associated with:

- 7.7% of light vehicle drivers who failed to obey the traffic signal.
- 5.3% of light vehicle drivers who failed to yield at traffic signals.
- 7.3% of light vehicle drivers who failed to obey the stop sign.
- 7.9% of light vehicle drivers who failed to yield at stop signs.

Inattention was the most prevalent among other factors in failure to yield crashes at traffic signals or stop signs. Operating vehicle in erratic or reckless manner was cited to about 4.3% of all violating light vehicles in multi-vehicle fatal crashes. The relative frequency of this factor was

similar between traffic signal and stop sign crashes, accounting for 4.4% of traffic signal crashes and 4.2% of stop sign crashes. Reckless driving was linked to:

- 6.0% of light vehicle drivers who failed to obey the traffic signal.
- 1.2% of light vehicle drivers who failed to yield at traffic signals.
- 5.3% of light vehicle drivers who failed to obey the stop sign.
- 3.5% of light vehicle drivers who failed to yield at stop signs.

Vision obscured was reported in 1.7% of all violating light vehicles in multi-vehicle fatal crashes:

- 0.9% of light vehicle drivers who failed to obey the traffic signal.
- 3.0% of light vehicle drivers who failed to yield at traffic signals.
- 1.3% of light vehicle drivers who failed to obey the stop sign.
- 2.2% of light vehicle drivers who failed to yield at stop signs.

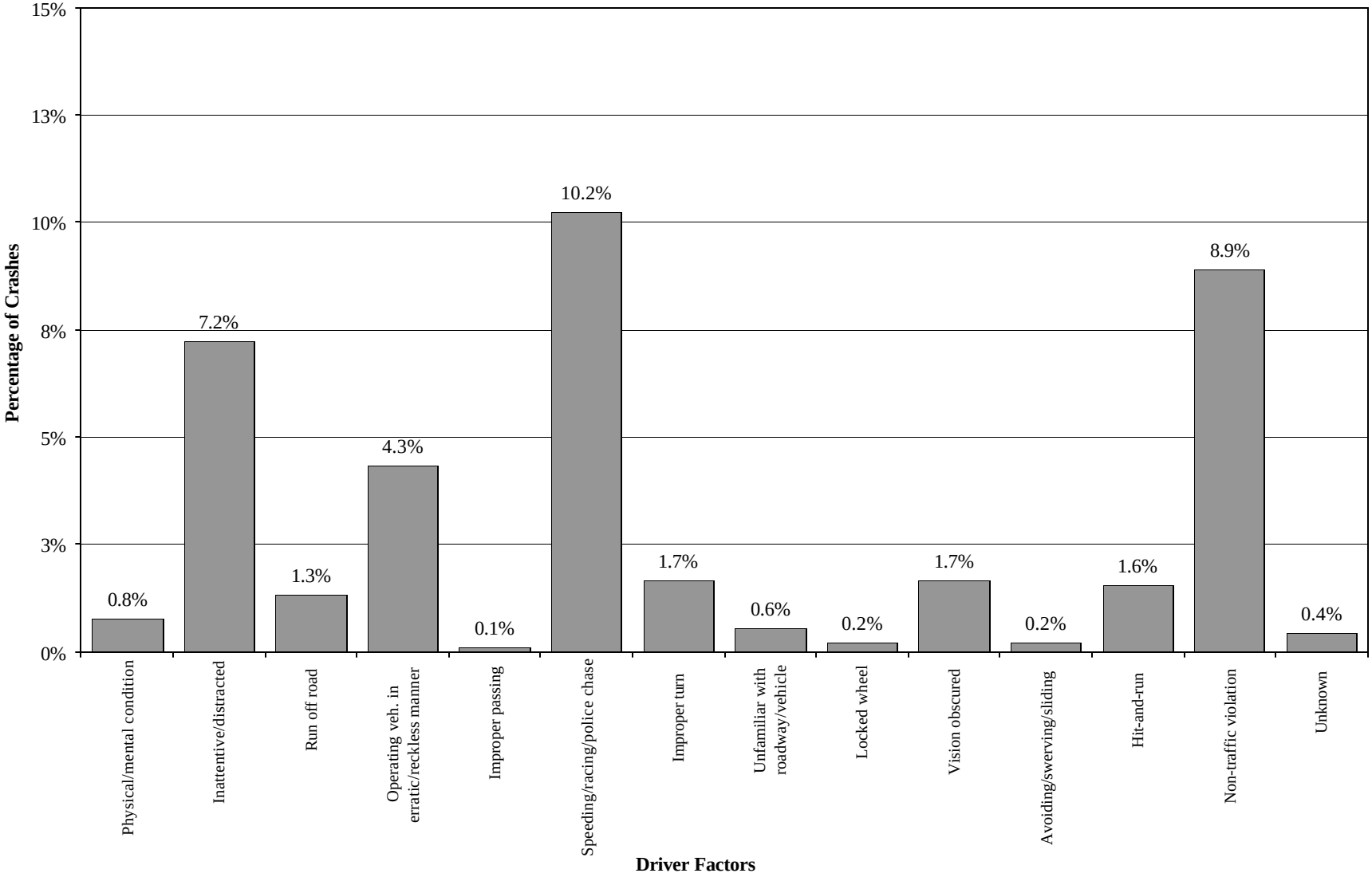


Figure 35: Breakdown of Driver Related Factors for All Fatal Multi-Vehicle Crashes Involving at Least One Light Vehicle that Violated the Traffic Signal or Stop Sign.

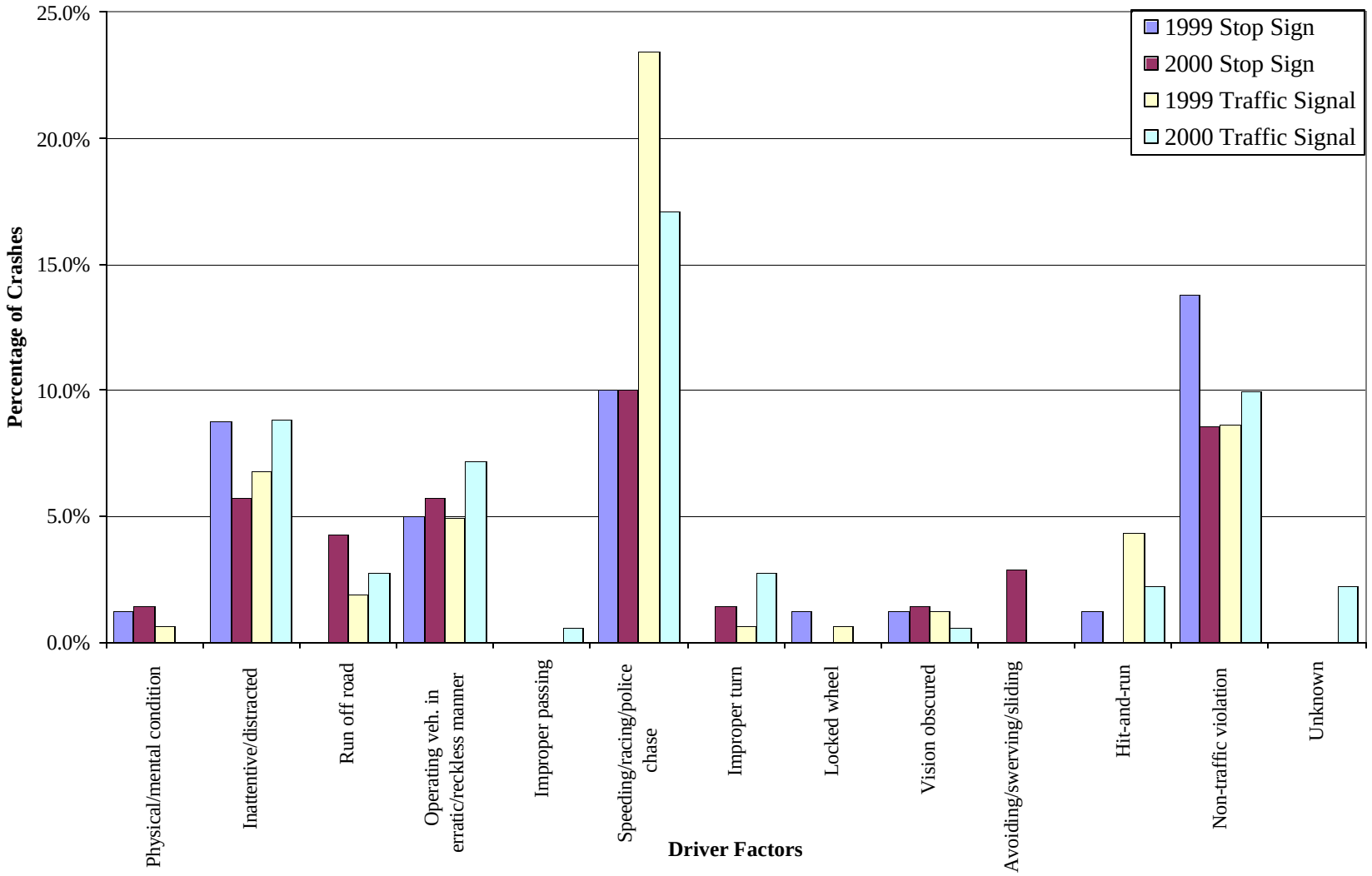


Figure 36: Breakdown of Driver Related Factors for Fatal Multi-Vehicle Crashes in which the Driver Failed to Obey.

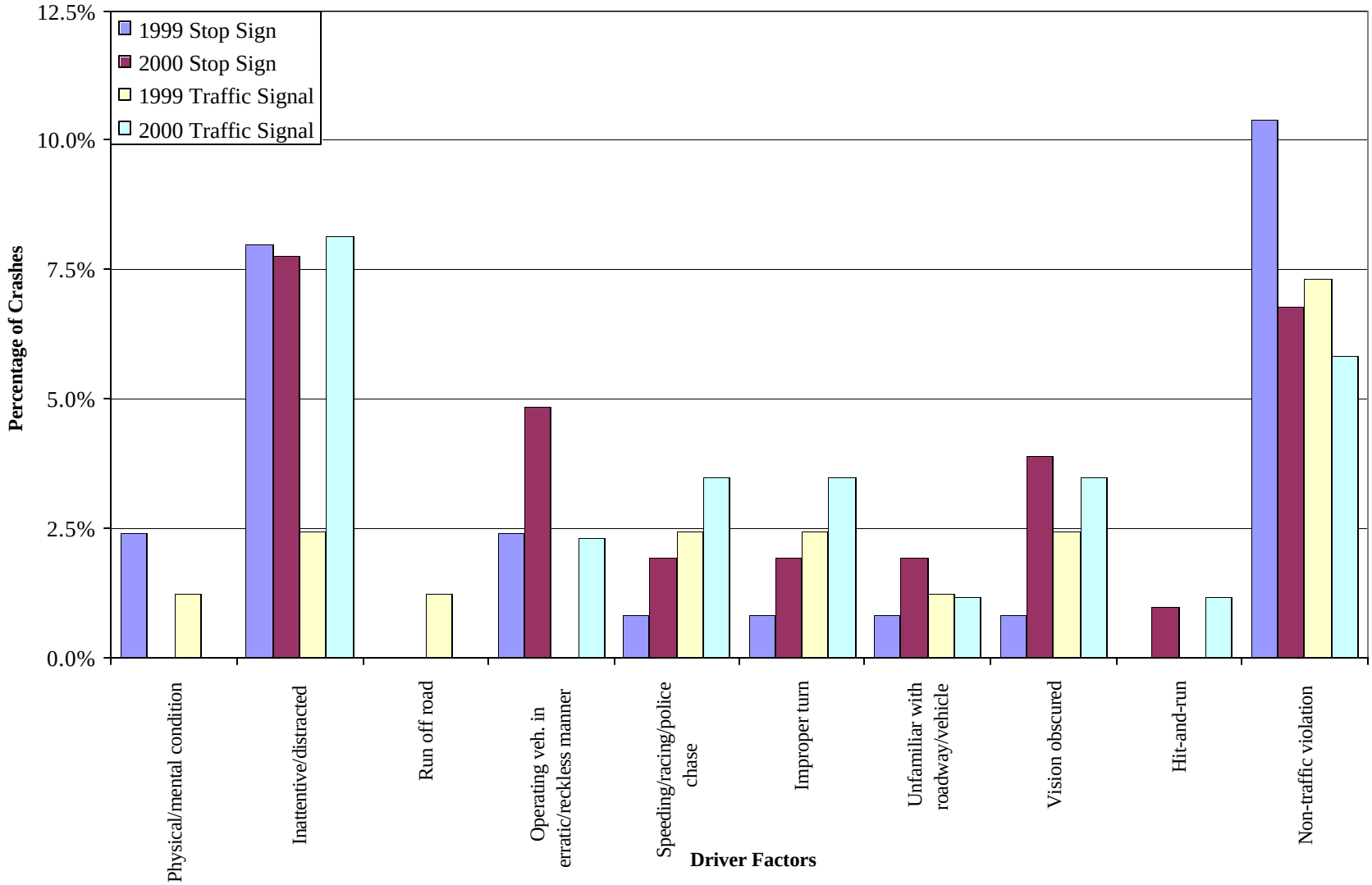


Figure 37: Breakdown of Driver Related Factors for Fatal Multi-Vehicle Crashes in which the Driver Failed to Yield.

5.2 Alcohol Involvement

Table 27 lists the statistics of alcohol involvement for violating light vehicle drivers in multi-vehicle fatal crashes by violation type and traffic control device in 1999 and 2000. Overall, alcohol was linked to 12.8% of all violating light vehicles involved in these crashes. Thus, the relative frequency of this factor exceeded speeding as the most dominant contributing factor in these crashes. Alcohol involvement was relatively higher in traffic signal crashes than in stop sign crashes, accounting for 14.6% of traffic signal crashes and 10.3% of stop sign crashes. Specifically, the percentages of violating light vehicle drivers who were charged with alcohol involvement were broken down as follows:

- 18.9% of drivers in failure to obey crashes at traffic signals.
- 5.9% of drivers in failure to yield crashes at traffic signals.
- 17.3% of drivers in failure to obey crashes at stop signs.
- 5.7% of drivers in failure to yield crashes at stop signs.

As with two-vehicle fatal crashes, alcohol involvement was more dominant in failure to obey than in failure to yield multi-vehicle fatal crashes.

Table 27: Breakdown of Police Reported Alcohol Involvement in Fatal Multi-Vehicle Crashes.

	Percent Alcohol Involvement
1999 FARS	
Fail to Obey Traffic Signal	15.1% (166)
Fail to Yield Traffic Signal	6.0% (83)
Fail to Obey Stop Sign	21.3% (80)
Fail to Yield Stop Sign	4.8% (126)
2000 FARS	
Fail to Obey Traffic Signal	22.3% (184)
Fail to Yield Traffic Signal	5.8% (86)
Fail to Obey Stop Sign	12.9% (70)
Fail to Yield Stop Sign	6.8% (103)

5.3 Infrastructure Characteristics

The majority of multi-vehicle fatal crashes that involved light vehicles violating the traffic signal happened on urban roadways, accounting for 82.0% of these crashes. In contrast, 57.1% of multi-vehicle fatal crashes at stop signs occurred on rural roadways. About 81.6% and 82.7% of traffic signal crashes in which the driver respectively failed to obey and failed to yield happened on urban roadways. At stop signs, 58.0% of failure to obey and 56.6% of failure to yield crashes occurred on rural roadways.

Roadway Functional Class

Table 28 provides the distributions of multi-vehicle fatal crashes by roadway class in 1999 and 2000 for traffic signals and stop signs, respectively. The urban principal arterial was the most reported roadway in traffic signal crashes among other roadway functional classes, accounting for

44.4% of these crashes. About 42.0% and 49.4% of traffic signal crashes in which the driver failed to obey and failed to yield, respectively, happened on the urban principal arterial. On the other hand, the rural principal arterial-other was the most reported roadway class at 18.5% of the stop sign crashes in 1999 and 2000. This roadway class was followed by the urban principal arterial that accounted for 16.4% of the stop sign crashes. About 20.7% of the failure to obey crashes at stop signs occurred on the rural principal arterial-other, while 19.7% of the failure to yield crashes at stop signs happened on the urban principal arterial.

Table 28: Breakdown of Roadway Classification for Fatal Multi-Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(162)	(82)	(80)	(125)
Rural Principal Arterial-Interstate				0.8%
Rural Principal Arterial-Other	6.8%	11.0%	18.8%	17.6%
Rural Minor Arterial	4.3%	1.2%	10.0%	12.8%
Rural Major Collector	1.9%		13.8%	16.0%
Rural Minor Collector	0.6%		6.3%	4.8%
Rural Local Road/Street	3.7%	2.4%	7.5%	11.2%
Urban Principal Arterial-Interstate	1.9%			
Urban Principal Arterial-Other Freeway	4.3%	3.7%	1.3%	
Urban Principal Arterial	42.0%	53.7%	15.0%	19.2%
Urban Minor Collector	17.9%	15.9%	15.0%	11.2%
Urban Collector	1.9%	2.4%	8.8%	2.4%
Urban Local Road/Street	14.2%	8.5%	3.8%	4.0%
Urban Unknown		1.2%		
Unknown	0.6%			
Total	100%	100%	100%	100%
2000 FARS	(181)	(86)	(70)	(103)
Rural Principal Arterial-Interstate	0.6%			
Rural Principal Arterial-Other	6.6%	2.3%	22.9%	16.5%
Rural Minor Arterial	1.7%	4.7%	7.1%	10.7%
Rural Major Collector	3.3%	4.7%	14.3%	14.6%
Rural Minor Collector			2.9%	1.0%
Rural Local Road/Street	0.6%	3.5%	8.6%	4.9%
Rural Unknown	1.1%		4.3%	1.0%
Urban Principal Arterial-Interstate	0.6%	1.2%		
Urban Principal Arterial-Other Freeway	4.4%	3.5%	1.4%	
Urban Principal Arterial	42.0%	45.3%	7.1%	20.4%
Urban Minor Collector	22.7%	17.4%	11.4%	12.6%
Urban Collector	4.4%	5.8%	4.3%	6.8%
Urban Local Road/Street	6.1%	7.0%	10.0%	8.7%
Urban Unknown	1.1%			
Unknown	5.0%	4.7%	5.7%	2.9%
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Number of Travel Lanes

Table 29 presents data on the number of travel lanes for multi-vehicle fatal crashes that involved at least one light vehicle violating the traffic signal or stop sign. The majority or 80.7% of stop sign crashes occurred on two-lane roadways – 82.0% of the failure to obey crashes and 79.8% of the failure to yield crashes at stop signs. On the other hand, half the traffic signal crashes (50.1%) happened on two-lane roadways – 49.0% of the failure to obey crashes and 52.4% of the failure to yield crashes at traffic signals. The relative frequency of traffic signal crashes on multi-lane (≥ 3 lanes) roadways was highest on four lanes, or 22.7% of all traffic signal crashes. About 24.8% of the failure to obey crashes and 18.5% of the failure to yield crashes at traffic signals were reported on four-lane roadways.

Table 29: Number of Travel Lanes Breakdown for Fatal Multi-Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(162)	(82)	(80)	(125)
2 Lanes	45.7%	61.0%	80.0%	80.8%
3 Lanes	14.2%	7.3%	1.3%	5.6%
4 Lanes	28.4%	15.9%	15.0%	11.2%
5 Lanes	2.5%	1.2%		
6 Lanes	6.2%	11.0%		1.6%
7 or More Lanes	0.6%			
Unknown	2.5%	3.7%	3.8%	0.8%
Total	100%	100%	100%	100%
2000 FARS	(181)	(86)	(70)	(103)
2 Lanes	51.9%	44.2%	84.3%	78.6%
3 Lanes	14.9%	16.3%	2.9%	4.9%
4 Lanes	21.5%	20.9%	7.1%	12.6%
5 Lanes	2.2%	1.2%		1.0%
6 Lanes	5.0%	12.8%		2.9%
7 or More Lanes		1.2%		
Unknown	4.4%	3.5%	5.7%	
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

Speed Limit

Table 30 shows crash statistics on the posted speed limit and the type of violation based on the 1999 and 2000 FARS. About 27.8% of all multi-vehicle fatal crashes at traffic signals occurred on roadways with 45-mph posted speed limit, while the 35-mph and 40-mph speed limits each experienced about 20% of these crashes. The ranking of these speed limits also applies to the failure to obey and the failure to yield crashes at traffic signals. In contrast, about 38.4% of the stop sign crashes were reported on 55-mph speed limit roadways, and 18.5% of these crashes

were reported on 45-mph roadways. The 55-mph and 45-mph speed limits were the most dominant in the failure to obey and the failure to yield crashes at stop signs.

Table 30: Speed Limit Breakdown for Fatal Multi-Vehicle Crashes.

	Traffic Signals		Stop Signs	
	Fail to Obey	**Fail to Yield**	**Fail to Obey**	**Fail to Yield**
1999 FARS	(162)	(82)	(80)	(125)
15 mph			1.3%	
20 mph	0.6%	0.6%		0.8%
25 mph	1.9%	1.7%	6.3%	
30 mph	5.6%	7.2%	10.0%	4.0%
35 mph	26.5%	18.2%	12.5%	11.2%
40 mph	21.0%	19.3%	5.0%	7.2%
45 mph	25.9%	26.0%	15.0%	16.8%
50 mph	4.3%	8.8%	3.8%	9.6%
55 mph	13.0%	14.4%	37.5%	44.0%
60 mph		0.6%	2.5%	1.6%
65 mph		1.1%	3.8%	3.2%
70 mph	0.6%		1.3%	
75 mph				0.8%
Unknown	0.6%	2.2%	1.3%	0.8%
Total	100%	100%	100%	100%
2000 FARS	(181)	(86)	(70)	(103)
25 mph			1.4%	4.9%
30 mph	4.9%	4.7%	1.4%	1.0%
35 mph	18.3%	17.4%	11.4%	12.6%
40 mph	18.3%	19.8%	8.6%	14.6%
45 mph	31.7%	31.4%	28.6%	16.5%
50 mph	4.9%	9.3%	7.1%	7.8%
55 mph	18.3%	11.6%	31.4%	36.9%
60 mph			1.4%	1.9%
65 mph	1.2%	2.3%	5.7%	1.9%
Unknown	2.4%	3.5%	2.9%	1.0%
Total	100%	100%	100%	100%

- Empty cells refer to scenarios that had no crashes in the 1999 or 2000 FARS.
- Relative frequencies may not add to 100% due to rounding error.
- Parentheses refer to actual crash counts.

5.4 Summary of Multi-Vehicle Crashes

Major observations were as follows:

- In 1999 and 2000 there were 889 fatal multi-vehicle crashes that involved violating light vehicles. Of these crashes, 57.5% happened at traffic signals while the remaining 42.5% occurred at stop signs. At traffic signals, drivers failed to obey the signal in 67.1% of the crashes and failed to yield the right-of-way in the remaining 32.9% of the crashes. In contrast, drivers failed to obey the sign in 39.7% of the stop sign crashes and failed to yield the right-of-way in 60.3% of these crashes.
- Speeding or racing, including police chase, was related to 10.2% of all violating light vehicles in multi-vehicle fatal crashes in 1999 and 2000.
- Inattention or distraction was reported for about 7.2% of all violating light vehicles in multi-vehicle fatal crashes.
- Operating vehicle in erratic or reckless manner was cited to about 4.3% of all violating light vehicles in multi-vehicle fatal crashes. Moreover, obscured vision was reported in 1.7% of all violating light vehicles.
- Alcohol was linked to 12.8% of all violating light vehicles involved in fatal multi-vehicle crashes. Alcohol involvement was relatively higher in traffic signal crashes than in stop sign crashes, accounting for 14.6% of traffic signal crashes and 10.3% of stop sign crashes.
- The majority, 82.0%, of multi-vehicle fatal crashes involved light vehicles violating the traffic signal happened on urban roadways. In contrast, 57.1% of multi-vehicle fatal crashes at stop signs occurred on rural roadways.
- About 81.6% and 82.7% of traffic signal crashes in which the driver respectively failed to obey and failed to yield happened on urban roadways. At stop signs, 58.0% of failure to obey and 56.6% of failure to yield crashes occurred on rural roadways.
- The urban principal arterial was the most reported roadway in traffic signal crashes among other roadway functional classes, accounting for 44.4% of these crashes.
- The rural principal arterial/other was the most reported roadway class at 18.5% of the stop sign crashes in 1999 and 2000.
- The majority or 80.7% of stop sign crashes occurred on two-lane roadways compared to half of the traffic signal crashes.
- About 27.8% of all multi-vehicle fatal crashes at traffic signals occurred on roadways with 45-mph posted speed limit, while the 35-mph and 40-mph speed limits each experienced about 20% of these crashes.
- About 38.4% of the stop sign crashes were reported on 55-mph speed limit roadways, and 18.5% of these crashes were reported on 45-mph roadways.

6.0 Concluding Remarks

The 1999 and 2000 FARS were analyzed to gain a better understanding of fatal crashes involving light vehicles that violated traffic signals or stop signs. There was a yearly average of 37,275 fatal motor vehicle crashes on U.S. roadways in these two years, resulting in a yearly average of 41,769 fatalities. Roadways controlled by traffic signals and stop signs experienced respectively 6.9% and 9.5% of all fatal crashes in 1999 and 2000. There were about 5 fatal crashes per 1,000 police-reported crashes at stop sign-controlled roadways, as opposed to 2 at traffic signals. Approximately 82% of traffic signal fatal crashes and 86% of stop sign fatal crashes occurred at intersections, accounting respectively for about 3 and 6 fatal crashes per 1,000 police-reported intersection crashes.

A total of 9,951 vehicles were involved in fatal crashes at traffic signals in 1999 and 2000 – 20% of these vehicles failed to obey the signal and 13% failed to yield the right-of-way. On the other hand, 13,627 vehicles were involved in fatal crashes at stop signs - 21% failed to obey the sign and 23% failed to yield the right-of-way. Light vehicles accounted for 89% of the 1,958 vehicles that failed to obey the traffic signal, and 91% of the 1,284 vehicles that failed to yield at traffic signals in 1999 and 2000. At stop signs, light vehicles comprised 93% of the 2,856 vehicles that failed to obey the sign and 95% of the 3,136 vehicles that failed to yield the right-of-way. Fatal crashes associated with failure to obey by the light vehicle were 1.5 times higher at stop signs than at traffic signals. Moreover, the "failure to yield" fatal crashes by the light vehicle were 2.6 times higher at stop signs than at traffic signals.

Our analysis separated fatal crashes involving light vehicles that violated the traffic signal or the stop sign into single vehicle, two-vehicle, and multi-vehicle (≥ 3 vehicles) crash categories. Two-vehicle crashes accounted for 75% and 87%, multi-vehicle crashes accounted for 18% and 7%, and single vehicle crashes accounted for 8% and 6% of all light vehicle violation fatal crashes at traffic signals and stop signs, respectively. For each crash category, this report identified the crash scenarios, described the crash contributing factors, and characterized the infrastructure where these fatal crashes happened in 1999 and 2000.

The following highlights major results from the analysis of single vehicle fatal crashes in which the light vehicle failed to obey or failed to yield at traffic signals and stop signs:

- About 64% and 95% respectively of the "failure to obey" and the "failure to yield" crashes at traffic signals were pedestrian crashes. On the other hand, 76% of the "failure to yield" crashes at stop signs were pedestrian crashes, while 95% of the "failure to obey" the stop sign crashes were other crashes such as run-off-road crashes.
- Speeding and inattention were cited respectively in 33% and 14% of all the single vehicle fatal crashes in which the driver violated the traffic signal/stop sign.
- Alcohol was involved in 37% of all single vehicle fatal crashes involving a light vehicle violating the traffic signal or the stop sign. Alcohol involvement was twice as high in failing to obey the stop sign as in failing to obey the traffic signal.
- About 91% and 8% of traffic signal crashes occurred respectively in urban and rural areas. In contrast, 42% and 57% of stop sign crashes occurred respectively in urban and rural areas.
- About 44% and 47% of traffic signal crashes in which the driver respectively failed to obey the signal and failed to yield the right-of-way occurred on urban principal arterial. On the other hand, 23% of stop sign crashes in which the driver failed to obey and 33%

of stop sign crashes in which the driver failed to yield happened respectively on rural local road/street and urban local road/street.

- About 92% of stop sign crashes and 53% of traffic signal crashes associated with failure to obey occurred on two-lane roadways. Similarly, two-lane roadways were reported in 77% of stop sign crashes and 52% of traffic signal crashes tied to failure to yield.
- About 31% of traffic signal crashes occurred on 35-mph speed limit roadways regardless of violation type. At stop signs, 33% of the "failure to obey" crashes happened on 55-mph speed limit while 39% of the "failure to yield" crashes occurred on 25-mph speed limit roadways.

Major results from the analysis of two-vehicle fatal crashes were as follows:

- The relative frequencies of the SCP and LTCP scenarios were respectively 65% and 29% of all failure to obey traffic signal crashes in 1999 and 2000 (SCP scenario 2.24 × higher than LTCP). Conversely, the relative frequencies of the SCP and LTCP scenarios were respectively 12% and 81% of all failure to yield crashes at traffic signals (LTCP scenario 6.55 × higher than SCP). On the other hand, the relative frequencies of the SCP and LTCP scenarios were respectively 83% and 8% of all failure to obey stop sign crashes in 1999 and 2000 (SCP scenario 10.08 × higher than LTCP).
- Inattention or distraction was reported for about 11% of all violating light vehicles in two-vehicle fatal crossing path crashes.
- Alcohol was linked to 14% of all violating light vehicles in two-vehicle fatal crossing path crashes. Furthermore, alcohol involvement was more prevalent in failure to obey than in failure to yield crashes.
- Approximately 48% of the LTCP crashes in which the driver failed to obey the traffic signal occurred on urban principal arterial as compared to 37% of the SCP crashes. Similarly, this roadway class was also reported in 46% of the LTCP crashes and 33% of the SCP crashes in which the driver failed to yield at traffic signals. The rural major collector was the most reported roadway class at 22% of the failure to obey crashes at stop signs in 1999 and 2000.
- About 52% of two-vehicle fatal crossing path crashes at traffic signals occurred on two-lane roadways. Four-lane roadways followed with 24% of these crashes. On the other hand, 83% of the two-vehicle fatal crossing path crashes at stop signs occurred on two-lane roadways, followed by 11% on four-lane roadways.
- About 29% of traffic signal crashes in which the driver failed to yield the right-of-way were reported on 45-mph roadways, as opposed to 23% in failure to obey crashes. About 46% of stop sign crashes in which the driver failed to obey the sign were reported on 55-mph roadways, as opposed to 39% in failure to yield crashes. For both traffic signal and stop sign crashes, there were relatively more LTCP crashes than SCP crashes reported on 45-mph roadways in both failure to obey and failure to yield crashes.

Major results from the analysis of multi-vehicle fatal crashes were as follows:

- In 1999 and 2000, there were 889 fatal multi-vehicle crashes that involved violating light vehicles. About 58% happened at traffic signals while the remaining 42% occurred at stop signs. At traffic signals, drivers failed to obey the signal in 67% of the crashes and failed to yield the right-of-way in the remaining 33% of the crashes. In contrast, drivers failed to obey the sign in 40% of the stop sign crashes and failed to yield the right-of-way in 60% of these crashes.
- Speeding or racing, including police chase, was related to 10% of all violating light vehicles in multi-vehicle fatal crashes in 1999 and 2000. This factor was 4 times more

prevalent in traffic signal crashes than in stop sign crashes. Inattention or distraction was the second most reported factor representing about 7% of all violating light vehicles in multi-vehicle fatal crashes.

- Alcohol was linked to 13% of all violating light vehicles in multi-vehicle crashes. The relative frequency of alcohol exceeded speeding as the most dominant contributing factor.
- About 82% of multi-vehicle fatal crashes that involved light vehicles violating the traffic signal occurred on urban roadways. In contrast, about 57% of multi-vehicle fatal crashes at stop signs occurred on rural roadways.
- The majority or 80% of stop sign crashes occurred on two-lane roadways. On the other hand, half the traffic signal crashes (50%) happened on two-lane roadways.
- About 28% of all multi-vehicle fatal crashes at traffic signals occurred on roadways with 45-mph posted speed limit, while the 35-mph and 40-mph speed limits each experienced about 20% of these crashes. In contrast, about 38% of the stop sign crashes were reported on 55-mph speed limit roadways, and 19% of these crashes were reported on 45-mph roadways.

No major difference was found between the single vehicle, two-vehicle, and multi-vehicle crash categories regarding the infrastructure where these fatal crashes occurred. In contract, the major contributing factors for each crash category provided valuable insight into the unique issues associated with these particular crashes. Single vehicle crashes were almost three times as likely to involve alcohol than two-vehicle or multi-vehicle crashes. Furthermore, single vehicle crashes had the highest rate of speeding and inattention. Two-vehicle crashes had the second highest involvement rate of inattention and multi-vehicle crashes had the second highest rate of speeding. In conclusion, fatal crashes involving a light vehicle violating the traffic signal or stop sign occur in similar locations regardless if they are single vehicle, two-vehicle, and multi-vehicle crashes. Additionally, alcohol, speeding, and inattention are the three most common contributing factors of fatal crashes at traffic signals and stop signs.

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APPENDICES

APPENDIX A: Additional Information On 1999 and 2000 Fatal Crashes with Violations

Vehicle and Fatality Breakdown for 1999 Fatal Crashes with Violations.

	Violations	No Violations	Unknown if Violations	Total
Traffic Signals				
No. of Fatal Crashes	658	1,789	124	2,571
No. of Vehicles Involved	1,312	3,382	247	4,941
No. of Fatalities	706	1,924	134	2,764
Stop Signs				
No. of Fatal Crashes	808	2,703	125	3,363
No. of Vehicles Involved	1,631	5,192	246	7,069
No. of Fatalities	893	3,078	142	4,113

Vehicle and Fatality Breakdown for 2000 Fatal Crashes with Violations.

	Violations	No Violations	Unknown if Violations	Total
Traffic Signals				
No. of Fatal Crashes	674	1,786	123	2,583
No. of Vehicles Involved	1,409	3,352	249	5,010
No. of Fatalities	722	1,929	129	2,780
Stop Signs				
No. of Fatal Crashes	700	2,611	113	3,424
No. of Vehicles Involved	1,412	4,917	229	6,558
No. of Fatalities	772	2,980	132	3,884

APPENDIX B: AASHTO Functional Classification

AASHTO Functional Classification	Functions	Typical Characteristics	Examples
Rural Principal Arterials	Main corridor movement for statewide or interstate travel. Movements between virtually all urban areas.	High volume, high speed Multi-lane Access control	Interstates and Turnpikes US highways
Rural minor Arterials	Linkage of cities, towns and other traffic generators. Integrated regional service.	Relatively high volume and speed Minimum interface to through movement	State Primary Routes
Rural Collector System	Serve intra-county movements. Relatively short trip lengths. Collect local traffic and direct it to the arterial system.	Moderate speed and volume	State Secondary Routes County Routes
Rural Local Road System	Provides access to residences and businesses.	Low volume, low speed	Any local road
Urban Principal Arterials	Connects major traffic generators in an urban area.	High volume Multi-lane Full or partial access control	Category B1-BIV roadways
Urban Minor Arterial System	Primarily mobility and some access. Connects primary system to collector system.	Moderate volume Bus routes Intracommunity service	Category C111 and CIV roadways
Urban Collector Street System	Land access. Connection to the arterial system. Traffic circulation within neighborhoods.	Low volume and speed Two lane undivided and one-way Bus traffic	Category DIV and DV roadways
Urban Local Street System	Purely land access. Low levels of mobility.	Low speed and volume Two lane undivided, one-way No bus traffic	Category EV and EVI roadways

Based on: *A Policy on Geometric Design of Highways and Streets*, American Association of State and Highway Officials, Washington, D.C., 2001.

APPENDIX C: *Vehicle Maneuver* Matrices For Two-Vehicle Crashes

1999 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	409	2	23	3	0	0	0	0	3	0	0	1	180	3	0	1	0	1	0
	02-Slowing or Stopping in Traffic Lane	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-1: 1999 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Obey Crashes at Traffic Signals.

1999 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	53	1	10	2	0	0	0	0	0	1	0	3	356	2	0	0	0	0	0
	02-Slowing or Stopping in Traffic Lane	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-2: 1999 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Yield Crashes at Traffic Signals.

2000 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	428	0	16	6	5	0	0	0	2	1	0	6	194	1	0	2	1	1	0
	02-Slowing or Stopping in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-3: 2000 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Obey Crashes at Traffic Signals.

2000 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	54	4	4	2	2	0	0	0	0	2	0	2	308	3	0	0	0	0	0
	02-Slowing or Stopping in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	1
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Figure C-4: 2000 FARS Vehicle Matrix for Fatal Two-Vehicle Failure to Yield Crashes at Traffic Signals.

1999 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	961	11	40	1	2	1	0	0	5	0	0	14	84	0	0	2	11	0	4
	02-Slowing or Stopping in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-5: 1999 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Obey Crashes at Stop Signs.

1999 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	649	6	218	7	1	0	0	1	2	3	0	14	426	3	0	1	8	4	5
	02-Slowing or Stopping in Traffic Lane	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	1	0	0	0	2	0	0	1	8	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-6: 1999 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Yield Crashes at Stop Signs.

2000 FARS		Vehicle 1																	
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	885	10	29	5	3	0	0	0	10	1	0	5	101	0	0	2	9	0	1
	02-Slowing or Stopping in Traffic Lane	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	0	1
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-7: 2000 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Obey Crashes at Stop Signs.

2000 FARS		Vehicle 1																		
		01-Going Straight	02-Slowing or Stopping in Traffic Lane	03-Starting in Traffic Lane	04-Stopped in Traffic Lane	05-Passing or Overtaking Another Vehicle	06-Leaving a Parked Position	07-Parked	08-Entering a Parked Position	09-Maneuvering to Avoid	10-Turning Right: RTOR Permitted	11-Turning Right: RTOR Not Permitted	12-Turning Right: RTOR Not Applicable	13-Turning Left	14-Making a U-Turn	15-Baking Up	16-Changing Lanes or Merging	17-Negotiating a Curve	98-Other	99-Unknown
Vehicle 2	01-Going Straight	536	10	208	4	4	1	0	0	3	0	0	13	424	4	0	2	7	2	5
	02-Slowing or Stopping in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	03-Starting in Traffic Lane	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0
	04-Stopped in Traffic Lane	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	05-Passing or Overtaking Another Vehicle	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
	06-Leaving a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	07-Parked	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	08-Entering a Parked Position	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	09-Maneuvering to Avoid	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
	10-Turning Right: RTOR Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11-Turning Right: RTOR Not Permitted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12-Turning Right: RTOR Not Applicable	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	13-Turning Left	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	24	0	0
	14-Making a U-Turn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15-Baking Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16-Changing Lanes or Merging	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	17-Negotiating a Curve	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	98-Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	99-Unknown	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-8: 2000 FARS Vehicle Maneuver Matrix for Fatal Two-Vehicle Failure to Yield Crashes at Stop Signs.

APPENDIX D: Intersection Violation Crash Analysis

Intersection Violation Crash Analysis

In response to the need for information on the critical event dynamics that precede specific types of intersection crossing path crashes, this research was undertaken to determine the crash causal and contributing factors for each intersection crash scenario. Crossing path collision violation warning systems could provide an in-vehicle violation warning to drivers who are in imminent danger of running a red light or stop sign. The goal of the system is to reduce the frequency of intersection crossing path crashes associated with unintentional violations of traffic signals and stop signs.

The FARS database was examined and primary contributing factors were determined for each crossing path crash scenario based on the pre-crash maneuver of the vehicle that violated the sign/signal. Countermeasure development requires a clear crash problem definition. Target crashes were defined, separated by traffic control device and violation of the sign/signal. Major crash causal and contributing factors were determined for each subtype of intersection control violation. Additional analysis was also performed on the speed behavior of light vehicles that violated the traffic control device and infrastructure characteristics of the intersections. This analysis differs from the main report in that only fatal crossing path crashes at intersections are examined here. Previously, all fatal crossing paths were included regardless of where they occurred on the trafficway.

Target Crashes

The FARS database was examined to statistically describe fatal crossing path crashes at intersections. The 1999 and 2000 FARS databases were analyzed to determine the factors that may have caused or contributed to the crashes. The target crashes were first defined to include at least one light vehicle, then separated out by traffic control device, and lastly analyzed by crossing path crash scenario. Information on the definition of the target crashes is provided below as well as in the schematic provided in Figure D-1.

Light Vehicles

All fatal crossing path collisions examined involved at least one light vehicle (passenger car, sport utility vehicle, van, or pickup truck). Light vehicles were identified by selecting codes 01-12, 14-22, 28-41, 45, or 48-49 from the *Body Type* variable and code 0 from the *Special Use* variable located is the FARS "Vehicle File." The following are the relevant codes of the *Body Type* variable (*4*):

Codes 01-09: Automobiles
Codes 10-12: Automobile Derivatives
Codes 14-19: Utility vehicles
Codes 20-22, 28-29: Van Based Light Trucks (Gross Vehicle Weight Ratio less than or equal to 10,000 lbs.)
Codes 30-39: Light Conventional Trucks (Pickup-style cab, Gross Vehicle Weight Ration less than or equal to 10,000 lbs.)
Codes 40-41, 45, 48-49: Other Light Conventional Trucks (Gross Vehicle Weight Ratio less than or equal to 10,000 lbs.)

The relevant code from the *Special Use* variable is (*4*):

Code 0: No Special Use

1999-2000 FATAL CROSSING PATH CRASH ANALYSIS

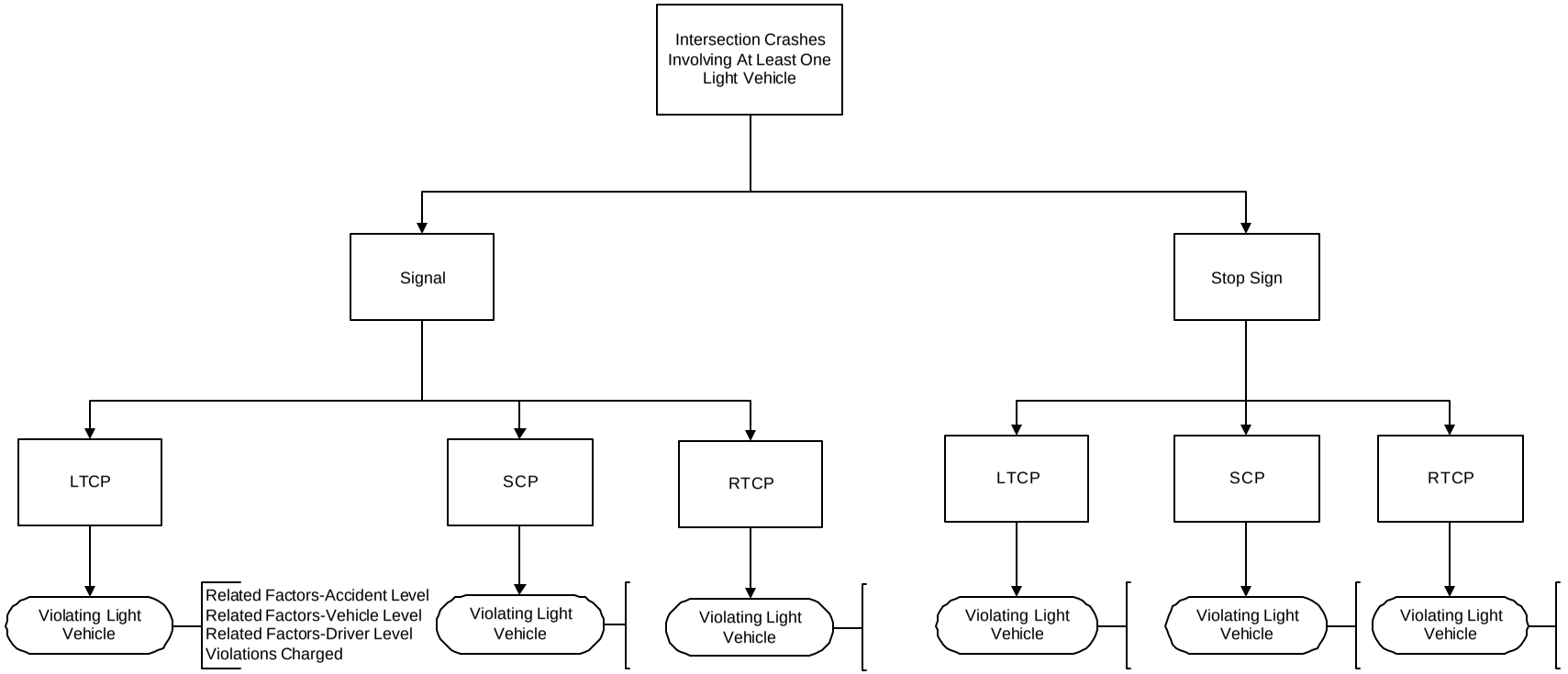


Figure D-1: Definition of Target Crashes.

Intersection Crashes
Target crashes were first restricted to those cases in which at least one light vehicle was present. Secondly, to ensure that the first harmful event occurred within the intersection or the immediate surrounding area, the Relation to Junction variable was restricted to crashes coded as intersection or intersection related for non-interchange junctions. The Relation to Junction variable is located within the FARS "Accident File" and indicates in what type of junction the first harmful event occurred. Intersection crashes were only examined at non-interchange junction (i.e., all roadways were on the same level).

Intersection Crash Scenarios
Intersection crash scenarios were identified based on the vehicle's pre-crash movement. Six pre-crash scenarios for crossing path crashes were determined (*7*):

1. Left Turn Across Path – Opposite Direction (LTAP/OD)
2. Left Turn Across Path – Lateral Direction (LTAP/LD)
3. Left Turn Into Path – Merge (LTIP)
4. Right Turn Into Path – Merge (RTIP)
5. Straight Crossing Paths (SCP)
6. Right Turn Across Path – Lateral Direction (RTAP/LD)

Graphical representations of the crossing path crash scenarios are provided in the main report. Since a variable similar to the *Accident Type* variable from the General Estimates System (GES) crash database is not available in the FARS, scenarios were determined using a combination of the FARS *Vehicle Maneuver* and *Manner of Collision* variables. Note that without a variable similar to *Accident Type*, the FARS crossing path crashes could only be segregated into the following categories: Left Turn Crossing Path (LTCP), Right Turn Crossing Path (RTCP), and SCP.

Table D-1 provides the definitions of the intersection crossing path crash scenarios. A complete breakdown of the *Vehicle Maneuver* and *Manner of Collision* variables is located in Figures D-2 and D-3.

Table D-1: Definitions of Intersection Crossing Path Crashes by *Vehicle Maneuver* and *Manner of Collision.*

Scenario	Vehicle Maneuver		Manner of Collision
	Vehicle A	Vehicle B	
LTCP	Going Straight	Turning Left	03 – Rear-to-Rear or 04 – Angle
RTCP	Going Straight	Turning Right	04 – Angle
SCP	Going Straight	Going Straight	04 – Angle

FARS DATA (1999-2000)

(A) Signal: (TRAF_CONT) codes 01-03

VEHICLE MANEUVER	MANNER OF COLLISION	CRASH COUNTS YEAR 1999		CRASH COUNTS YEAR 2000		CRASH COUNTS 1999-2000		
2-Straight	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Straight	Front-to-Rear (includes Rear-End)	7	1%	18	1%	25	1%	
2-Straight	Front-to-Front (includes Head-On)	9	1%	9	1%	18	1%	
2-Straight	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Straight	Angle	539	43%	536	44%	1075	43%	SCP
2-Straight	Sideswipe - Same Direction	1	0%	1	0%	2	0%	
2-Straight	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
2-Straight	Unknown	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Front-to-Rear (includes Rear-End)	4	0%	4	0%	8	0%	
1-Straight & 1-Turning Left	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Rear-to-Rear	44	3%	35	3%	79	3%	LTCP
1-Straight & 1-Turning Left	Angle	511	40%	469	39%	980	39%	
1-Straight & 1-Turning Left	Sideswipe - Same Direction	1	0%	0	0%	1	0%	
1-Straight & 1-Turning Left	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Unknown	4	0%	1	0%	5	0%	
1-Straight & 1-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	1	0%	1	0%	
1-Straight & 1-Turning Right	Front-to-Front (includes Head-On)	0	0%	1	0%	1	0%	
1-Straight & 1-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Angle	5	0%	7	1%	12	0%	RTCP
1-Straight & 1-Turning Right	Sideswipe - Same Direction	1	0%	1	0%	2	0%	
1-Straight & 1-Turning Right	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Unknown	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Angle	1	0%	2	0%	3	0%	
1-Turning Left & 1-Turning Right	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Unknown	0	0%	0	0%	0	0%	
2-Turning Left	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Turning Left	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
2-Turning Left	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
2-Turning Left	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Turning Left	Angle	2	0%	4	0%	6	0%	
2-Turning Left	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
2-Turning Left	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
2-Turning Left	Unknown	0	0%	0	0%	0	0%	
2-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
2-Turning Right	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
2-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Turning Right	Angle	0	0%	0	0%	0	0%	
2-Turning Right	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
2-Turning Right	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
2-Turning Right	Unknown	0	0%	0	0%	0	0%	
Other	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
Other	Front-to-Rear (includes Rear-End)	84	7%	77	6%	161	6%	
Other	Front-to-Front (includes Head-On)	1	0%	9	1%	10	0%	
Other	Rear-to-Rear	0	0%	0	0%	0	0%	
Other	Angle	53	4%	39	3%	92	4%	
Other	Sideswipe - Same Direction	0	0%	1	0%	1	0%	
Other	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
Other	Unknown	0	0%	0	0%	0	0%	
TOTALS:		1267		1215		2482		

Figure D-2: Complete Breakdown of Intersection Crash Scenarios by the FARS *Vehicle Maneuver* and *Manner of Collision* Variables at Traffic Signals.

(B) Stop sign: (TRAF_CONT) code 20

VEHICLE MANEUVER	MANNER OF COLLISION	CRASH COUNTS YEAR 1999		CRASH COUNTS YEAR 2000		CRASH COUNTS 1999-2000		
2-Straight	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Straight	Front-to-Rear (includes Rear-End)	3	0%	2	0%	5	0%	
2-Straight	Front-to-Front (includes Head-On)	10	0%	11	0%	21	0%	
2-Straight	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Straight	Angle	1592	63%	1368	62%	2960	62%	SCP
2-Straight	Sideswipe - Same Direction	1	0%	1	0%	2	0%	
2-Straight	Sideswipe - Opposite Direction	1	0%	0	0%	1	0%	
2-Straight	Unknown	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Front-to-Rear (includes Rear-End)	0	0%	2	0%	2	0%	
1-Straight & 1-Turning Left	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Rear-to-Rear	17	1%	10	0%	27	1%	LTCP
1-Straight & 1-Turning Left	Angle	498	20%	463	21%	961	20%	
1-Straight & 1-Turning Left	Sideswipe - Same Direction	2	0%	0	0%	2	0%	
1-Straight & 1-Turning Left	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Left	Unknown	0	0%	1	0%	1	0%	
1-Straight & 1-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	1	0%	1	0%	
1-Straight & 1-Turning Right	Front-to-Front (includes Head-On)	5	0%	1	0%	6	0%	
1-Straight & 1-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Angle	26	1%	18	1%	44	1%	RTCP
1-Straight & 1-Turning Right	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
1-Straight & 1-Turning Right	Unknown	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Angle	2	0%	1	0%	3	0%	
1-Turning Left & 1-Turning Right	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
1-Turning Left & 1-Turning Right	Sideswipe - Opposite Direction	1	0%	0	0%	1	0%	
1-Turning Left & 1-Turning Right	Unknown	0	0%	0	0%	0	0%	
2-Turning Left	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Turning Left	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
2-Turning Left	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
2-Turning Left	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Turning Left	Angle	1	0%	2	0%	3	0%	
2-Turning Left	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
2-Turning Left	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
2-Turning Left	Unknown	0	0%	0	0%	0	0%	
2-Turning Right	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
2-Turning Right	Front-to-Rear (includes Rear-End)	0	0%	0	0%	0	0%	
2-Turning Right	Front-to-Front (includes Head-On)	0	0%	0	0%	0	0%	
2-Turning Right	Rear-to-Rear	0	0%	0	0%	0	0%	
2-Turning Right	Angle	0	0%	0	0%	0	0%	
2-Turning Right	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
2-Turning Right	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
2-Turning Right	Unknown	0	0%	0	0%	0	0%	
Other	Not Collision with Motor Vehicle in Transport	0	0%	0	0%	0	0%	
Other	Front-to-Rear (includes Rear-End)	5	0%	11	0%	16	0%	
Other	Front-to-Front (includes Head-On)	6	0%	5	0%	11	0%	
Other	Rear-to-Rear	0	0%	0	0%	0	0%	
Other	Angle	357	14%	310	14%	667	14%	
Other	Sideswipe - Same Direction	0	0%	0	0%	0	0%	
Other	Sideswipe - Opposite Direction	0	0%	0	0%	0	0%	
Other	Unknown	0	0%	3	0%	3	0%	
TOTALS:		2527		2210		4737		

Figure D-3: Complete Break down of Intersection Crash Scenarios by the FARS *Vehicle Maneuver* and *Manner of Collision* Variables at Stop Sign Controlled Intersections.

As shown in Figures D-2 and D-3, fatal crashes involving one vehicle traveling straight and the other turning left existed in which the *Manner of Collision* was coded as rear-to-rear. These crashes may or may not have been crossing path crashes, however they were included in the LTCP analysis since the directions of travel of the vehicles may have been misunderstood. Moreover, due to their small frequency they have little effect on the overall results of the analysis.

Traffic Control Device

The target crashes were separated by traffic control device and then examined by intersection crash scenario. Figures D-4 and D-5 show the distribution of fatal crashes among the three crossing path crash scenarios occurring at intersections controlled by signals and stop signs, respectively.

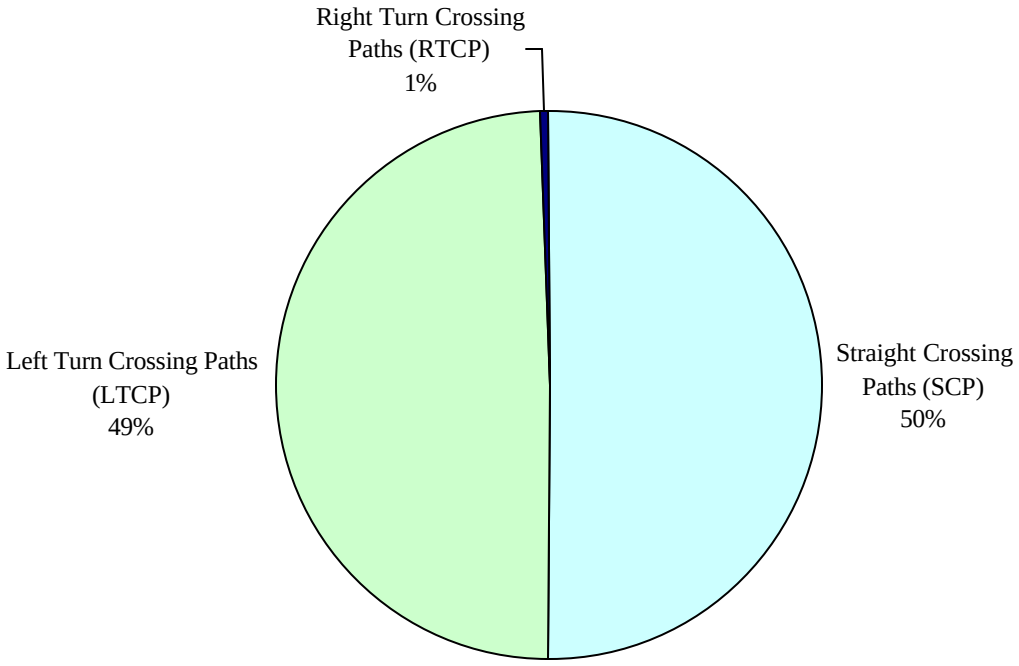


Figure D-4: Distribution of All Light Vehicle Fatal Crossing Path Crash Scenarios for Signalized Intersections.

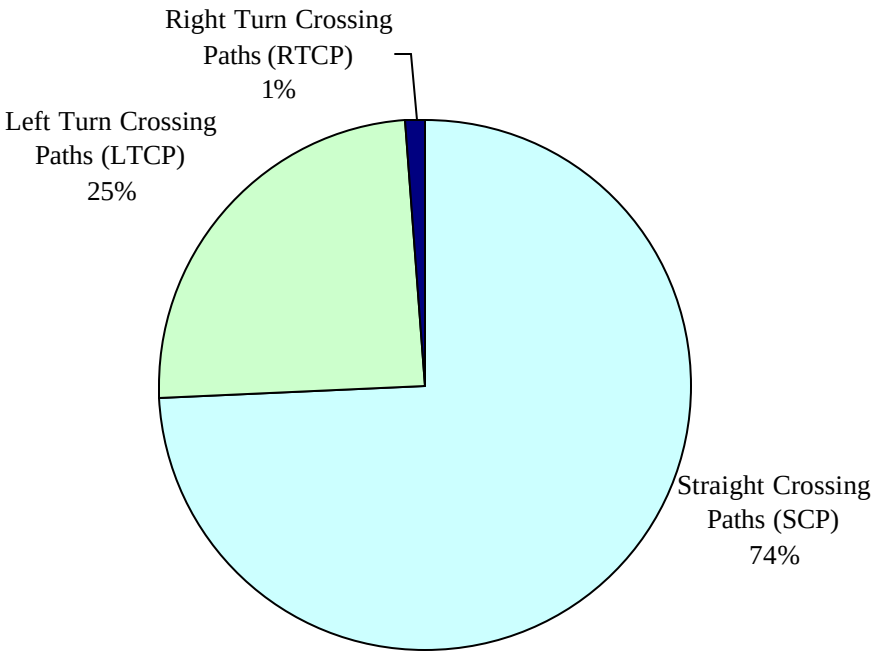


Figure D-5: Distribution of All Light Vehicle Fatal Crossing Path Crash Scenarios for Intersections Controlled by Stop Signs.

The SCP and LTCP scenarios dominated for both types of traffic control. Moreover, 1% of fatal crossing path crashes were RTCP for both traffic control devices. The frequencies of fatal crossing path crashes are provided in Table D-2.

Table D-2: Frequency of Light Vehicle Fatal Crossing Path Crash Scenarios by Traffic Control Device.

CRASH SEVERITY	Traffic Control Device	LTCP	SCP	RTCP	Total
Fatal	Signals	1059	1075	12	2146
	Stop Signs	988	2960	44	3992

Note: An additional 667 fatal crossing path crashes occurred at intersections controlled by a stop sign. These crashes were not included in the analysis since the vehicle maneuver of one or both the vehicles was coded as "other".

Note that the dynamics of turning left, going straight, or turning right were segregated since these are very different types of pre-event movements and each could require a different approach to sign/signal violation countermeasure development.

Traffic Control Device Violations

In this subtask, the crash population of light vehicles cited with a violation of the sign/signal were identified. The following approach is based on the notion that nearly all of the target crashes contain vehicles that were cited for failing to yield or obey the sign/signal. Vehicles were identified as "violating the signal" based on the following codes from the *Related Factors-Driver Level* and *Violations Charged* variables from the FARS database (*4*):

Related Factors-Driver Level:

Code 38: Failure to Yield Right-of-Way
Code 39: Failure to Obey Actual Traffic Sign, Traffic Control Devices or Traffic Officers

Violations Charged:

Code 31: Fail to Stop for Red Signal
Code 32: Fail to Stop for Flashing Red
Code 35: Fail to Obey Signal, Generally
Code 38: Fail to Obey Yield Sign
Code 39: Fail to Obey Traffic Control Device

Vehicles were identified as "violating the stop sign" or "failing to yield" based on the following codes from the *Related Factors-Driver Level* and *Violations Charged* variables from the FARS database (*4*):

Related Factors-Driver Level:

Code 38: Failure to Yield Right-of-Way
Code 39: Failure to Obey Actual Traffic Sign, Traffic Control Devices or Traffic Officers

Violations Charged:

Code 37: Fail to Obey Stop Sign
Code 39: Fail to Obey Traffic Control Device

Vehicles that were identified as "violating the stop sign" or "failing to yield" were later separated out by the type of violation: failure to obey the sign or failure to yield (Additional information on the classification of the *Failure to Obey* and *Failure to Yield* cases can be found in the *Traffic Control Device: Stop Sign* section). Table D-3 provides the distribution of crashes in which one or both vehicles were cited for a violation. Note that the statistics shown in Table are presented on the crash level.

Table D-3: Distribution of Crashes With One or Both Light Vehicles Violating the Sign/Signal or Failing to Yield.

CRASH SEVERITY	Signals			Stop Signs		
	LTCP	SCP	RTCP	LTCP	SCP	RTCP
Fatal	905	849	10	883	2700	33
	85%	79%	83%	89%	91%	75%

% represents what percentage of the total crossing path crash scenario collisions involved one or both light vehicles violating the sign/signal or failing to yield.

Between 79% and 85% of the fatal crashes that occurred at signalized intersections involved at least one light vehicle violating the signal. Similarly, for fatal stop sign crashes, between 75% and 91% of the crashes involved a violation of the stop sign or failure to yield by a light vehicle.

Traffic Signal Violations

Table D-4 provides the distribution of light vehicles that violated the signal. Note that in Table D-4 the crashes are sorted on the vehicle level by the pre-crash maneuver that the violating vehicle was trying to perform. Since the crashes are sorted on the vehicle level, the sum of the pre-crash maneuvers may be larger than the number of crashes presented in Table D-3 for a

particular scenario. For example, in an LTCP crash, it is possible for both vehicles to violate the signal; the vehicle traveling straight may try to beat the red signal and the turning vehicle may have been stuck in the intersection waiting for an appropriate gap. Both vehicles would be accounted for in Table D-4 since they both violated the signal.

Table D-4: Distribution of Pre-Crash Maneuvers by Light Vehicles that Violated the Signal.

CRASH SEVERITY	Signals				
	LTCP		SCP	RTCP	
	Left Turn	Straight		Right Turn	Straight
Fatal	702	220	862	9	2

Note: Sum of pre-crash maneuvers may be larger than number of crashes since both vehicles violated the signal in some crashes.

Based on the LTCP distribution of pre-crash maneuvers, 78% (702/905) of the fatal crashes involved vehicles turning left compared to 24% (220/905) traveling straight through the intersection, approximately a ratio of three to one. The large number of fatal crashes for vehicles turning left may be due to vehicles that were sitting in the middle of the intersection waiting to turn, the signal turned red, and then they completed their maneuver. Since the signal had already turned red they would have been cited for violating the signal. Additionally, the large number of fatal collisions involving vehicles turning left may also reflect drivers that misjudged the gap distance (i.e., LTAP/OD scenario).

Due to the timing of a traffic signal, at least one vehicle has to violate a red signal in the following scenarios: SCP, LTAP/LD and LTIP. However, a citation is not issued in all of the crashes in the FARS database; Table D-4 only shows the vehicles in which a citation was issued. For the LTAP/OD and RTIP scenarios, a red light violation may or may not exist.

Stop Sign Violations

In the case of stop sign crashes, a distinction was made between a vehicle that "entered the intersection without stopping" and a vehicle that "stopped first and then proceeded against traffic." Only vehicles that "entered the intersection without stopping" entail a stop sign violation. Cases where the driver ran the stop sign were coded as *Failure to Obey;* drivers that stopped first and then proceeded against crossing traffic were generally coded as *Failure to Yield*. Drivers were identified as *Failure to Obey* or *Failure to Yield* based on codes from the *Related Factors-Driver Level* variable from the FARS database. Drivers that were coded as both *Failure to Obey* and *Failure to Yield* were classified as *Failure to Obey*.

The vehicle-based warning system currently under investigation by VTTI would only provide a warning for drivers who are about to run a stop sign, not for drivers who stop first and then proceed against traffic. However, it is still important to analyze both the *Failure to Obey* and *Failure to Yield* cases since drivers that violated the stop sign may have been coded as *Failure to Yield*.

The distribution of light vehicles that violated the stop sign is provided in Table D-5. The vehicles are sorted by the type of pre-crash maneuver that the vehicle was trying to complete in addition to the type of violation issued.

Table D-5: Distribution of Pre-Crash Maneuvers by Light Vehicles at Stop Sign Controlled Intersections.

CRASH SEVERITY	Type of Violation	Stop Sign				
		LTCP		SCP	RTCP	
		Left Turn	Straight		Right Turn	Straight
Fatal	Failure to Obey	123	18	1639	12	1
	Failure to Yield	735	12	1077	19	1

Note: Sum of pre-crash maneuvers may be larger than number of crashes since both vehicles violated the sign in some crashes.

Similar to vehicles that violated the signal in LTCP crashes, the majority of violating vehicles in LTCP stop sign crashes were also turning left. Additionally for RTCP crashes, 94% (31/33) of the violating vehicles were attempting to take a right turn. One possible scenario to explain the discrepancy between the pre-crash maneuvers would be the intersection of a major street and a minor street; the major uncontrolled and the minor controlled by a stop sign. As an example, vehicles from the minor street may be attempting to turn left onto the major street and misjudge the gap. Furthermore, drivers from the major street may fail to yield as they cross traffic while turning left onto the minor street.

It is also interesting to note the type of violation that was issued. For LTCP crashes, 83% (735/883) of the violating vehicles performing a left turn maneuver were cited with *Failure to Yield*, compared to 14% (123/883) that were cited with *Failure to Obey.* However, the reverse is true when looking at vehicles traveling straight through the intersection. In LTCP crashes, more vehicles were cited with *Failure to Obey* than with *Failure to Yield*. For SCP fatal crashes, 61% (1639/2700) of the violating vehicles were cited with *Failure to Obey* compared to 40% (1077/2700) cited with *Failure to Yield*. (Note the sums of the distributions do not add to 100% since two vehicles may have both been cited for violating the stop sign in the same crash.) For RTCP crashes, 61% (20/33) of the violating vehicles were cited with *Failure to Yield* and 39% (13/33) were cited with *Failure to Obey.*

Crash Contributing Factors

Crash causal or contributing factors were determined for all light vehicles that violated the signal or stop sign based on the pre-crash maneuver that the vehicle was trying to perform. Based on an in-depth examination of the 1999 and 2000 FARS databases, the following contributing factors were identified for the target crashes:

- Deliberate Unsafe Driving Act
- Police Pursuit
- Alcohol/Drugs
- Ill/Blackout
- Sleepy/Drowsy
- Other Driver Physical Impairments
- Vehicle Defects
- Emotion
- Inattention
- Driver's Vision Obscured
- Speeding
- Erratic Action
- Infrastructure Factor
- Unfamiliarity

The contributing factors: *Deliberate Unsafe Driving Act* and *Police Pursuit* are characterized by the driver's deliberate violation of the signal. In the case of a deliberate unsafe driving act, the driver was charged with either vehicular manslaughter/homicide or willful reckless driving. For police pursuit cases, the driver deliberately violated the sign/signal to elude the police. FARS defines a police pursuit as an "event that is initiated when a law enforcement officer, operating an authorized emergency vehicle, gives notice to stop to a motorist, and that motorist fails to comply with the signal to stop by either maintaining his/her speed, increasing speed, of taking other evasive actions to elude the officer's continued attempts to stop the motorist" (*4*).

Other Physical Impairments encompass additional physical impairments not previously accounted for in the factors: *Ill/Blackout* and *Sleepy/Drowsy*; for example, a driver who was physically impaired as a result of a previous injury. The driver's mental condition was also included as a crash contributing factor in *Emotion*. Particular attention was paid to whether the driver was depressed, angry, disturbed, etc. An example of a case coded as *Emotion* would be if the driver and a passenger were having a disagreement in the vehicle.

Additional factors that contributed to fatal crashes include: *Erratic Actions*, *Infrastructure Factor*, and *Unfamiliarity*. The factor, *Vehicle Defect*, describes preexisting vehicle conditions that were not caused by the damage in the crash. *Erratic Actions* were considered as reckless, careless, or negligent actions taken by the driver. The *Infrastructure Factor* encompasses improper roadway signing, construction-created conditions, poor pavement markings, as well as if a recent collision scene is located nearby. *Unfamiliarity* accounts for drivers with limited operator experience, in addition to drivers who are unfamiliar with the roadway.

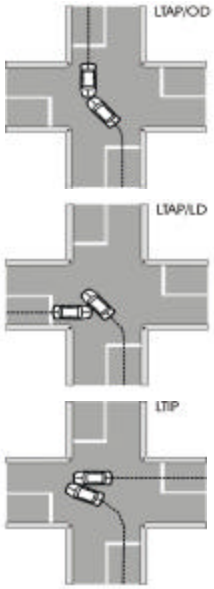
Hit and Run crashes were also added to the above list of possible contributing factors. Since the police accident report typically contains little information about the drivers' actions, contributing factors for hit and run crashes are generally unknown. In addition to the previous factors, the environmental conditions at the time of the crash were analyzed to see if they might have possibly contributed towards the collision. Based on the Indiana Tri-Level Study, environmental factors were shown to play a definite role in 12.4% of all roadway crashes (*8*). The environmental conditions recorded at the crash scene in the FARS database include the light condition, roadway surface condition, and atmospheric condition. The *Light Condition* variable, describes the ambient, artificial, or natural sources of light at the time of the crash. The *Roadway Surface Condition* variable describes the surface condition of the roadway immediately prior to the location of the vehicle's critical pre-crash event. The *Atmospheric Condition* variable attempts to depict any precipitation or particle dispersion that may have affected the driver's visibility or the vehicle's control. Adverse environmental conditions were noted in all cases unless the crash occurred during daylight hours (lighting condition), on dry pavement (roadway surface condition), and in clear weather (atmospheric condition).

The relative frequency distributions of the contributing factors for each fatal crossing path crash scenario are provided in Figures D-6 through D-8. For LTCP and SCP crashes, *Inattention* was one of the top three contributing factors for all vehicles that violated the signal/stop sign. Other influential contributing factors include: *Speeding* and *Deliberate Unsafe Driving Acts*. Due to the small number of RTCP fatal crashes, a clear picture of the contributing factors for RTCP crashes was unable to be obtained.

LTCP

Total # of Fatal LTCP (Signal) cases = 1059
One or both vehicles violated the signal in 85% of the cases [count=905]
Both vehicles violated the signal in 1.6% of the cases [count=17]
A total of 922 vehicles violated the signal

Total # of Fatal LTCP (Stop Sign) cases = 988
One or both vehicles violated the sign in 89% of the cases [count=883]
Both vehicles violated the sign in 0.5% of the cases [count=5]
A total of 888 vehicles violated the sign



Straight Causal Factor Analysis

	LTCP(Signal)				LTCP(Stop Sign)							
					Failure to Obey				*Failure to Yield*			
	Turning Left		Traveling Straight		Turning Left		Traveling Straight		Turning Left		Traveling Straight	
Deliberate Unsafe Driving Act	**46**	**7%**	**34**	**15%**	4	3%	0	0%	20	3%	1	8%
Police Pursuit	1	0%	5	2%	0	0%	0	0%	1	0%	0	0%
Alcohol/Drugs	20	3%	18	8%	3	2%	0	0%	4	1%	0	0%
Ill/Blackout	1	0%	2	1%	0	0%	0	0%	4	1%	1	8%
Sleepy/Drowsy	0	0%	3	1%	0	0%	0	0%	2	0%	0	0%
Other Driver Physical Impairments	1	0%	0	0%	0	0%	0	0%	1	0%	0	0%
Vehicle Defects	2	0%	7	3%	1	1%	0	0%	3	0%	1	8%
Emotion	0	0%	0	0%	0	0%	0	0%	1	0%	0	0%
Inattention	**67**	**10%**	21	10%	**15**	**12%**	**2**	**11%**	**69**	**9%**	0	0%
Driver's Vision Obscured	13	2%	1	0%	3	2%	0	0%	**42**	**6%**	1	8%
Speeding	4	1%	**37**	**17%**	4	3%	**4**	**22%**	1	0%	**2**	**17%**
Erratic Action	18	3%	10	5%	3	2%	1	6%	17	2%	**2**	**17%**
Infrastructure Factor	3	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Unfamiliarity	8	1%	0	0%	2	2%	0	0%	3	0%	0	0%
Hit & Run	12	2%	4	2%	2	2%	0	0%	4	1%	0	0%
Adverse Environmental Conditions	**287**	**41%**	**87**	**40%**	**46**	**37%**	**6**	**33%**	**206**	**28%**	**3**	**25%**
Sum:		*69%*		*104%*		*67%*		*72%*		*51%*		*92%*
Total Cases:	*702*		*220*		*123*		*18*		*735*		*12*	

Priority Scheme

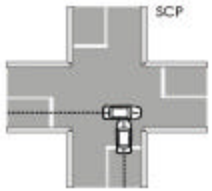
	LTCP(Signal)				LTCP(Stop Sign)							
					Failure to Obey				*Failure to Yield*			
	Turning Left		Traveling Straight		Turning Left		Traveling Straight		Turning Left		Traveling Straight	
(-1) Deliberate Unsafe Driving Act	46	7%	34	15%	4	3%	0	0%	20	3%	1	9%
(-2) Police Pursuit	1	0%	4	2%	0	0%	0	0%	1	0%	0	0%
1 Alcohol/Drugs	11	2%	3	2%	3	3%	0	0%	2	0%	0	0%
2 Ill/Blackout	0	0%	2	1%	0	0%	0	0%	4	1%	1	9%
3 Sleepy/Drowsy	0	0%	3	2%	0	0%	0	0%	2	0%	0	0%
4 Other Driver Physical Impairments	1	0%	0	0%	0	0%	0	0%	1	0%	0	0%
5 Vehicle Defects	1	0%	5	3%	1	1%	0	0%	3	0%	1	9%
6 Emotion	0	0%	0	0%	0	0%	0	0%	1	0%	0	0%
7 Inattention	64	10%	16	9%	15	13%	2	11%	66	9%	0	0%
8 Driver's Vision Obscured	13	2%	0	0%	1	1%	0	0%	38	5%	0	0%
9 Speeding	1	0%	22	12%	3	3%	4	22%	1	0%	1	9%
10 Erratic Action	14	2%	6	3%	1	1%	1	6%	12	2%	2	18%
11 Infrastructure Factor	2	0%	0	0%	0	0%	0	0%	0	0%	0	0%
12 Unfamiliarity	5	1%	0	0%	1	1%	0	0%	0	0%	0	0%
13 Hit & Run	9	1%	1	1%	1	1%	0	0%	3	0%	0	0%
14 Adverse Environmental Conditions	208	32%	46	25%	34	29%	2	11%	162	23%	2	18%
Sum (1-14):	329	*50%*	104	*57%*	60	50%	9	50%	295	41%	7	64%
Number Cases:	*702*		*220*		*123*		*18*		*735*		*12*	
- Deliberate Violations	*47*	*7%*	*38*	*17%*	*4*	*3%*	*0*	*0%*	*21*	*3%*	*1*	*8%*
Total Target Cases:	*655*		*182*		*119*		*18*		*714*		*11*	

Figure D-6: LTCP Crash Contributing and Primary Factors.

SCP

Total # of Fatal SCP (Signal) cases = 1075
One or both vehicles violated the signal in 79% of the cases [count=849]
Both vehicles violated the signal in 1.2% of the cases [count=13]
A total of 862 vehicles violated the signal

Total # of Fatal SCP (Stop Sign) cases = 2960
One or both vehicles violated the sign in 91% of the cases [count=2700]
Both vehicles violated the sign in 0.5% of the cases [count=16]
A total of 2716 vehicles violated the sign



Straight Causal Factor Analysis

	SCP(Signal)		SCP(Stop Sign)			
			Failure to Obey		*Failure to Yield*	
	Traveling Straight		Traveling Straight		Traveling Straight	
Deliberate Unsafe Driving Act	**106**	**12%**	**182**	**11%**	**51**	**5%**
Police Pursuit	21	2%	16	1%	0	0%
Alcohol/Drugs	61	7%	61	4%	25	2%
Ill/Blackout	4	0%	6	0%	1	0%
Sleepy/Drowsy	3	0%	3	0%	3	0%
Other Driver Physical Impairments	2	0%	1	0%	2	0%
Vehicle Defects	13	2%	21	1%	8	1%
Emotion	2	0%	2	0%	0	0%
Inattention	82	10%	**198**	**12%**	**119**	**11%**
Driver's Vision Obscured	12	1%	37	2%	37	3%
Speeding	**124**	**14%**	159	10%	18	2%
Erratic Action	38	4%	71	4%	26	2%
Infrastructure Factor	7	1%	6	0%	1	0%
Unfamiliarity	5	1%	13	1%	9	1%
Hit & Run	45	5%	54	3%	13	1%
Adverse Environmental Conditions	**403**	**47%**	**674**	**41%**	**316**	**29%**
Sum:	928	*108%*	1504	*92%*	629	*58%*
Total Cases:	*862*		*1639*		*1077*	

Priority Scheme

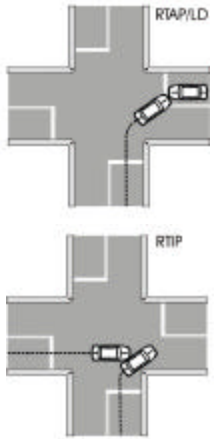
		SCP(Signal)		SCP(Stop Sign)			
				Failure to Obey		*Failure to Yield*	
		Traveling Straight		Traveling Straight		Traveling Straight	
(-1)	Deliberate Unsafe Driving Act	106	12%	182	11%	51	5%
(-2)	Police Pursuit	15	2%	10	1%	0	0%
1	Alcohol/Drugs	25	3%	20	1%	12	1%
2	Ill/Blackout	4	1%	5	0%	1	0%
3	Sleepy/Drowsy	2	0%	1	0%	3	0%
4	Other Driver Physical Impairments	1	0%	1	0%	2	0%
5	Vehicle Defects	10	1%	17	1%	7	1%
6	Emotion	0	0%	1	0%	0	0%
7	Inattention	67	9%	171	12%	107	10%
8	Driver's Vision Obscured	7	1%	28	2%	26	3%
9	Speeding	69	9%	98	7%	10	1%
10	Erratic Action	10	1%	33	2%	19	2%
11	Infrastructure Factor	4	1%	2	0%	1	0%
12	Unfamiliarity	2	0%	5	0%	5	0%
13	Hit & Run	15	2%	16	1%	9	1%
14	Adverse Environmental Conditions	215	29%	405	28%	230	22%
	Sum (1-14):	431	58%	803	55%	432	42%
	Number Cases:	*862*		*1639*		*1077*	
	- Deliberate Violations	*121*	*14%*	*192*	*12%*	*51*	*5%*
	Total Target Cases:	*741*		*1447*		*1026*	

Figure D-7: SCP Crash Contributing and Primary Factors.

RTCP

Total # of Fatal RTCP (Signal) cases = 12
One or both vehicles violated the signal in 92% of the cases [count=11]
Both vehicles violated the signal in 0% of the cases [count=0]
A total of 11 vehicles violated the signal

Total # of Fatal RTCP (Stop Sign) cases = 44
One or both vehicles violated the sign in 75% of the cases [count=33]
Both vehicles violated the sign in 0% of the cases [count=0]
A total of 33 vehicles violated the sign



Straight Causal Factor Analysis

	RTCP(Signal)				RTCP(Stop Sign)							
					Failure to Obey				*Failure to Yield*			
	Turning Right		Traveling Straight		Turning Right		Traveling Straight		Turning Right		Traveling Straight	
Deliberate Unsafe Driving Act	**1**	**11%**	0	0%	**1**	**8%**	**1**	**100%**	1	5%	0	0%
Police Pursuit	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Alcohol/Drugs	0	0%	0	0%	**1**	**8%**	0	0%	0	0%	0	0%
Ill/Blackout	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Sleepy/Drowsy	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Other Driver Physical Impairments	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Vehicle Defects	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Emotion	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Inattention	**1**	**11%**	0	0%	0	0%	0	0%	1	5%	0	0%
Driver's Vision Obscured	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Speeding	0	0%	0	0%	0	0%	0	0%	1	5%	0	0%
Erratic Action	0	0%	0	0%	0	0%	0	0%	**2**	**11%**	0	0%
Infrastructure Factor	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Unfamiliarity	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Hit & Run	0	0%	**1**	**50%**	0	0%	0	0%	0	0%	0	0%
Adverse Environmental Conditions	**3**	**33%**	**2**	**100%**	**5**	**42%**	**1**	**100%**	**7**	**37%**	0	0%
Sum:	5	*56%*	3	*150%*	7	*58%*	2	*200%*	12	*63%*	0	*0%*
Total Cases:	*9*		*2*		*12*		*1*		*19*		*1*	

Priority Scheme

	RTCP(Signal)				RTCP(Stop Sign)							
					Failure to Obey				*Failure to Yield*			
	Turning Right		Traveling Straight		Turning Right		Traveling Straight		Turning Right		Traveling Straight	
(-1) Deliberate Unsafe Driving Act	1	11%	0	0%	1	8%	1	100%	1	5%	0	0%
(-2) Police Pursuit	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
1 Alcohol/Drugs	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
2 Ill/Blackout	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
3 Sleepy/Drowsy	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
4 Other Driver Physical Impairments	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
5 Vehicle Defects	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
6 Emotion	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
7 Inattention	1	13%	0	0%	0	0%	0	0%	1	6%	0	0%
8 Driver's Vision Obscured	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
9 Speeding	0	0%	0	0%	0	0%	0	0%	1	6%	0	0%
10 Erratic Action	0	0%	0	0%	0	0%	0	0%	2	11%	0	0%
11 Infrastructure Factor	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
12 Unfamiliarity	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
13 Hit & Run	0	0%	1	50%	0	0%	0	0%	0	0%	0	0%
14 Adverse Environmental Conditions	3	38%	1	50%	5	45%	0	0%	5	28%	0	0%
Sum (1-14):	4	*50%*	2	*100%*	5	45%	0	0%	9	50%	0	0%
Number Cases:	*9*		*2*		*12*		*1*		*19*		*1*	
- Deliberate Violations	*1*	*11%*	*0*	*0%*	*1*	*8%*	*1*	*100%*	*1*	*5%*	*0*	*0%*
Total Target Cases:	*8*		*2*		*11*		*0*		*18*		*1*	

Figure D-8: RTCP Crash Contributing and Primary Factors.

Primary Contributing Factors

From multiple crash contributing factors, one primary factor was assigned for each crash through the use of a priority scheme that ranked the contributing factors in descending order by their degree of influence on a possible cause (*9*). This descending order of crash contributing factors was arranged as follows: alcohol/drugs, ill/blackout, sleepy/drowsy, other driver physical impairments, vehicle defects, emotion, inattention, driver's vision obscured, speeding, erratic action, infrastructure factor, unfamiliarity, and hit and run. Note that the first two contributing factors identified for the target crashes: *Deliberate Unsafe Driving Act* and *Police Pursuit*, represent vehicles that deliberately violated the signal or stop sign. Cases in which the vehicle deliberately violated the signal/stop sign were first removed from the target crashes prior to performing the priority scheme. This approach is based on the notion that regardless if a violation warning system was present, these vehicles would have still deliberately violated the signal/stop sign.

The priority scheme was implemented by first extracting all of the cases within a target crash type involving alcohol/drugs. A process of elimination was then used to determine the involvement of other contributing factors. The remaining target crashes were examined for signs of illness or blacked-out drivers. The process was continued until all remaining primary contributing factors were analyzed. After all target crashes involving the contributing factors were extracted, the remaining crashes were examined to see if adverse environmental conditions played a role in the cause of the collision.

The relative frequency distributions of the primary contributing factors for each fatal crossing path crash scenario are provided in Figures D-6 through D-8. For LTCP crashes, *Inattention* was the primary crash contributing factor for vehicles attempting to perform a left turn. *Speeding* and *Inattention* were the top two primary factors for the pre-crash maneuver, traveling straight in LTCP and SCP crashes. *Speeding* may have been a factor for vehicles traveling straight through the intersection due to the driver not being aware of the stop sign or red signal and failing to slow down, or the driver may have been trying to beat the amber/orange light. Similar to the crash contributing factors, a clear picture of the causal factors for the RTCP scenario was unable to be determined.

Multiple Contributing Factors

Collisions are often caused by more than one factor. For example, a crash may occur while a driver is speeding and adjusting the car radio. The question arises as to whether the crash was caused by the vehicle's speed or by the inattentive driver. Cross-correlation charts were created to account for the crash contributing factors in scenarios that involve multiple factors. First, an initial contributing factor was chosen, and then cases which involved this contributing factor were extracted from the database. These extracted cases were then examined to see what other factors might have contributed to the crash. In the case of the previous example, the crash would be represented three times on the cross-correlation chart, having the following contributing factors: speeding, inattention, and both factors, speeding and inattention.

A sample cross-correlation chart is shown in Figure D-9. The primary factors are listed on the Y-axis (vertical axis) and the contributing factors are listed on the X-axis (horizontal axis). For example, in examining the contributing factors for F1, look across the row associated with F1. Block A represents all of the cases which include contributing factor F1. Block B represents all of the cases which involved contributing factors F1 and F2, block C all cases involving factors F1 and F3, and block D all cases affected by F1 and F4.

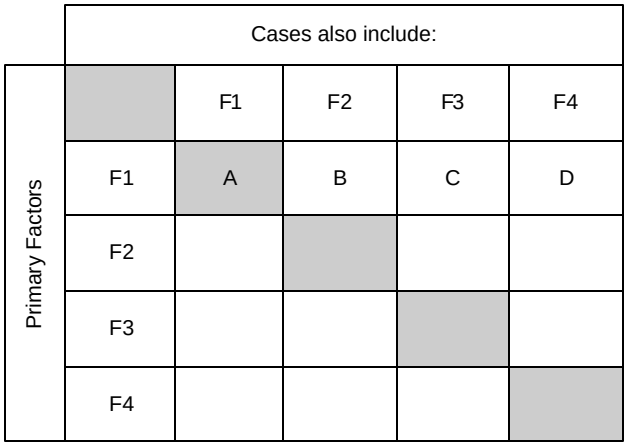


Figure D-9: Sample Cross-Correlation Chart.

Block A represents all cases that include contributing factor F1. It might be assumed that the sum of block B + block C + block D would be equal to or less than the total of block A; however, this is not always the case. For some crash types, the sum of the contributing factor blocks exceeds the total of the shaded block. As previously stated, crashes are often caused by more than one factor; sometimes they are caused by a combination of three or more factors. For example, a crash may have been caused by factors F1, F2, and F3. Therefore, it would be included in blocks A, B, and C, so when summing the total of blocks B and C this case would be counted twice.

Cross-correlation charts for each of the pre-crash maneuvers for each scenario are provided in Figures D-10 through D-24. In addition to the cross-correlation charts that portray multiples of two contributing factors per collision, multiples of three contributing factors are also listed in the figures.

Figure D-10: LTCP (Signal) - Pre-Crash Maneuver: Turning Left

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	40	0	9	1	0	0	0	0	3	0	1	1	0	0	3
Police Pursuit		1	0	0	0	0	1	0	0	0	1	0	0	0	0
Alcohol / Drugs			20	1	0	0	0	0	0	0	0	1	0	0	1
Ill/Blackout				1	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						1	0	0	0	0	0	0	0	0	0
Vehicle Defects							2	0	0	0	1	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									67	0	1	2	1	2	0
Driver's Vision Obscured										13	0	0	1	1	0
Speeding											4	0	0	0	0
Erratic Actions												18	0	0	0
Infrastructure Factor													3	0	0
Unfamiliarity														8	0
Hit & Run															12

Figure D-11: LTCP (Signal) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	34	1	15	0	0	0	0	0	2	0	7	2	0	0	1
Police Pursuit		5	1	0	0	0	1	0	0	0	3	1	0	0	0
Alcohol / Drugs			18	0	0	0	0	0	2	0	6	2	0	0	1
Ill/Blackout				2	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					3	0	1	0	1	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							7	0	2	1	2	1	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									21	0	4	0	0	0	0
Driver's Vision Obscured										1	0	0	0	0	0
Speeding											17	4	0	0	1
Erratic Actions												10	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															4

Combinations of Three:
Deliberate Unsafe Driving Act / Alcohol & Drugs / Adverse Environmental Conditions = 12
Deliberate Unsafe Driving Act / Alcohol & Drugs / Speeding = 4

Figure D-12: (A) Fail to Obey LTCP (Sign) - Pre-Crash Maneuver: Turning Left

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			3	0	0	0	0	0	0	0	0	2	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							1	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									15	2	0	0	0	0	0
Driver's Vision Obscured										3	1	0	0	0	0
Speeding											4	0	0	1	1
Erratic Actions												3	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														2	0
Hit & Run															2

Combinations of Three:
Alcohol & Drugs / Erratic Action / Adverse Environmental Conditions = 2

Figure D-13: (A) Fail to Obey LTCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									2	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											4	0	0	0	0
Erratic Actions												1	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-14: (B) Fail to Yield LTCP (Sign) - Pre-Crash Maneuver: Turning Left

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	20	0	2	0	0	0	0	2	0	0	0	1	0	0	1
Police Pursuit		1	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			4	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				4	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					2	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						1	0	0	1	0	0	0	0	0	0
Vehicle Defects							3	0	0	0	0	0	0	0	0
Emotion								1	0	0	0	0	0	0	0
Inattention									69	3	0	4	0	1	0
Driver's Vision Obscured										42	0	0	0	1	0
Speeding											1	0	0	0	0
Erratic Actions												17	0	1	0
Infrastructure Factor													0	0	0
Unfamiliarity														3	0
Hit & Run															4

Figure D-15: (B) Fail to Yield LTCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				1	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							1	0	0	1	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									0	0	0	0	0	0	0
Driver's Vision Obscured										1	0	0	0	0	0
Speeding											2	0	0	0	0
Erratic Actions												2	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-16: SCP (Signal) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	106	6	36	0	1	1	3	1	11	1	34	13	1	2	19
Police Pursuit		21	0	0	0	0	0	0	0	0	13	9	0	0	5
Alcohol / Drugs			61	0	1	1	3	2	1	0	13	5	1	0	9
Ill/Blackout				4	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					3	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						2	0	1	0	0	1	0	0	0	0
Vehicle Defects							13	0	2	0	2	0	0	1	0
Emotion								2	0	0	0	1	0	0	1
Inattention									82	5	10	3	1	0	3
Driver's Vision Obscured										12	2	0	0	0	0
Speeding											124	13	3	1	16
Erratic Actions												38	0	0	5
Infrastructure Factor													7	0	0
Unfamiliarity														5	0
Hit & Run															45

Combinations of Three:
Deliberate Unsafe Driving Act / Alcohol & Drugs / Speeding = 7
Deliberate Unsafe Driving Act / Police Pursuit / Speeding = 5
Deliberate Unsafe Driving Act / Alcohol & Drugs / Hit & Run = 6
Deliberate Unsafe Driving Act / Speeding / Hit & Run = 9
Deliberate Unsafe Driving Act / Speeding / Erratic Action = 5
Police Pursuit / Speeding / Erratic Action =5
Speeding / Erratic Action / Hit & Run =3

Figure D-17: (A) Fail to Obey SCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	182	6	40	1	1	0	4	0	22	4	32	23	0	2	22
Police Pursuit		16	1	0	0	0	0	0	2	0	5	4	0	0	0
Alcohol / Drugs			61	0	0	0	0	1	5	0	17	7	0	0	7
Ill/Blackout				6	1	0	1	0	0	1	2	0	0	0	0
Sleepy / Drowsy					3	0	0	0	0	1	0	0	0	0	0
Other Driver Physical Impairments						1	0	0	0	0	0	1	0	0	0
Vehicle Defects							21	0	2	0	3	1	0	0	0
Emotion								2	1	0	1	0	0	0	0
Inattention									198	4	19	3	1	4	5
Driver's Vision Obscured										37	4	1	1	1	0
Speeding											159	19	2	2	15
Erratic Actions												71	1	0	6
Infrastructure Factor													6	1	0
Unfamiliarity														13	0
Hit & Run															54

Combinations of Three:
Delibrate Unsafe Driving Act / Speeding / Erratic Action = 10
Delibrate Unsafe Driving Act / Alcohol & Drugs / Speeding = 9
Delibrate Unsafe Driving Act / Alcohol & Drugs / Hit & Run = 4
Delibrate Unsafe Driving Act / Speeding / Hit & Run = 3

Figure D-18: (B) Fail to Yield SCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	51	0	13	0	0	0	1	0	10	4	5	4	0	3	3
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			25	0	0	0	0	0	4	0	3	2	0	0	1
Ill/Blackout				1	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					3	0	0	0	0	1	0	0	0	0	0
Other Driver Physical Impairments						2	0	0	0	0	0	0	0	0	0
Vehicle Defects							8	0	2	0	1	0	0	1	0
Emotion								0	0	0	0	0	0	0	0
Inattention									119	6	1	2	0	3	3
Driver's Vision Obscured										37	0	0	0	0	1
Speeding											18	0	0	0	0
Erratic Actions												26	0	0	0
Infrastructure Factor													1	0	0
Unfamiliarity														9	0
Hit & Run															13

Figure D-19: RTCP (Signal) - Pre-Crash Maneuver: Turning Right

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									1	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											0	0	0	0	0
Erratic Actions												0	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-20: RTCP (Signal) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									0	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											0	0	0	0	0
Erratic Actions												0	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															1

Figure D-21: (A) Fail to Obey RTCP (Sign) - Pre-Crash Maneuver: Turning Right

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									0	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											0	0	0	0	0
Erratic Actions												0	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-22: (A) Fail to Obey RTCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									0	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											0	0	0	0	0
Erratic Actions												0	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-23: (B) Fail to Yield RTCP (Sign) - Pre-Crash Maneuver: Turning Right

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									1	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											1	0	0	0	0
Erratic Actions												2	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Figure D-24: (B) Fail to Yield RTCP (Sign) - Pre-Crash Maneuver: Traveling Straight

	Deliberate Unsafe Driving Acts	Police Pursuit	Alcohol / Drugs	Ill/Blackout	Sleepy / Drowsy	Other Driver Physical Impairments	Vehicle Defects	Emotion	Inattention	Driver's Vision Obscured	Speeding	Erratic Actions	Infrastructure Factor	Unfamiliarity	Hit & Run
Deliberate Unsafe Driving Acts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Police Pursuit		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcohol / Drugs			0	0	0	0	0	0	0	0	0	0	0	0	0
Ill/Blackout				0	0	0	0	0	0	0	0	0	0	0	0
Sleepy / Drowsy					0	0	0	0	0	0	0	0	0	0	0
Other Driver Physical Impairments						0	0	0	0	0	0	0	0	0	0
Vehicle Defects							0	0	0	0	0	0	0	0	0
Emotion								0	0	0	0	0	0	0	0
Inattention									0	0	0	0	0	0	0
Driver's Vision Obscured										0	0	0	0	0	0
Speeding											0	0	0	0	0
Erratic Actions												0	0	0	0
Infrastructure Factor													0	0	0
Unfamiliarity														0	0
Hit & Run															0

Speed Behavior

The speeding behavior of the drivers who violated the sign/signal was characterized based on the traffic control device. The correlation and distribution of the posted speed limits, travel speed, and speeding status of the violating vehicles were determined. Crash statistics in Tables D-6 and D-7 show the correlations between the speed behavior and the crossing path crash scenarios for intersections, based on the 1999 and 2000 FARS. The speed behavior column was separated into three categories; whether a violation was issued, whether the travel speed was greater than the posted speed limit, and whether one or both of the previous behaviors was cited. The following codes from the *Related Factors-Driver Level* and *Violations Charged* variables were used to determine if the driver was cited for speeding (*4*):

Related Factors-Driver Level:

Code 44: Driving Too Fast for Conditions or In Excess of Posted Maximum
Code 46: Racing

Violations Charged:

Code 21: Racing
Code 22: Speeding (above the speed limit)
Code 23: Speed Greater than Reasonable & Prudent (not necessarily over the limit)
Code 24: Exceeding Special Limit (e.g.: for trucks, buses, cycles, or on bridge, in school zone, etc.)
Code 29: Speed Related Violations, Generally

A few of the drivers in Tables D-6 and D-7 were cited for a speeding violation; however, their travel speed did not exceed the posted speed limit. These would be the cases of code 23 "Speed Greater than Reasonable and Prudent (not necessarily over the limit)."

The travel speed of the vehicle is coded on the vehicle level, in the *Travel Speed* variable. The travel speed is coded in actual miles per hour except for the following cases (*4*):

Code 00: Stopped Vehicle
Code 97: Ninety-seven mph or Greater
Code 98: Not Reported
Code 99: Unknown

The posted speed limit is coded on the accident level, in the *Speed Limit* variable. Since the variable is coded on the accident level, only one posted speed limit is coded for each crash, regardless of whether the intersecting roadways have different posted speeds. For the case of intersecting roadways with different speed limits, the speed limit for the roadway where the unstabilizing situation began was coded. The posted speed limit is coded in actual or statutory miles per hour except for the following cases (*4*):

Code 00: No Statutory Limit
Code 99: Unknown

Table D-6: Speed Behavior of Light Vehicles Involved in Fatal Crossing Path Crashes that Violated the Signal.

CRASH SEVERITY	Speed Behavior	Signal				
		LTCP		SCP	RTCP	
		Left Turn	Straight		Right Turn	Straight
Fatal	Violation Cited	4	37	124	0	0
	TS > PSL	7	33	93	0	0
	Violation &/or TS > PSL	10	55	168	0	0

Note: Sum of counts may be larger than number of crashes since both vehicles violated the signal in some crashes; Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-7: Speed Behavior of Light Vehicles Involved in Fatal Crossing Path Crashes at Stop Sign Controlled Intersections.

CRASH SEVERITY	Speed Behavior	Stop Sign				
		LTCP		SCP	RTCP	
		Left Turn	Straight		Right Turn	Straight
Fatal	Failure to Obey					
	Violation Cited	4	4	159	0	0
	TS > PSL	0	3	99	0	0
	Violation &/or TS > PSL	4	4	208	0	0
	Failure to Yield					
	Violation Cited	1	2	18	1	0
	TS > PSL	5	2	14	0	0
	Violation &/or TS > PSL	5	2	25	1	0

Note: Sum of counts may be larger than number of crashes since both vehicles violated the sign in some crashes; Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Speed was largely a factor for vehicles attempting to travel straight through the intersection. For LTCP crashes, 25% (55/220) of the violating vehicles attempting to travel straight through the signalized intersection were traveling at a speed of at least 5 mph over the posted speed limit and/or were issued a violation for speeding. Examining LTCP stop sign violations for vehicles traveling straight, speed was a factor in 22% (4/18) of the *Failure to Obey* and 17% (2/12) of the *Failure to Yield*. For SCP crashes, speed was a factor in 19% (168/862) of the signal violations and 13% (208/1639) of the *Failure to Obey* stop sign collisions.

A further breakdown of the posted speed limit and variance of the travel speed is provided in Tables D-8 through D-22 for each of the pre-crash maneuvers for each crossing path crash scenario. Based on the following tables, approximately 61% of the travel speeds coded in the 1999 and 2000 FARS database were either not reported or unknown.

Table D-8: LTCP-Signal (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
0	1	0	0	0	1	0	0
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	5	0	0	0	2	0	3
30	11	1	0	0	0	0	10
35	46	2	1	1	2	8	32
40	38	2	1	0	1	10	24
45	56	11	0	2	1	20	22
50	23	4	0	0	0	8	11
55	30	1	0	0	0	10	19
60	0	0	0	0	0	0	0
65	4	0	0	0	0	3	1
70	0	0	0	0	0	0	0
Unknown	6	0	0	0	0	0	6

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-9: LTCP-Signal (*Pre-Crash Maneuver: Turning Left)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	1	0	0	0	0	1	0
25	16	0	0	0	0	3	13
30	31	0	0	0	0	7	24
35	117	1	0	0	0	31	85
40	131	1	0	0	1	55	74
45	212	2	0	0	0	105	105
50	63	0	0	0	0	29	34
55	105	0	0	0	1	35	69
60	5	0	0	0	1	1	3
65	5	0	0	0	0	3	2
70	0	0	0	0	0	0	0
Unknown	16	0	0	0	0	5	11

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-10: LTCP-Sign (A) Fail to Obey (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	1	0	0	0	0	0	1
35	5	0	1	0	0	2	2
40	4	0	0	0	1	1	2
45	2	1	0	0	0	0	1
50	1	0	0	0	0	0	1
55	4	0	0	0	0	1	3
60	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0
Unknown	1	0	0	0	0	0	1

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-11: LTCP-Sign (A) Fail to Obey (*Pre-Crash Maneuver: Turning Left)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	2	0	0	0	0	0	2
30	6	0	0	0	0	1	5
35	10	0	0	0	0	4	6
40	10	0	0	0	0	4	6
45	24	0	0	0	0	8	16
50	7	0	0	0	0	2	5
55	50	0	0	0	0	19	31
60	3	0	0	0	0	1	2
65	6	0	0	0	0	4	2
70	2	0	0	0	0	0	2
Unknown	3	0	0	0	0	1	2

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-12: LTCP-Sign (B) Fail to Yield (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	1	1	0	0	0	0	0
35	2	0	0	0	0	1	1
40	2	0	0	1	0	0	1
45	2	0	0	0	0	0	2
50	2	0	0	0	0	1	1
55	1	0	0	0	0	1	0
60	0	0	0	0	0	0	0
65	2	0	0	0	0	0	2
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-13: LTCP-Sign (B) Fail to Yield (*Pre-Crash Maneuver: Turning Left)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
5	1	0	0	0	0	1	0
20	0	0	0	0	0	0	0
25	16	0	0	0	0	2	14
30	41	1	0	0	0	6	34
35	71	0	0	0	1	30	40
40	78	1	0	0	0	34	43
45	168	0	0	0	0	77	91
50	48	1	0	0	0	20	27
55	252	0	0	0	1	105	146
60	18	0	0	0	0	9	9
65	28	0	0	0	0	13	15
70	6	0	0	0	0	1	5
Unknown	8	0	0	0	0	0	8

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-14: SCP-Signal (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	1	1	0	0	0	0	0
25	59	0	0	2	4	6	47
30	94	3	2	2	5	15	67
35	207	12	6	4	14	33	138
40	119	6	2	1	4	33	73
45	181	6	1	2	11	61	100
50	58	1	0	1	0	15	41
55	108	2	0	0	0	18	78
60	7	1	0	0	0	3	3
65	4	0	0	0	0	3	1
70	0	0	0	0	0	0	0
Unknown	25	0	0	0	0	0	25

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-15: SCP-Sign (A) Fail to Obey(*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
0	5	0	0	0	2	0	3
15	1	0	0	0	0	1	0
20	2	0	0	0	0	2	0
25	97	4	2	4	8	11	68
30	119	4	2	1	4	16	92
35	127	9	0	0	7	35	76
40	63	4	0	0	0	21	38
45	163	6	1	1	3	60	92
50	82	2	1	1	0	20	58
55	793	16	5	4	5	323	440
60	42	0	0	0	0	8	34
65	91	2	0	0	1	29	59
70	41	0	0	0	0	5	36
Unknown	13	0	0	0	0	1	12

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-16: SCP-Sign (B) Fail to Yield (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	1	0	0	0	0	0	1
20	2	0	0	0	0	0	2
25	32	1	0	0	1	7	23
30	68	2	0	0	0	13	53
35	94	2	1	0	0	35	56
40	62	0	1	0	1	23	37
45	150	1	0	0	0	77	72
50	51	0	0	0	0	11	40
55	430	3	1	0	0	153	273
60	39	0	0	0	0	14	25
65	106	0	0	0	0	45	61
70	36	0	0	0	0	10	26
Unknown	6	0	0	0	0	0	6

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-17: RTCP-Signal (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
35	1	0	0	0	0	0	1
40	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0
60	1	0	0	0	0	1	0
65	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-18: RTCP-Signal (*Pre-Crash Maneuver: Turning Right)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	2	0	0	0	0	1	1
35	1	0	0	0	0	0	1
40	3	0	0	0	0	0	3
45	1	0	0	0	0	1	0
50	0	0	0	0	0	0	0
55	1	0	0	0	0	1	0
60	1	0	0	0	0	1	0
65	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-19: RTCP-Sign (A) Fail to Obey(*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0
50	1	0	0	0	0	1	0
55	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-20: RTCP-Sign (A) Fail to Obey (*Pre-Crash Maneuver: Turning Right)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	2	0	0	0	0	0	2
30	2	0	0	0	0	1	1
35	1	0	0	0	0	1	0
40	1	0	0	0	0	0	1
45	2	0	0	0	0	1	1
50	0	0	0	0	0	0	0
55	3	0	0	0	0	2	1
60	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0
70	1	0	0	0	0	1	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-21: RTCP-Sign (B) Fail to Yield (*Pre-Crash Maneuver: Traveling Straight)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0
50	0	0	0	0	0	0	0
55	1	0	0	0	0	0	1
60	0	0	0	0	0	0	0
65	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Table D-22: RTCP-Sign (B) Fail to Yield (*Pre-Crash Maneuver: Turning Right)*

Posted Speed Limit [mph]	# Cases	TS>PSL				TS = PSL	TS Unknown
		5-10 mph	11-15 mph	16-20 mph	21+ mph		
15	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
25	2	0	0	0	0	1	1
30	1	0	0	0	0	0	1
35	2	0	0	0	0	0	2
40	1	0	0	0	0	1	0
45	7	0	0	0	0	2	5
50	1	0	0	0	0	0	1
55	3	0	0	0	0	1	2
60	1	0	0	0	0	1	0
65	1	0	0	0	0	0	1
70	0	0	0	0	0	0	0
Unknown	0	0	0	0	0	0	0

Note: Vehicles only counted as speeding when the TS was = 5 mph more than the PSL.
TS = Travel Speed
PSL = Posted Speed Limit

Infrastructure Characteristics

Three characteristics of the infrastructure were examined for fatal crossing path crashes at signalized intersections: the number of lanes, the traffic flow, and the roadway functional class.

Number of Travel Lanes and Trafficway Flow

The FARS *Number of Travel Lanes* variable was used to obtain information about the number of lanes of travel. The variable indicates the number of all travel lanes, regardless of their direction if the roadway is not divided; however, if the roadway is divided the variable only indicates the number of travel lanes in the direction of travel. Note that unlike the GES, only lanes open for travel are counted, turn lanes are excluded. The *Trafficway Flow* variable was used to determine if the roadway was divided or not. The number of travel lanes and the traffic flow of the roadway (i.e., divided or not divided) are presented in Table D-23 (a-e). Crash statistics on the number of travel lanes and the traffic flow are important since they may influence the design of the vehicle-based signal violation warning system since the system will track the vehicle's position within the roadway boundaries.

Table D-23 (a-e): Infrastructure Characteristics in Fatal Crossing Path Crashes at Signalized Intersections Where the Driver Violated the Signal.

(a) LTCP-Signal *(Pre-Crash Maneuver: Traveling Straight)*

Number of Lanes Reported	Traffic Flow		
	Divided	Non-Divided	Unknown
1	0	0	0
2	73	31	1
3	43	3	0
4	16	31	0
5	0	2	0
6 or more lanes	11	5	0
Unknown	0	1	3

(b) LTCP-Signal *(Pre-Crash Maneuver: Turning Left)*

Number of Lanes Reported	Traffic Flow		
	Divided	**Non-Divided**	**Unknown**
1	4	0	0
2	243	101	1
3	81	12	0
4	52	140	1
5	1	10	0
6 or more lanes	22	19	0
Unknown	1	4	10

(c) SCP-Signal *(Pre-Crash Maneuver: Traveling Straight)*

Number of Lanes Reported	Traffic Flow		
	Divided	**Non-Divided**	**Unknown**
1	3	2	0
2	212	240	0
3	96	48	0
4	42	145	0
5	7	12	0
6 or more lanes	12	19	0
Unknown	1	3	20

(d) RTCP-Signal *(Pre-Crash Maneuver: Traveling Straight)*

Number of Lanes Reported	Traffic Flow		
	Divided	**Non-Divided**	**Unknown**
1	0	0	0
2	0	1	0
3	0	0	0
4	0	1	0
5	0	0	0
6 or more lanes	0	0	0
Unknown	0	0	0

(e) RTCP-Signal *(Pre-Crash Maneuver: Turning Right)*

Number of Lanes Reported	Traffic Flow		
	Divided	**Non-Divided**	**Unknown**
1	0	0	0
2	1	4	0
3	2	0	0
4	0	2	0
5	0	0	0
6 or more lanes	0	0	0
Unknown	0	0	0

For LTCP fatal signalized crossing path crashes, the majority of the collisions occurred on divided roadways, regardless of whether the vehicle was turning left or traveling straight. However, for SCP crashes, the majority of the fatal collisions (54%) (469/862) occurred at non-divided-roadways. LTCP crashes in which the violating vehicle was traveling straight were further examined for the correlation between the number of traffic lanes and traffic flow. For divided roadways, 51% (73/143) of the fatal crashes occurred at roadways with two lanes; for non-divided roadways, 42% (31/73) occurred at two lane and 42% (31/73) at four lane intersections. For LTCP crashes in which the violating vehicle was turning left, 60% (243/404) of the divided-roadway crashes occurred on two lane roads and 49% (140/286) of the non-divided roadway crashes occurred on four lane roadways. For SCP crashes, regardless of the traffic flow of the intersection, the majority of the fatal crashes occurred at two lane roadways.

Roadway Functional Class

The FARS *Roadway Functional Class* variable was used to obtain the functional class of the roadway on which the vehicle(s) is traveling. For an intersection crash, the highest functional class of the intersecting trafficways was coded. A ranking of the roadway functional class by crossing path crash scenario is provided in Tables D-24 through D-28 for signalized intersections.

Table D-24: Rank of Roadway Classification for LTCP (*Pre-Crash maneuver: Turning Left)*

Roadway Functional Class	Count	Percentage
1. Other Principal Arterial (Urban)	321	46%
2. Minor Arterial (Urban)	140	20%
3. Local Road or Street (Urban)	56	8%
4. Principal Arterial-Other (Rural)	44	6%
5. Minor Arterial (Rural)	31	4%
6. Local Road or Street (Rural)	27	4%
7. Principal Arterial-Other Freeways/Expressways (Urban)	22	3%
8. Collector (Urban)	17	3%
9. Major Collector (Rural)	16	2%
10. Unknown Rural	9	1%
11. Minor Collector (Rural)	5	1%
12. Unknown Urban	4	1%
13. Principal Arterial-Interstate (Urban)	3	0%
14. Principal Arterial-Interstate (Rural)	0	0%
Unknown	*7*	*1%*

Table D-25: Rank of Roadway Classification for LTCP (*Pre-Crash maneuver: Traveling Straight)*

Roadway Functional Class	Count	Percentage
1. Other Principal Arterial (Urban)	129	59%
2. Minor Arterial (Urban)	26	12%
3. Local Road or Street (Urban)	23	10%
4. Principal Arterial-Other (Rural)	11	5%
5. Local Road or Street (Rural)	6	3%
6. Principal Arterial-Other Freeways/Expressways (Urban)	5	2%
6. Collector (Urban)	5	2%
8. Minor Arterial (Rural)	4	2%
8. Major Collector (Rural)	4	2%
10. Principal Arterial-Interstate (Urban)	2	1%
11. Unknown Urban	1	0%
12. Principal Arterial-Interstate (Rural)	0	0%
12. Minor Collector (Rural)	0	0%
12. Unknown Rural	0	0%
Unknown	4	2%

Table D-26: Rank of Roadway Classification for SCP (*Pre-Crash maneuver: Traveling Straight)*

Roadway Functional Class	Count	Percentage
1. Other Principal Arterial (Urban)	3223	37%
2. Minor Arterial (Urban)	164	19%
3. Local Road or Street (Urban)	113	13%
4. Principal Arterial-Other (Rural)	54	6%
5. Collector (Urban)	43	5%
6. Principal Arterial-Other Freeways/Expressways (Urban)	35	4%
7. Local Road or Street (Rural)	33	4%
8. Minor Arterial (Rural)	32	4%
9. Major Collector (Rural)	22	3%
10. Unknown Rural	12	1%
11. Unknown Urban	6	1%
12. Minor Collector (Rural)	4	0%
12. Principal Arterial-Interstate (Urban)	4	0%
14. Principal Arterial-Interstate (Rural)	2	0%
Unknown	16	2%

Note: Sum of counts may not equal 100% due to rounding error.

Table D-27: Rank of Roadway Classification for RTCP (*Pre-Crash maneuver: Turning Right)*

Roadway Functional Class	Count	Percentage
1. Minor Arterial (Urban)	3	33%
1. Local Road or Street (Urban)	3	33%
3. Principal Arterial-Other (Rural)	1	11%
3. Other Principal Arterial (Urban)	1	11%
5. Principal Arterial-Interstate (Rural)	0	0%
5. Minor Arterial (Rural)	0	0%
5. Major Collector (Rural)	0	0%
5. Minor Collector (Rural)	0	0%
5. Local Road or Street (Rural)	0	0%
5. Unknown Rural	0	0%
5. Principal Arterial-Interstate (Urban)	0	0%
5. Principal Arterial-Other Freeways/Expressways (Urban)	0	0%
5. Collector (Urban)	0	0%
5. Unknown Urban	0	0%
Unknown	1	11%

Note: Sum of counts may not equal 100% due to rounding error.

Table D-28: Rank of Roadway Classification for RTCP (*Pre-Crash maneuver: Traveling Straight)*

Roadway Functional Class	Count	Percentage
1. Principal Arterial-Other (Rural)	1	50%
1. Minor Arterial (Urban)	1	50%
3. Principal Arterial-Interstate (Rural)	0	0%
3. Minor Arterial (Rural)	0	0%
3. Major Collector (Rural)	0	0%
3. Minor Collector (Rural)	0	0%
3. Local Road or Street (Rural)	0	0%
3. Unknown Rural	0	0%
3. Principal Arterial-Interstate (Urban)	0	0%
3. Principal Arterial-Other Freeways/Expressways (Urban)	0	0%
3. Other Principal Arterial (Urban)	0	0%
3. Collector (Urban)	0	0%
3. Local Road or Street (Urban)	0	0%
3. Unknown Urban	0	0%
Unknown	0	0%

Examining all fatal crossing path crashes at signalized intersections, Table D-29 shows that 81% (1451/1795) of the crashes occurred in an urban area and 18% (318/1795) occurred in a rural area. An urban area is defined as a locality set by the responsible state and local officials having a population of 5,000 or more (6). Additionally, for LTCP and SCP rural crashes, the largest distribution of fatal crashes (34%) (109/316) occurred on "other principal arterials". For LTCP and SCP urban crossing path crashes, 54% (772/1441) occurred on "other principal arterials". Regardless of rural or urban, 49% (881/1795) of all fatal crossing path crashes occurred on roadways classified as "other principal arterial".

Table D-29: Roadway Functional Class For Fatal Crossing Path Crashes at Signalized Intersections Where the Driver Violated the Signal.

CRASH SEVERITY	Roadway Functional Class	Signal				
		LTCP		SCP	RTCP	
		Left Turn	Straight		Right Turn	Straight
Fatal	Rural					
	Principal Arterial-Interstate	0	0	2	0	0
	Principal Arterial-Other	44	11	54	1	1
	Minor Arterial	31	4	32	0	0
	Major Collector	16	4	22	0	0
	Minor Collector	5	0	4	0	0
	Local Road or Street	27	6	33	0	0
	Unknown Rural	9	0	12	0	0
	Urban					
	Principal Arterial-Interstate	3	2	4	0	0
	Principal Arterial-Other Freeways/Expressways	22	5	35	0	0
	Other Principal Arterial	321	129	322	1	0
	Minor Arterial	140	26	164	3	1
	Collector	17	5	43	0	0
	Local Road or Street	56	23	113	3	0
	Unknown Urban	4	1	6	0	0
	Unknown	7	4	16	1	0

Note: Sum of counts may be larger than number of crashes since both vehicles violated the sign in some crashes.

Concluding Remarks

Two distinct trends were observed for the LTCP and SCP intersection scenarios. The top primary contributing factor for vehicles with the pre-crash maneuver, turning left, was *Inattention.* For vehicles attempting to travel straight through the intersection, two primary contributing factors were largely observed, *Speeding* and *Inattention.* Two possible explanations of why *Speeding* may have been a contributing factor for vehicles traveling straight through the intersection may be 1) drivers not aware of the approaching sign/signal and failing to slow down, or 2) drivers may have been trying to beat the amber/orange light. Due to the small number of RTCP fatal crashes, a clear picture of the contributing factors for that crash scenario could not be obtained.

Additional analysis was also performed on the speed behavior of the vehicles that violated the traffic control device and the infrastructure characteristics of the intersections. Similar to the primary contributing factor analysis, speed was largely a factor for vehicles attempting to travel straight through the intersection. Twenty-five percent of the violating vehicles traveling straight through signalized intersections in LTCP crashes were traveling at a speed of at least 5 mph over the posted speed limit and/or were issued a violation for speeding. For LTCP stop sign violations, speed was a factor in 22% of the *Failure to Obey* and 17% of the *Failure to Yield*. For SCP crashes, speed was a factor in 19% of the signal violations and 13% of the *Failure to Obey* stop sign collisions.

In examining the infrastructure characteristics of the fatal signalized crossing path crashes, 81% of the crashes were found to occur in an urban area compared to 18% which occurred in rural areas. Additionally, regardless of whether a roadway was in a rural or urban area, roadways classified as "other principal arterials" contained the largest distribution of fatal crossing path crashes. Furthermore, LTCP intersection crossing path crashes were most likely to occur on divided roadways, whereas SCP intersection crashes predominantly occurred on non-divided roadways.

Based on the 1999 and 2000 FARS crash causal and contributing factor results, the LTCP and SCP intersection scenarios are the most prevalent in fatal crashes and the primary contributing factors for these crashes are *Inattention* and *Speeding*.

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