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Analysis of Crossing Path Crashes

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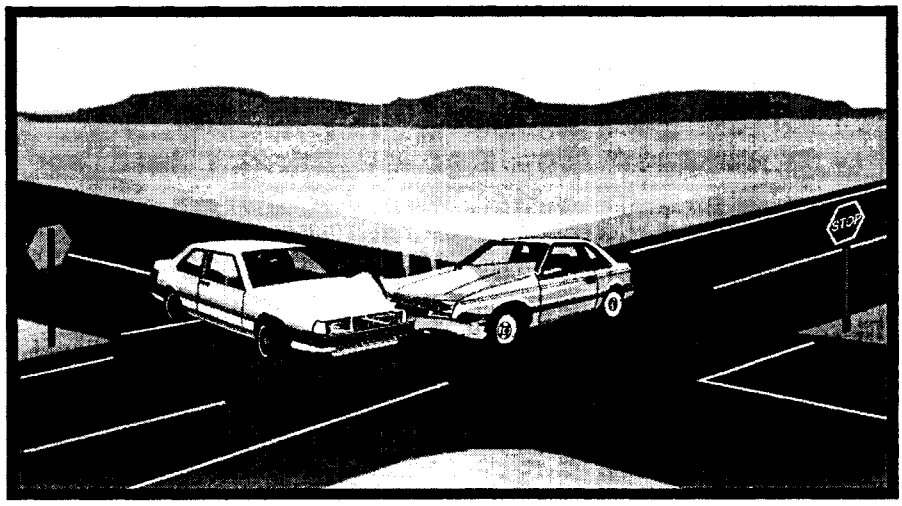

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13. ABSTRACT (Maximum 200 words)

This report defines the problem of crossing path crashes in the United States. This crash type involves one moving vehicle that cuts across the path of another when their initial approach comes from either lateral or opposite directions and they typically collide at, or near junctions. The frequency, manner of collision, and location of these crashes are described using the 1998 National Automotive Sampling System/General Estimates System (GES) crash database. This report separates crossing path crashes into five common scenarios that represent vehicle movements immediately prior to the crash. The frequency and fatality rate of these crash scenarios are delineated in relation to their occurrence at intersections and at driveways under distinct traffic controls using data from the GES and the Fatality Analysis Reporting System. This report also identifies contributing factors of the major crossing path crash scenarios based on 1998 GES data. In addition to vehicle-vehicle crossing path crashes, this report addresses the problem of vehicle-pedestrian and vehicle-pedalcyclist collisions at intersections and elsewhere. The results of this analysis are intended to support the development of effective countermeasure concepts and provide data for design effectiveness assessments.

14. SUBJECT TERMS
Crossing path crash, traffic conflict, crash scenario, crash frequency, opposite direction conflict, lateral direction conflict, merge conflict, straight crossing paths, relation to junction, traffic control device, violations charged, vision obstruction, driver distraction, pedestrian, pedalcyclist

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PREFACE

The National Highway Traffic Safety Administration (NHTSA) Office of Vehicle Safety Research, in conjunction with the Research and Special Programs Administration Volpe National Transportation Systems Center (Volpe Center), is conducting separate analyses of major vehicular crashes in support of the Intelligent Vehicle Initiative (IVI). The IVI is focused on solving traffic safety problems through development and deployment of vehicle-based and vehicle-infrastructure cooperative countermeasure systems that address rear-end, roadway departure, lane change, crossing paths, driver impairment, reduced visibility, and vehicle instability crashes. Research in these crash problem areas is being conducted in the context of four vehicle platforms including light, commercial, transit, and specialty vehicles (e.g., emergency vehicles, snowplows, etc.).

This report presents the results obtained from the analysis of the crossing path crash problem based on statistics from the 1998 National Automotive Sampling System/General Estimates System and the Fatality Analysis Reporting System crash databases. Crossing path crashes accounted for 1.72 million police-reported collisions or about 27 percent of the total 6.33 million crashes reported in the United States in 1998.

The authors of this report are Dr. Wassim G. Najm and Mr. John D. Smith of the Volpe Center, and Dr. David L. Smith of NHTSA.

The authors gratefully acknowledge the technical support provided by Mr. Jonathan Koopmann and Mr. Marco daSilva of the Volpe Center, the drawing of schematics made by Ms. Yvette Johnson of Information Systems and Services Inc, and the editing of this report by Mr. James Lannon of EG&G Technical Services. Also acknowledged are the following persons for reviewing and providing insightful comments on this report: Dr. August Burgett and Ms. Nancy Bondy of NHTSA, Ms. Barbara Rhea with the Bureau of Transportation Statistics (formerly with NHTSA), and Mr. John Hitz of the Volpe Center.

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

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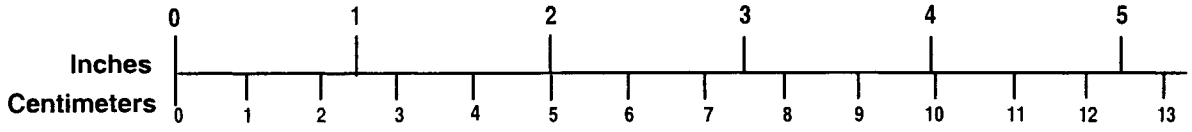

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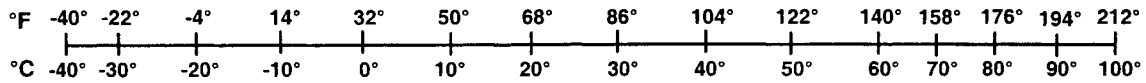

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

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ACRONYMS

CDS	Crashworthiness Data System
FARS	Fatality Analysis Reporting System
GES	General Estimates System
ITS	Intelligent Transportation Systems
LTAP/OD	Left Turn Across Path – Opposite Direction Conflict
LTAP/LD	Left Turn Across Path – Lateral Direction Conflict
LTIP	Left Turn Into Path – Merge Conflict
NASS	National Automotive Sampling System
NHTSA	National Highway Traffic Safety Administration
PARs	Police Accident Reports
PTP	Parallel Turning Path
RTIP	Right Turn Into Path – Merge Conflict
SCP	Straight Crossing Paths

EXECUTIVE SUMMARY

This report addresses the problem of crossing path crashes in the United States. Crossing path crashes are defined as those that involve the type of traffic conflict where one moving vehicle cuts across the path of another, when they were initially approaching from either lateral or opposite directions in such a way that they collided at or near a junction. In 1998, about 1.72 million such crossing path crashes occurred in the United States.

This analysis of crossing path crashes is concerned with understanding the pre-crash scenarios in order to evaluate proposed countermeasure designs. These crashes are identified and counted by vehicle pre-crash movements, not by impact types. This report separates crossing path crashes into five common scenarios. These are 1) left turn across path – opposite direction conflict (LTAP/OD); 2) left turn across path – lateral direction conflict (LTAP/LD); 3) left turn into path – merge conflict (LTIP); 4) right turn into path – merge conflict (RTIP); and 5) straight crossing paths (SCP).

The National Highway Traffic Safety Administration (NHTSA) National Automotive Sampling System (NASS) was principally used in this analysis. The NASS is based upon a large sample of Police Accident Reports (PARs) that are sorted into two systems, the Crashworthiness Data System (CDS) and the General Estimates System (GES). The CDS is a nationally representative sample of about 5,000 police-reported crashes involving at least one light vehicle that was towed from the crash scene due to damage from the crash. The GES is a nationally representative sample of police-reported crashes involving all vehicle types and all severities and results in about 50,000 sample cases each year. The 1998 GES was used for crash count estimates because it contained a broader, more numerous sample than the CDS.

This study also queried the 1998 GES for fatal crashes to see if the fatality demographics followed the crash demographics, or if some types of crossing path crash scenarios had more fatalities than others. These GES fatal crash counts were also compared to statistics from the 1998 Fatality Analysis Reporting System (FARS). The FARS contains data on all fatal traffic crashes in the United States.

This report describes the locations where crossing path crashes occurred, in terms of their relation to a roadway junction and the type of traffic control device at these locations. Although it is easy to conceive of the crossing path crash problem as existing mainly at signalized intersections, in fact, the GES estimated that more crossing path crashes occurred at unsignalized intersections and driveways. About 42 percent of crossing path crashes at intersections occurred in the presence of signals, while the remaining 58 percent occurred at unsignalized intersections. The analysis of the 1998 GES revealed that crossing path crashes at intersections with no controls had the highest fatality rates.

The study also examined three 1998 GES variables from the "Vehicle/Driver File" to identify factors that may have contributed to the cause of the crash, including "violations charged," " vision obstruction," and "driver distraction." "Failure to Yield Right-of-

Way" was the most dominant violation in all crossing path crash scenarios at intersections and driveways controlled by stop signs or with no controls. "Running a Traffic Signal" violation was principally charged to drivers in straight crossing path crashes, as well as in left turn across path and left turn into path crashes, especially to vehicles going straight through the intersection. Alcohol and drug violations were charged to fewer than 2 percent of the vehicles involved in crossing path crashes at intersections and driveways. About 9 percent of drivers attributed vision obstruction as a contributing factor in left turn across path crashes at intersections with either no controls or stop signs. Vision obstruction was also reported by about 16 percent and 10 percent of drivers involved in left turn across path crashes at driveways with stop signs and no controls, respectively.

This report also analyzes pedestrian and pedalcyclist collisions to obtain estimates of their crash counts and to describe their pre-crash events using the 1998 GES. While the number of these collisions is small with regard to the overall crash population, pedestrian crashes are typically severe and account for about 15 percent of the total collision fatality population each year. The actual number of fatal crashes with pedestrians and pedalcyclists was found in the 1998 FARS at intersections with different traffic control devices. Results showed that crashes of these types at intersections were of a similar count size to those not at intersections, but that the non-intersection crashes resulted in a higher number of fatalities.

As a rule, pedestrian and pedalcyclist collisions are more likely to be fatal at non-junction locations than at intersections, and more likely to be fatal at intersections than at driveways. Pedestrian collisions are more often fatal than pedalcyclist collisions. This fact may be attributed to differences in relative speed at impact. Pedalcyclists usually ride with the traffic and therefore experience lower impact speeds than pedestrians. The most dominant pre-crash event of both pedestrian and pedalcyclist collisions involved a vehicle that was in the process of turning and merging, was preparing to turn and merge, or had just completed a turning and merging maneuver.

The results of this study are intended to support the development of effective countermeasure concepts and to provide data for design effectiveness assessments.

1. INTRODUCTION

Crossing path crashes are defined in this report as those that involve the type of traffic conflict where one moving vehicle cuts across the path of another, when they were initially approaching from either lateral or opposite directions, in such a way that they collided at or near a junction. In 1998, about 1.72 million such crossing path crashes occurred in the United States, based on estimates in the National Automotive Sampling System (NASS)/General Estimates System (GES) crash database of the National Highway Traffic Safety Administration (NHTSA). This is about 27.3 percent of the total 6.33 million police-reported crashes for that year. These crashes are most often observed by police and field investigators as angle impacts at intersections, but significant amounts of other types of impacts and locations occur as well. In any case, this report identifies and counts these crashes by vehicle pre-crash movements, not by impact types. The pre-crash conflict dynamics of this crash type are significantly different from other types and, therefore, their crash countermeasures are also expected to be significantly different.

This analysis of crossing path crashes is concerned with understanding the pre-crash scenarios in order to evaluate proposed countermeasure designs, or to offer insight to countermeasure designers. This report provides answers to four definitive questions:

1. What are crossing path crashes and how do their pre-crash events unfold?
2. Where in the infrastructure does this crash type predominantly occur?
3. What type of traffic control device is involved?
4. What are the crash's major contributing factors?

In addition to vehicle-vehicle crossing path crashes, this report also addresses vehicle-pedestrian and vehicle-pedalcyclist collisions. The research questions that were addressed surrounding these crashes were:

1. How many collisions with pedestrians or pedalcyclists on the road occur at intersections or are intersection-related?
2. How do the pre-crash events unfold in vehicle-pedestrian and vehicle-pedalcyclist collisions at intersections?

This report begins with a review of previous work that investigated crossing path crashes based on data available in national crash databases such as the GES. A general description follows of the 1998 crash databases used in this analysis. The report quantifies the problem of crossing path crashes by providing statistics on their crash frequency and manner of collision. Then, major pre-crash scenarios are identified based on vehicle movements immediately prior to the collision. Each pre-crash scenario is described in terms of its physical setting and major crash contributing factors relative to crash location and traffic control. This is followed by a detailed analysis of pedestrian and pedalcyclist collisions. Finally, the report concludes with a brief summary of the major results and remarks.

The body of this report contains results for the entire vehicle fleet in the United States. Similar tables and analyses for the light vehicle platform (passenger cars, sport utility vehicles, vans, and pickups), the commercial vehicle platform (large trucks - medium and heavy trucks), the transit

vehicle platform (buses, but not school buses), and emergency vehicles (police, fire, and ambulance) are presented in the appendices.

1.1 Previous Work

Two specific crossing path crash scenarios related to intersections were previously analyzed using the 1991 GES to devise countermeasure concepts for the Intelligent Transportation Systems (ITS) program [1-3]. The first crash scenario dealt with vehicles on straight crossing paths, which was analyzed in two separate reports for signalized and unsignalized intersections [1,2]. "Signalized" intersections referred to intersections controlled by a signal (green, amber, and red lights) or a flashing beacon while "unsignalized" intersections had no controls or were controlled by stop or yield signs. These two previous reports did not distinguish crashes by the specific traffic control device present at the intersection [1,2]. The second crash scenario in the previous work had one vehicle turning left across the path of another, both initially traveling in opposite directions through intersections [3]. The analysis of this scenario did not consider whether the intersection was signalized or unsignalized. The primary causal factors of these two crossing path crash scenarios were investigated by conducting a detailed analysis of 291 crash cases from the 1992 NASS/Crashworthiness Data System (CDS) crash database [1-3].

In 1994, NHTSA produced a thorough report on the crossing path crash problem [4]. The title of that research (*Intersection Crossing Path Crashes: Problem Size Assessment and Statistical Description*) suggests that the report was limited to intersections, not the greater problem of junctions, which was the actual subject of the report. Those results were organized similarly to the present study, and, in fact, that study was used as a model. However, a major difference with that work is that the present report attempts to add more infrastructure detail and thus creates a more intuitive view of crashes. The present report also attempts to paint a clearer picture with regard to crash-contributing factors, down to the vehicle level.

In another prior work, an analysis of crossing path crashes at intersections was conducted in a project designed to develop performance guidelines for intersection collision avoidance systems [5]. That project provided crash counts of the three most common crossing path crash scenarios and described the circumstances surrounding all crossing path crashes at intersections using the 1992 GES. The three crash scenarios analyzed were: vehicles on intersecting straight paths, one vehicle turning across the path of another, and one vehicle turning into the path of another; however, the latter of these did not specify whether the vehicle was turning left or right at intersections. In addition to GES statistics, a sample of 207 crossing path crash cases from the 1993 CDS was clinically analyzed to identify the primary causes of these crashes [5].

1.2 Analysis Databases

The NHTSA National Automotive Sampling System, formerly called the National Accident Sampling System, was mainly used for the present analysis. The NASS is based upon a large sample of Police Accident Reports (PARs) that are sorted into two systems: the CDS and the GES. The CDS is a nationally representative sample of about 5,000 police reported crashes involving at least one passenger vehicle that was towed from the crash scene due to damage from the crash. The GES is a nationally representative sample of police reported crashes involving all

vehicle types and all severities and results in about 55,000 sample cases each year. The 1998 GES was utilized for crash count estimates because it contained a broader, more numerous sample than the CDS.

This study also queried the 1998 GES for fatal crashes in order to see if the fatality demographics followed the crash demographics, or if some types of crossing path crash scenarios were more fatal than others. The GES fatal crash counts were also compared to statistics from the 1998 Fatality Analysis Reporting System (FARS). The FARS contains data on all fatal traffic crashes within the United States. To be included in FARS, a crash must involve a motor vehicle traveling on a traffic way customarily open to the public and result in the death of a person (either an occupant of a vehicle or a non-motorist) within 30 days of the crash.

2. CROSSING PATH CRASHES

The *Accident Type* variable from the "Vehicle/Driver File" in the GES crash database was used to implement the definition of the crossing path crash type in the analysis [6]. This variable categorizes the pre-crash situation. All the possible values of this variable are shown in Appendix A. Note that only one of the accident codes is possible in a given GES case. The relevant values for the present analysis are described in Category IV "Changing Trafficway, Vehicle Turning" or Category V "Intersecting Paths" as shown in Appendix A, with the exception of codes 70-73 that were left out because these did not fit the definition of the crossing path crash type.

2.1 Crossing Path Crash Frequency

Crossing path crashes accounted for about 1.72 million police-reported collisions in 1998 based on GES statistics. The national estimates produced from GES data may differ from the true values, because they are based on a probability sample of crashes and not a census of all crashes. The size of these differences may vary depending on which sample of crashes was selected. Generalized standard errors for estimates of totals are provided in [6]. The standard error of an estimate is a measure of the precision or reliability with which an estimate from the GES sample approximates the results of a census. The 1998 GES crash standard error is 400 for a crash estimate of 1,000. Then, the 95 percent confidence interval for this estimate would be $1,000 \pm 2 \times 400$ or 200 to 1,800. The 95 percent confidence interval for the estimate of 1.72 million crashes would be approximately 1,509,000 to 1,931,000 crossing path crashes in 1998.

2.2 Crossing Path Crash Scenarios

The following list identifies all of the relevant crossing path crash scenarios based on the *Accident Type* variable from the "Vehicle/Driver File" in the GES crash database:

1. Codes 68-69: Left Turn Across Path - Opposite Direction Conflict (LTAP/OD)
2. Codes 82-83: Left Turn Across Path - Lateral Direction Conflict (LTAP/LD)
3. Codes 76-77: Left Turn Into Path - Merge Conflict (LTIP)
4. Codes 78-79: Right Turn Into Path - Merge Conflict (RTIP)
5. Codes 86-89: Straight Crossing Paths (SCP)
6. Codes 74-75, 80-81, 84-85, 90-91: Crossing Path Other/Unknown

Graphic representations of these crossing path crash scenarios are shown in Figure 2-1. Note that in cases 1 through 4, one of the vehicles is going straight through the junction while one is turning. In case 5, both are going straight before they collide. Note also that a four-way, perpendicular intersection is shown for all the crash depictions in Figure 2-1 – this is not necessarily the case in the data, of course.

Figure 2-2 shows the distribution of these crashes among the six crash scenarios listed above. Note that the main crash problem from a fleet view was seen in SCP and LTAP crashes. Collectively, the SCP, LTAP/OD, and LTAP/LD crash scenarios accounted for 77.1 percent of all crossing path crashes. Appendix B breaks down these data further by four vehicle platform types: light, heavy truck, transit bus, and emergency vehicles.

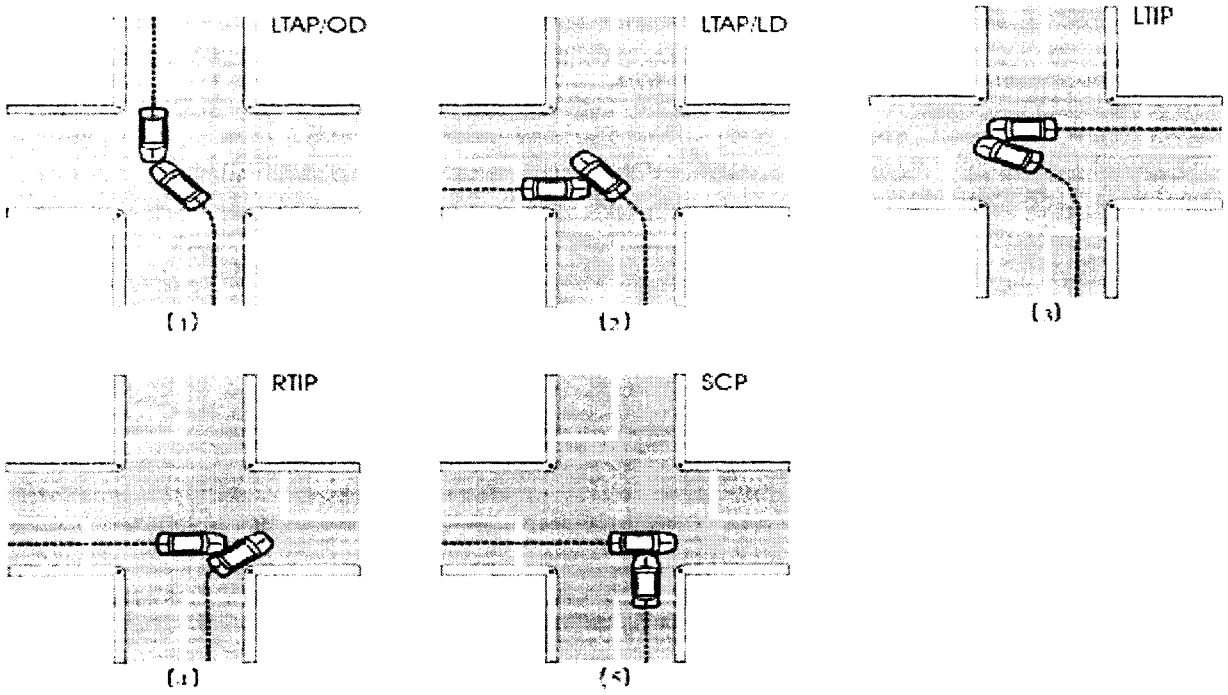

Figure 2-1. Schematics of Common Crossing Path Crash Scenarios

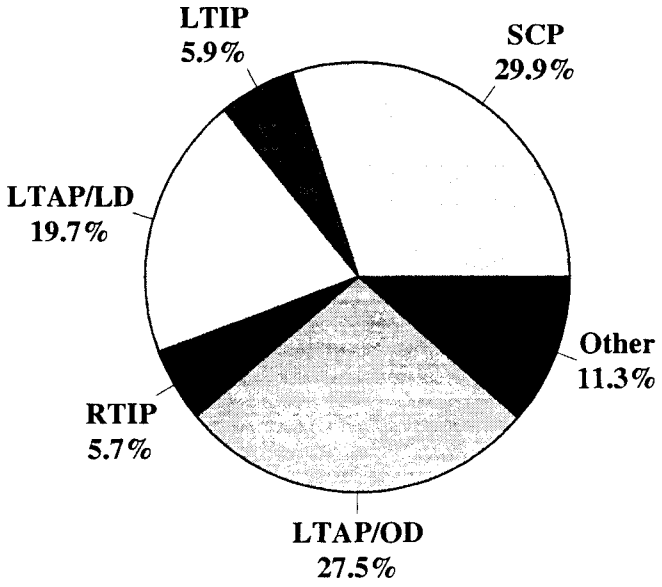

Figure 2-2. Distribution of Crossing Path Crash Scenarios for *All* Vehicles (Based on 1998 GES)

The type of crashes that can result from any crash scenario may be determined from the *Manner of Collision* variable in the GES "Accident File." This variable indicates the orientation of the vehicles in a collision.

The range of possible codes for this variable is:

Code 0:	Not a collision with a 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
Codes 8,9:	Other, Unknown respectively

The correlation between crossing path crash scenarios and manner of collision is shown in Table 2-1 for all vehicles. Clearly, the dominant impact type is angle crash at 95.9 percent, which is an expected result given the crash scenario diagrams of Figure 2-1. Note that the data also show a few head-ons (2.3 percent) and sideswipes (1.1 percent), but angle crashes clearly predominate. This result is important in crashworthiness analyses and injury severity reduction since it helps to establish threat and countermeasure requirements.

Table 2-1. Distribution of Crossing Path Crashes vs. *Manner of Collision* for *All* Vehicles (Based on 1998 GES)

Manner of Collision	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Rear-End			3,000	2,000		2,000	7,000	0.4%
Head-On	24,000	9,000	*		*	7,000	40,000	2.3%
Angle	447,000	330,000	96,000	94,000	514,000	169,000	1,650,000	**95.9%**
Sideswipe/Same Dir.			4,000	2,000		13,000	19,000	1.1%
Sideswipe/Opposite Dir.	1,000	*	*	*		3,000	5,000	0.3%
Total	472,000	339,000	102,000	99,000	514,000	194,000	1,720,000	100.0%
% Total	**27.5%**	**19.7%**	5.9%	5.7%	**29.9%**	11.3%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

3. PHYSICAL SETTING OF CROSSING PATH CRASHES

This report describes the locations where crossing path crashes occurred, in terms of their relation to a roadway junction and the type of traffic control device present at these locations.

3.1 Relation to Junction

The *Relation to Junction* variable in the GES "Accident File" offers several types of junctions for crossing path crashes. This variable indicates whether or not the location of the first harmful event occurred at different types of junctions within or outside the boundaries of an interchange. An interchange is a connection between two roadways that involves a change in grade. These are typically found at an overpass and, in metropolitan areas, usually involve signalized intersections to provide a transition between the two roadways. The range of possible values for this variable is:

Non-Interchange		Interchange	
Code 00:	Non-Junction	Code 10:	Non-Junction
Code 01:	Intersection	Code 11:	Intersection
Code 02:	Intersection-Related	Code 12:	Intersection-Related
Code 03:	Driveway, Alley Access, etc.	Code 13:	Driveway, Alley Access, etc.
Code 04:	Exit/Entrance Ramp	Code 14:	Exit/Entrance Ramp
Code 05:	Rail Grade Crossing	Code 15:	Rail Grade Crossing
Code 06:	On a Bridge	Code 16:	On a Bridge
Codes 08, 09:	Other, Unknown	Codes 18, 19:	Other, Unknown

The GES is fairly precise about the descriptive term "Intersection" for crash analysis and uses the relationship shown in Figure 3-1 [7]. The GES intersection is defined as the area enclosed by the extension of the lateral curb lines of the intersecting roadways, shown in the solid black area in Figure 3-1. To be coded as an intersection crash, the first harmful event, such as collision, must occur in this area.

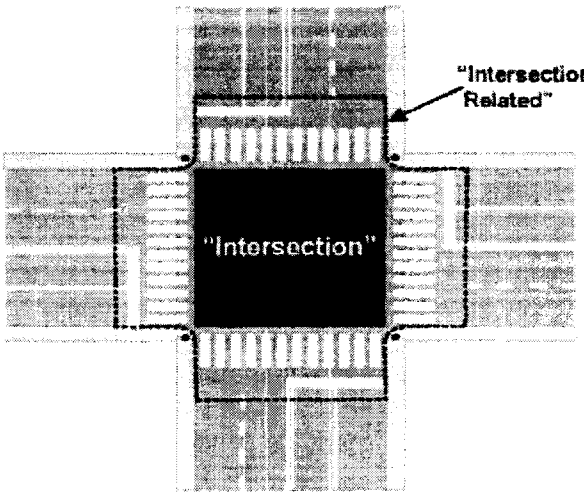

Figure 3-1. GES Schematic of Intersection and Intersection-Related Locations

For a crash to be coded as Intersection-Related, the first harmful event must occur in the somewhat vague "intersection-related" area shown in Figure 3-1 and be related to motion through the intersection. The codes for "Driveway, Alley Access," "Ramp," and "Grade Crossing" mean that the crossing path crash must be related to motion through a junction between these and a roadway.

The correlation between crossing path crash scenarios and relation to junction is shown in Table 3-1 for all vehicles. Note that 98.1 percent of crossing path crashes are collected into three GES categories: intersection (75.1 percent), intersection-related (3.0 percent), and driveway/alley access (21.0 percent) at both non-interchange and interchange locations. This observation led this study to subsequently focus mainly on these GES types of junctions. Further, the intersection category was lumped with the intersection-related category into a single collection to describe intersections. All the data were thus collected into two bins for infrastructure analysis: "intersection" that includes GES intersection and intersection-related crashes, and "driveway" that encompasses driveway and alley access crashes. As seen in Table 3-2, the SCP crash scenario was the most dominant in crossing path crashes at intersections based on its frequency of occurrence in 1998. The LTAP/LD crash scenario was the most dominant at driveways. The LTAP/OD crash scenario was the second most dominant in crossing path crashes at either intersections or driveways. The data shown in Table 3-1 are separated in Appendix C into the four major vehicle platform types discussed earlier.

Table 3-1. Distribution of Crossing Path Crashes vs. *Relation to Junction* for *All* Vehicles (Based on 1998 GES)

Relation to Junction		Crossing Path (CP) Crash Scenarios							
		LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Non-Interchange	Non-Junction	4,000	*	1,000		2,000	2,000	9,000	0.5%
	Intersection	357,000	204,000	57,000	57,000	486,000	112,000	1,274,000	**74.1%**
	Intersection-Related	4,000	6,000	4,000	4,000	2,000	30,000	50,000	**2.9%**
	Driveway, Alley, etc.	101,000	124,000	35,000	34,000	21,000	46,000	360,000	**20.9%**
	Ramp	*		*	*	*		1,000	
	Grade Crossing	*					*	*	
	Bridge	*	*		*	*		1,000	
	Other	1,000		1,000	1,000		1,000	3,000	0.2%
Interchange	Non-Junction								
	Intersection	5,000	4,000	2,000	1,000	4,000	2,000	17,000	1.0%
	Intersection-Related	1,000	*	*	*	*	*	2,000	0.1%
	Driveway, Alley, etc.				1,000	*	*	1,000	0.1%
	Ramp	*	*	1,000	*	*	*	2,000	0.1%
	Bridge	*						*	
	Other	*			*		*	*	
	Total	472,000	339,000	102,000	99,000	514,000	194,000	1,720,000	100.0%
	% Total	27.5%	19.7%	5.9%	5.7%	29.9%	11.3%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

3.2 Traffic Control Device

Traffic control is also an important physical parameter for every crossing path crash scenario and is coded through the *Traffic Control Device* variable in the GES "Accident File." This variable measures the presence and the type of traffic control device that regulates vehicular traffic. There are many possible signs that were less important for the present crash analysis, so the range of possible values used was:

Code 00: No Controls

Trafficway Traffic Signals, not at a railroad grade crossing:

Code 01: Traffic Control Signal (on colors)

Regulatory Signs, not at a railroad grade crossing:

Code 21: Stop Sign

Codes 04-09, 22-99: Other (as classified in this report)

The coding of the 1998 GES *Traffic Control Device* variable applies at the accident level, not at the vehicle level. That is, if several types of controls were present at a junction, then the control device with the lowest number was coded for the entire crash. This coding logic will be changed in 1999 to apply the traffic control variable on a vehicle basis for more accurate portrayals of crashes. According to the GES coding manual, the *Traffic Control Signal (On Colors)* code is used if the police accident report indicates a signal that processes through the green, amber, and red times [7]. A *Stop Sign* is coded in the GES if there is at least one stop sign present at an intersection or driveway. The stop sign takes precedence over other signs such as a "yield" sign. The GES does not provide information on whether an intersection or a driveway is 2-way or 4-way stop sign controlled. *No Controls* is coded in the GES if at the time of the crash there was no intent to control (regulate or warn) vehicle traffic (i.e., an uncontrolled intersection). This code is also used if statutory controls apply (e.g., state law requires that when two vehicles meet at an uncontrolled intersection, the one on the right has the right-of-way).

Crash statistics in Tables 3-2 and 3-3 show the correlation between traffic control devices and crossing path crash scenarios for intersections, based on the 1998 GES. The difference between Tables 3-2 and 3-3 is that the first is simple crash counts, while the second is an estimate of the fraction of those crashes that resulted in one or more on-the-scene fatalities. The GES fatal crash statistics in Table 3-3 were drawn from a sample of PARs that only reported the on-scene conditions and were then weighted to estimate the national figures. Any fatalities that may have occurred at a later time were not reflected. In contrast, the FARS gives actual counts of the fatalities attributable to crashes, even if the death occurred later in the hospital. Unfortunately, the FARS does not contain any variable similar to the GES *Accident Type* variable that allows the identification of the five major crossing path crash scenarios. Therefore, it was not possible

to make a direct comparison of fatal crash statistics between the two crash databases, but both were used in this study to give perspective.

Table 3-2. Distribution of All Crossing Path Crashes vs. *Traffic Control Device* for *All* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	229,000	53,000	15,000	20,000	182,000	59,000	559,000	41.6%
Stop Sign	16,000	128,000	34,000	29,000	236,000	45,000	488,000	36.3%
No Controls	94,000	26,000	10,000	11,000	35,000	34,000	209,000	15.6%
Other	27,000	8,000	4,000	3,000	38,000	6,000	88,000	6.5%
Total	366,000	214,000	64,000	63,000	492,000	144,000	1,343,000	100.0%
% Total	27.3%	15.9%	4.7%	4.7%	36.6%	10.8%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.

Table 3-3. Distribution of *Fatal* Crossing Path Crashes per 1,000 Crashes vs. *Traffic Control Device* for *All* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device (TCD)	Crossing Path (CP) Crash Scenarios						
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP
Signal	2.7	3.9			3.2		2.5
Stop Sign	5.4	3.5			3.8	0.3	2.9
No Controls	4.5	3.2			5.7	0.5	3.5
All 3 TCDs	3.3	3.6			3.7	0.22	2.8

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

As seen in the right-most column of Table 3-2, about 42 percent of all crossing path crashes at intersections occurred in the presence of signals, while the remaining 58 percent occurred at unsignalized intersections. In addition, LTAP/OD crashes were the most prevalent at intersections controlled by signals, followed closely by SCP crashes. Crossing path crashes at stop-sign-controlled intersections were mostly SCP crashes. Intersections with no controls experienced the most crashes from the LTAP/OD scenario. A number of intersections might have been coded as "No Controls" in LTAP/OD crash cases if the involved vehicles were traveling on a major trafficway without any controls and the minor crossing trafficway had a traffic control device such as a stop sign.

Table 3-3 shows the GES fatality picture for crossing path crashes at intersections. It is noteworthy that the 1998 GES did not contain any LTIP or RTIP crash cases that resulted in fatal injuries at intersections. Signalized intersections have the lowest fatality rate when compared to the other types of intersection controls as seen in the right-most column of Table 3-3. Further, the FARS data were queried to compare to these GES figures using the traffic control device, relation to junction, and manner of collision (angle). It was found that FARS ratios in the right-most column, from top to bottom, were 2.8 (signal), 5.8 (stop sign), and 4.2 (no controls). These data confirmed the higher overall fatality ratios for the last two rows. Moreover, the data also

suggested that GES may significantly underestimate the crossing path fatal crash picture, especially for unsignalized intersections, though again it was found that precise matching between the FARS and the GES was not possible due to unmatched coding schemes.

When the cells of Table 3-2 are compared to the cells of Table 3-3 to determine if the fatality demographics follow the crash demographics, we see that they do not. For example, while there are many LTAP/OD crashes at signalized intersections, they have the lowest fatality rate on the table. When the cells of Table 3-2 are placed in a descending rank order, the following order occurs:

- 236,000 SCP crashes at intersections with stop signs;
- 229,000 LTAP/OD crashes at intersections with signals;
- 182,000 SCP crashes at intersections with signals;
- 128,000 LTAP/LD crashes at intersections with stop signs;
- 94,000 LTAP/OD crashes at intersections with no controls; and
- 53,000 LTAP/LD crashes at intersections with signals.

Again, the same three scenarios (i.e., SCP, LTAP/OD, and LTAP/LD) dominated as seen earlier in the pie chart of Figure 2-2, but here the infrastructure has been added to paint a clearer picture.

As seen in Table 3-3, the same three scenarios mentioned above also dominated in terms of the relative number of fatal collisions, but for different combinations with the infrastructure. The descending order of the cells for fatal crossing path crashes per 1000 crossing path crashes is:

- 5.7 fatal crashes/1,000 SCP crashes at intersections with no controls;
- 5.4 fatal crashes/1,000 LTAP/OD crashes at intersections with stop signs;
- 4.5 fatal crashes/1,000 LTAP/OD crashes at intersections with no controls;
- 3.9 fatal crashes/1,000 LTAP/LD crashes at intersections with signals; and
- 3.8 fatal crashes/1,000 SCP crashes at intersections with stop signs.

The higher fatality rates for unsignalized (stop signs and no controls) intersections seem clear from the above data.

Table 3-4 indicates the number of crossing path crashes related to driveways based on 1998 GES. Crash data at this type of junction were strongly dominated by locations with no controls, about 82.4 percent of all crossing path crashes at this type of junction. The data show two dominant crash frequencies ranked in a descending order as follows:

- 101,000 LTAP/LD crashes at driveways with no controls; and
- 86,000 LTAP/OD crashes at driveways with no controls.

The data shown in Tables 3-2 and 3-4 are separated in Appendix D into the light, commercial, transit, and emergency vehicle platform types as discussed earlier.

Table 3-4. Distribution of Crossing Path Crashes vs. *Traffic Control Device* for *All* Vehicles at Driveways (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	7,000	5,000	1,000	3,000	1,000	2,000	19,000	5.4%
Stop Sign	1,000	12,000	4,000	3,000	3,000	4,000	26,000	7.3%
No Controls	86,000	101,000	29,000	28,000	16,000	38,000	298,000	82.4%
Other	7,000	6,000	1,000	1,000	1,000	2,000	18,000	5.0%
Total	101,000	124,000	35,000	35,000	21,000	46,000	361,000	100.0%
% Total	27.9%	34.3%	9.8%	9.6%	5.7%	12.9%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.

4. CONTRIBUTING FACTORS IN CROSSING PATH CRASHES

Perhaps the most difficult part of this analysis was to determine the representative causal factors of the crossing path crash scenarios. In doing this analysis, it was necessary that the causal factor frequencies be captured for each crash scenario in each cell of Tables 3-2 and 3-4, for the overall fleet and for each vehicle platform type. This conclusion was arrived at by reasoning that the physical setting was critical to driver behavior and the causality behind a given crash scenario could be quite different for different physical settings (e.g., uncontrolled versus controlled intersections and the trust that drivers put in traffic control devices). In order to obtain such information on potential causes, our analysis then relied on a number of GES variables to identify factors and circumstances that may have contributed to the cause of the crash. Specifically, a query of the *Imputed Violations Charged*, *Driver's Vision Obscured By*, and *Driver Distracted By* variables from the GES "Vehicle/Driver File" was conducted to capture major contributing factors in crossing path crashes.

4.1 Violations Charged in Crossing Path Crashes

The *Imputed Violations Charged* variable indicates the type of violation charged to the driver of a vehicle involved in the crash. The range of possible codes for this variable is:

Code 00: None
Code 01: Alcohol or Drugs
Code 02: Speeding
Code 03: Alcohol or Drugs and Speeding
Code 04: Reckless Driving
Code 05: Driving with a Suspended or Revoked License
Code 06: Failure to Yield Right-of-Way
Code 07: Running a Traffic Signal or Stop Sign
Code 50: Hit and Run (and No Information)
Code 97: Violation Charged - No Details
Code 98: Other Violation

The codes 01 or 02, and 04 through 07 are prioritized in decreasing numerical value (e.g., 01 or 02 takes precedence over 04, 04 takes precedence over 05, etc.). Tables 4-1 and 4-2 show the 1998 GES statistics for violations charged to drivers in common crossing path crash scenarios at intersections and driveways, respectively. "Other Violation" in Tables 4-1 and 4-2 encompasses codes 05, 50, 97, and 98 listed above.

Most violations were issued to drivers involved in LTAP/OD and SCP crashes at intersections according to crash statistics in Table 4-1. About 32 percent and 31 percent of all vehicles involved respectively in LTAP/OD and SCP crashes at signalized intersections were charged with violations. "Failure to Yield Right-of-Way" was the dominant violation charged to drivers attempting to turn through signalized intersections in LTAP/OD crashes. In fact, this violation was also the most dominant in all crossing path crash scenarios at intersections with stop signs or no controls especially to vehicles turning through the intersection. This is because the rules of

Table 4-1. Violations Charged to Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs	1.6%	0.3%	0.2%	0.7%	0.5%		2.6%		1.0%	0.9%
	Speeding	0.2%	0.5%	1.4%	0.7%			0.7%	0.3%	0.4%	0.9%
	Alcohol or Drugs and Speeding										
	Reckless Driving	0.2%	0.1%	0.2%	0.8%					0.2%	0.5%
	Failure to Yield Right-of-Way	29.4%	0.8%	4.7%	1.0%	3.6%	2.1%	19.2%		1.5%	1.5%
	Running a Traffic Signal or Stop Sign	1.3%	3.6%	3.6%	23.3%	5.2%	10.8%	4.1%	4.2%	14.7%	1.0%
	Other Violation	16.3%	9.3%	11.3%	11.8%	13.5%	11.8%	15.9%	5.6%	13.6%	17.3%
Stop Sign	Alcohol or Drugs		1.5%	1.1%	0.3%	0.9%		0.3%		0.3%	1.4%
	Speeding			0.2%	0.5%			0.3%		0.5%	0.6%
	Alcohol or Drugs and Speeding				0.1%						0.0%
	Reckless Driving			0.1%		0.4%	0.5%			0.2%	0.5%
	Failure to Yield Right-of-Way	37.5%	4.9%	36.0%	0.4%	34.9%	0.8%	31.9%	1.9%	17.0%	8.7%
	Running a Traffic Signal or Stop Sign		2.6%	3.0%	0.9%	9.6%	0.3%	4.3%	0.3%	6.1%	0.5%
	Other Violation	12.8%	7.4%	11.2%	7.8%	12.4%	5.9%	14.0%	7.9%	11.0%	16.0%
No Controls	Alcohol or Drugs	1.0%		1.5%	0.5%	0.9%	3.0%			0.6%	1.4%
	Speeding	0.4%	0.3%		1.9%		2.5%		2.9%	1.3%	1.1%
	Alcohol or Drugs and Speeding		0.2%								
	Reckless Driving	0.2%						0.9%			0.2%
	Failure to Yield Right-of-Way	37.8%	0.9%	21.2%	0.4%	15.3%		12.6%	1.1%	17.2%	0.6%
	Running a Traffic Signal or Stop Sign		0.1%							0.1%	
	Other Violation	16.6%	10.1%	23.4%	4.0%	9.1%	2.4%	18.2%	8.0%	11.8%	17.0%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table 4-2. Violations Charged to Vehicles in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs			4.8%		24.1%		7.5%			
	Speeding										0.1%
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	26.6%	1.3%	11.1%	1.8%		7.9%	15.8%		4.1%	3.2%
	Running a Traffic Signal or Stop Sign		3.8%		8.2%					16.6%	1.3%
	Other Violation	11.0%	13.7%	20.9%	3.4%		13.5%	30.5%	0.1%	0.2%	15.1%
Stop Sign	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	63.3%		30.9%	0.7%	40.2%		41.7%		19.0%	13.8%
	Running a Traffic Signal or Stop Sign			3.9%		2.7%		5.1%			
	Other Violation			14.7%	2.4%	14.6%	0.1%	20.2%		4.9%	9.0%
No Controls	Alcohol or Drugs	0.9%		0.7%		0.5%				0.2%	0.3%
	Speeding		0.7%	0.1%		1.0%			0.3%		1.3%
	Alcohol or Drugs and Speeding								0.3%		
	Reckless Driving	0.6%			0.1%			0.5%			
	Failure to Yield Right-of-Way	31.2%	0.1%	38.6%	0.1%	36.2%	0.3%	28.6%		14.4%	5.9%
	Running a Traffic Signal or Stop Sign			0.1%							
	Other Violation	17.1%	7.3%	17.2%	6.1%	10.6%	5.2%	26.1%	10.2%	10.5%	17.8%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

the road generally assign to the turning vehicle the responsibility of avoiding an LTAP/OD, LTAP/LD, LTIP, or RTIP crash. Appendix E presents statistics on the distribution of vehicle maneuvers (i.e., turning or going straight) in these four crossing path crash scenarios for light, commercial, transit, and emergency vehicle platforms.

"Running a Traffic Signal" was the most cited charge in SCP crashes at signalized intersections. This violation was also the most dominant in LTAP/LD and LTIP crashes, especially to vehicles crossing straight through the intersection. An analysis of 81 SCP crash cases drawn from the 1992-1993 CDS was conducted to identify the errors made by drivers who violated the traffic signal and crossed the intersection [1,5]. The results showed that:

- 46 percent of drivers did not see the traffic signal or its status;
- 18 percent of drivers tried to beat the amber light; and
- 36 percent of drivers deliberately ran the red light.

Approximately 35 percent and 33 percent of all vehicles involved in SCP and LTAP/OD crashes at intersections controlled by stop signs were charged with violations respectively. "Running a Stop Sign" violation was charged to only 6 percent of the vehicles involved in SCP crashes. This violation would be cited to drivers who ran the stop sign without stopping. An examination of the errors made by drivers who ran the stop sign without stopping in 40 SCP crash cases from the 1992 CDS revealed that [2]:

- 90 percent of drivers did not detect the presence of the stop sign; and
- 10 percent of drivers deliberately ran the stop sign.

The reader is cautioned about the statistical reliability of the above results that were based on small, non-representative crash samples from the 1992 and 1993 CDS crash databases.

Drivers who first stopped and then proceeded against cross traffic through a stop sign-controlled intersection would most likely be charged with "Failure to Yield Right-of-Way" when involved in a crossing path crash. This particular violation was charged to 17 percent of the vehicles involved in SCP crashes at intersections controlled by stop signs, about three times more than "Running a Stop Sign" violation. "Failure to Yield Right-of-Way" violation was near 21 percent of all vehicles involved in LTAP/OD crashes, 18 percent in LTAP/LD and LTIP crashes, and 17 percent in RTIP crashes at stop sign-controlled intersections. About 34 percent of the vehicles were charged with violations in LTAP/OD crashes at intersections with no controls, followed by 31 percent in SCP crashes. "Failure to Yield Right-of-Way" violation was the most prevalent in each crossing path crash scenario at intersections with no controls. Alcohol or drug violations were charged to less than 2 percent of the vehicles involved in each of the five common crossing path crash scenarios at intersections, as indicated in Table 4-1.

The most dominant violation in crossing path crashes at driveways was "Failure to Yield Right-of-Way," based on 1998 GES statistics provided in Table 4-2. Similar to unsignalized intersections, the driver of the turning vehicle was mostly charged with "Failure to Yield Right-of-Way" in LTAP/OD, LTAP/LD, LTIP, and RTIP crashes at unsignalized driveways. "Running a Traffic Signal" violation was charged to about 17 percent of drivers involved in SCP

crashes at signalized driveways. Fewer than 2.5 percent of all vehicles involved in each of the scenarios were charged with "Running a Stop Sign." Alcohol or drug violations were rarely issued in crossing path crashes at driveways with stop signs or no controls. However, the number of these violations seemed too high at signalized driveways. This is most likely an anomaly in GES statistics because the GES sample contains very few crossing path crash cases at signalized driveways. The crash statistics shown in Tables 4-1 and 4-2 are separated in Appendix F into the four vehicle platform types discussed earlier.

4.2 Vision Obstruction and Driver Distraction in Crossing Path Crashes

The *Driver's Vision Obscured By* and *Driver Distracted By* variables from the "Vehicle/Driver File" in the GES were examined to observe whether these two factors played any role in crossing path crashes. The former variable attempts to identify visual circumstances that may have contributed to the cause of the crash. Driver or witness statements are not considered unless verified by the investigating police officer. The latter variable attempts to capture distractions that may have influenced driver performance and contributed to the cause of the crash. The distractions can be either inside or outside the vehicle and are described as having interrupted the drivers' normal attention to the roadway.

Tables 4-3 and 4-4 list the statistics of vision obstructed and driver distraction in each of the crossing path crash scenarios respectively at intersections and driveways based on 1998 GES. Vision obstructed and driver distracted statistics were obtained from a combination of codes in each of their respective variables, which include:

Driver's Vision Obscured By

Code 01: Rain, snow, smoke, sand, dust
Code 02: Reflected glare, bright sunlight, headlights
Code 03: Curve or hill
Code 04: Building, billboard, or other design features
Code 05: Trees, crops, vegetation
Code 06: Moving vehicle (including load)
Code 07: Parked vehicle
Code 08: Splash or spray of passing vehicle
Code 09: Inadequate defrost or defog system
Code 10: Inadequate lighting system
Code 11: Obstruction interior to the vehicle
Code 12: External mirrors
Code 13: Head restraints
Code 14: Broken or improperly cleaned windshield
Code 15: Fog
Code 97: Vision obscured - No details
Code 98: Other obstruction

Driver Distracted By

Code 01: Passengers, occupants
Code 02: Vehicle instrument display
Code 03: Phone
Code 04: Other internal distractions
Code 05: Other accident
Code 06: Other external distractions
Code 97: Distraction - No details

Table 4-3. Vision Obstruction and Driver Distraction Statistics for *All* Vehicles Involved in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed	2.8%	1.0%	3.5%	3.4%				0.3%	1.8%	1.5%
	Driver Distracted	3.1%	1.4%	1.5%	4.1%	0.5%	3.4%	5.5%	5.1%	2.7%	1.1%
Stop Sign	Vision Obstructed	5.3%	3.5%	12.5%	4.4%	8.0%	2.6%	4.1%	1.0%	3.4%	1.6%
	Driver Distracted	2.7%	0.4%	4.7%	0.4%	1.7%		2.6%	1.1%	2.8%	2.0%
No Controls	Vision Obstructed	8.3%	2.7%	13.2%	4.4%	6.7%	2.5%	10.2%	4.7%	6.9%	3.8%
	Driver Distracted	3.8%	0.6%	3.4%	0.4%	5.7%		3.4%		1.4%	3.5%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table 4-4. Vision Obstruction and Driver Distraction Statistics for *All* Vehicles Involved in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed	12.1%	1.3%	9.8%	4.8%					12.4%	0.5%
	Driver Distracted	5.1%		5.5%	7.3%						
Stop Sign	Vision Obstructed			22.6%	8.7%	20.0%	14.6%			5.1%	4.8%
	Driver Distracted			0.7%		7.3%				1.4%	5.8%
No Controls	Vision Obstructed	8.2%	3.2%	15.6%	5.2%	2.1%	0.7%	7.9%	1.2%	4.1%	6.0%
	Driver Distracted	4.4%	0.1%	4.8%	0.3%	3.0%		1.2%	0.8%	2.5%	0.7%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

High rates of vision obstruction were reported in crossing path crash scenarios that involved mostly turning maneuvers at intersections and driveways controlled by stop signs or with no controls. As seen in Table 4-3, the top five vision obstruction rates at intersections are ranked in a descending order as follows:

- 8.8 percent of drivers involved in LTAP/LD crashes at intersections with no controls;
- 8.5 percent of drivers involved in LTAP/LD crashes at intersections with stop signs;
- 7.5 percent of drivers involved in RTIP crashes at intersections with no controls;
- 6.9 percent of drivers involved in SCP crashes at intersections with no controls; and
- 5.5 percent of drivers involved in LTAP/OD crashes at intersections with no controls.

Similarly, the reported vision obstruction rates at driveways in crossing path crash scenarios that had an individual frequency of over 10,000 crashes are ranked in a descending order as follows:

- 15.7 percent of drivers involved in LTAP/LD crashes at driveways with stop signs;
- 10.4 percent of drivers involved in LTAP/LD crashes at driveways with no controls;
- 5.7 percent of drivers involved in LTAP/OD crashes at driveways with no controls; and
- 4.6 percent of drivers involved in RTIP crashes at driveways with no controls.

Vision obstruction was associated more with drivers of the turning vehicles than with drivers of the vehicles that were going straight. Moreover, this factor was highest in LTAP/LD and RTIP crashes where drivers have to look first to their left side before turning. In these two scenarios, parked vehicles in parking lanes normally mask the view of drivers who would inch into the intersection to observe any crossing traffic. The *Driver's Vision Obscured By* variable was coded as "unknown" in fewer than 5 percent of crossing path crash cases in the 1998 GES.

Driver distraction was linked to over 2.5 percent of the drivers in only 6 of the cells in both Tables 4-3 and 4-4 that contained an individual frequency higher than 10,000 crashes. In a descending order, these cells are:

- 5.3 percent of drivers involved in RTIP crashes at intersections with signals;
- 2.8 percent of drivers involved in LTAP/LD crashes at intersections with signals;
- 2.8 percent of drivers involved in SCP crashes at intersections with stop signs;
- 2.7 percent of drivers involved in SCP crashes at intersections with signals;
- 2.6 percent of drivers involved in LTAP/LD crashes at intersections with stop signs; and
- 2.6 percent of drivers involved in LTAP/LD crashes at driveways with no controls.

The *Driver Distracted By* variable was also coded as "unknown" in fewer than 5 percent of crossing path crash cases in the 1998 GES. In order to qualify as a distraction in the GES, the occurrence must be classified on the PAR as a "distraction." This factor is rarely noted in such reports and thus it is underestimated in the GES. The CDS is a more appropriate source to obtain better estimates of driver distraction. However, multiple years of CDS data must be queried in order to satisfy all the cells in Tables 4-3 and 4-4. Appendix F provides statistics on vision obstruction and driver distraction by each of the four vehicle platform types discussed earlier.

5. PEDESTRIAN AND PEDALCYCLIST COLLISIONS AT INTERSECTIONS

Until now, vehicle-vehicle crossing path crashes have been discussed in this report. However, a confusing factor for this analysis was the presence of pedestrians and pedalcyclists at intersections. While the number of these collisions is small with regard to the overall crash population, pedestrian crashes are typically very severe and account for about 15 percent of the total collision fatality population each year. This severity merits an additional analysis for pedestrians and pedalcyclists at intersections.

5.1 Problem Size

Table 5-1 shows statistics of pedestrian and pedalcyclist collisions based on 1998 GES. These statistics were found by setting the GES *Pedestrian/Cyclist Crash Type* variable in the "Accident File" equal to 1 through 99 for pedalcyclists and 110 through 920 for pedestrians, which excludes pedestrians in wheelchairs. Note that the greatest number of pedestrian crashes occurred at non-junction sites in 1998, while the greatest number of pedalcyclist crashes occurred at intersections. About 28,000 pedestrian collisions or 39.4 percent of all pedestrian collisions occurred at intersections. At driveways, pedestrian collisions accounted for about 5.7 percent of all pedestrian collisions. On the other hand, pedalcyclist collisions at intersections were estimated at about 35,000 or about 59.4 percent of all pedalcyclist collisions, with approximately 19.0 percent of all pedalcyclist collisions occurring at driveways. Further, it was possible to extract from the GES the number of intersection vehicle-vehicle crashes due to avoiding pedestrians (509) and pedalcyclists (107), as well as the number of collisions following an avoidance maneuver with pedestrians (358) and pedalcyclists (28).

Table 5-1. Distribution of Pedestrian and Pedalcyclist Collisions by Relation to Junction (Based on 1998 GES)

	Relation to Junction	Pedalcyclist	Pedestrian	Both
Non-Interchange	Non-Junction	12,000	39,000	52,000
	Intersection	33,000	25,000	58,000
	Intersection-Related	1,000	3,000	4,000
	Driveway	11,000	4,000	15,000
	Ramp		*	*
	Grade Crossing			
	Bridge	*	*	*
	Other		*	*
Interchange	Non-Junction		*	*
	Intersection	*	*	*
	Intersection-Related	*		*
	Driveway			
	Ramp	*	*	*
	Bridge			
	Other			
	Total	58,000	72,000	130,000

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

Table 5-2 shows the FARS data for pedestrian and pedalcyclist crashes in 1998. Here the patterns are more comparable to each other and show that the majority of the fatalities did not occur at or near intersections, with only 22.8 percent of pedestrian fatalities and 30.5 percent of pedalcyclist fatalities occurring there. Using the numbers listed in Tables 5-1 and 5-2, the following fatality rates can be observed:

- 9.8 fatal collisions per 100 pedestrian collisions at non-junctions;
- 4.2 fatal collisions per 100 pedestrian collisions at intersections;
- 4.1 fatal collisions per 100 pedalcyclist collisions at non-junctions;
- 1.8 fatal collisions per 100 pedestrian collisions at driveways;
- 0.7 fatal collision per 100 pedalcyclist collisions at intersections; and
- 0.2 fatal collision per 100 pedalcyclist collisions at driveways.

Based on the results indicated above, pedestrian and pedalcyclist collisions are more fatal at non-junctions than at intersections and more fatal at intersections than at driveways. This is due to higher vehicle speeds at non-junctions as compared to speeds normally observed at intersections and driveways. Moreover, pedestrian collisions are more fatal than pedalcyclist collisions, which may be attributed to differences in relative speed at impact. Pedalcyclists usually ride with the traffic and thus experience lower impact speeds than pedestrians.

Table 5-3 shows the correlation of fatal crash counts for pedestrians and pedalcyclists to traffic control devices at intersections. The cells in this table with the most pedestrian fatal crashes are about equally divided between intersections with no controls (540 crashes) and signalized intersections (515 crashes). References [8] and [9] provide additional statistics on collisions that involved pedestrians and pedalcyclists in 1998, respectively.

Table 5-2. Distribution of Pedestrian and Pedalcyclist Fatal Collisions by Relation to Junction (Based on 1998 FARS)

Relation to Junction		Pedalcyclist	Pedestrian	Both
Non-Interchange	Non-Junction	497	3,852	4,348
	Intersection	172	694	866
	Intersection-Related	55	471	526
	Driveway	24	73	97
	Ramp	2	26	28
	Grade Crossing	1		1
	Unknown	1	2	3
Interchange	Intersection	1	25	26
	Intersection-Related	4		4
	Ramp	3	35	38
	Unknown		3	3
	Other	1	34	35
	Unknown		5	5
	Total	761	5,220	5,981

Table 5-3. Distribution of Pedestrian and Pedalcyclist Fatal Collisions at Intersections vs. Traffic Control Device (Based on 1998 FARS)

Traffic Control Device	Pedalcyclist	Pedestrian	Both
Signal (on colors) *without* Pedestrian Signal	2	11	13
Signal (on colors) *with* Pedestrian Signal	9	133	142
Signal (on colors) *not known* whether or not Pedestrian Signal	68	371	439
Stop Sign	70	89	159
No Controls	76	540	616
Total	225	1,144	1,369

5.2 Description of Pedestrian and Pedalcyclist Collision Events

Table 5-4 ranks, in descending order, the events of pedestrian collisions at intersections in terms of their relative frequency of occurrence based on 1998 GES. The most dominant pedestrian collision event was coded as "intersection - other" that refers to a collision occurring at an intersection but is not covered by, or there is insufficient information to code any of the rows in Table 5-4 based on the GES coding manual. In 38.1 percent of pedestrian collisions, the vehicle and the pedestrian collided while the vehicle was in the process of turning/merging, was preparing to turn/merge, or had just completed a turning/merging maneuver. The driver's view of the pedestrian was blocked by some obstruction in the third highest collision event, until an instant before impact and/or the pedestrian was running. The driver was charged with a violation in 2.2 percent of pedestrian collisions due to alcohol, speeding, or signal/sign violation.

Table 5-5 describes the events of pedalcyclist collisions at intersections based on 1998 GES. The driver took an inappropriate action in 56.0 percent of pedalcyclist collisions while 32.0 percent of these collisions were attributed to errors made by the pedalcyclist. Moreover, the vehicle was attempting a turning maneuver in 44.0 percent of pedalcyclist collisions as opposed to only 2.8 percent of the collisions in which the pedalcyclist was making a turn. A traffic control device was tied to 38.6 percent of pedalcyclist collisions including 26.4 percent at intersections controlled by a stop sign or flashing red signal, 8.2 percent at signalized intersections, and 4.0 percent at intersections with no controls.

Table 5-4. Distribution of Pedestrian Collisions at Intersections (Based on 1998 GES)

Crash Event Description	%
Intersection - other	41.7%
Vehicle turn/merge	38.1%
Intersection dash/driver view obstructed	6.5%
Not in roadway, shoulder or curb	2.5%
Driver violation (DUI, speeding, sign viol.)	2.2%
Vehicle backing up	1.6%
Waiting to cross, standing at/near curb	1.0%
Multiple threat	1.0%
Play vehicle related	1.0%
Walking along roadway against traffic	0.8%
Disabled vehicle related	0.5%
Working on roadway	0.5%
School bus/school bus stop	0.4%
Commercial bus/stop	0.3%
Entering/exiting a parked vehicle	0.3%
Other -Weird	0.3%
Midblock (> 50 ft from intersection) - other	0.3%
Walked into vehicle	0.2%
Trapped at signalized intersections	0.2%
Walking along roadway with traffic	0.1%
Unknown	0.1%
Inadequate information	0.1%
Playing in roadway	0.1%
Total	100.0%

Table 5-5. Distribution of Pedalcyclist Collisions at Intersections (Based on 1998 GES)

Crash Event Description	%
Cyclist rides out into or in front of motorist at intersection	15.2%
Motorist turns or drives out in front of cyclist at an intersection controlled by a stop sign or flashing red signal, motorist obeys the sign but fails to yield to cyclist	13.5%
Cyclist fails to yield to motorist at an intersection controlled by stop sign or flashing red signal (crossing path)	11.0%
Motorist turns right in front of cyclist proceeding in a parallel path, cyclist either proceeding in same direction or from opposite direction	10.9%
Controlled intersection - other	10.3%
Motorist makes left turn in front of cyclist approaching from straight ahead	8.4%
Motorist obeys signal but fails to yield to cyclist while making right turn on red at an intersection controlled by signal	8.0%
Motorist drives out into or in front of cyclist at intersection	5.3%
Motorist collides with cyclist at uncontrolled intersection: crossing paths	4.0%
Motorist makes left turn in front of cyclist proceeding in the same direction	2.8%
Cyclist turns left in front of motorist proceeding in the same direction (parallel path)	2.2%
Motorist fails to stop at an intersection controlled by a stop sign	1.9%
Cyclist rides out, fails to yield to motorist at midblock location (parallel path)	1.4%
Motorist collides with cyclist head on: wrong way cyclist	1.0%
Weird (cyclist struck by falling cargo, motorist or cyclist intentionally caused the crash)	1.0%
Motorist overtaking cyclist	0.6%
Parallel path - unknown	0.4%
Cyclist overtaking motor vehicle	0.3%
Parking lot: crossing paths	0.2%
Unknown	0.2%
Cyclist turns left in front of motorist approaching from straight ahead (opposite direction)	0.2%
Motorist cuts corner when turning left: crossing paths	0.2%
Motorist swings wide when turning right: crossing paths	0.2%
Cyclist cuts corner when turning left: crossing paths	0.2%
Cyclist fails to clear intersection controlled by signal before light turns green for cross traffic; motorist's view of cyclist was not obstructed	0.1%
Cyclist fails to clear intersection controlled by signal before light turns green for cross traffic; motorist's view of cyclist was obstructed by standing traffic	0.1%
Cyclist riding on wrong side of street makes right turn in path of approaching motorist	0.1%
Motorist backing from driveway fails to yield to cyclist	0.1%
Motorist misjudges space required to pass cyclist	0.1%
Cyclist loses control and swerves into the path (head on) of a motorist proceeding in the same direction	0.1%
Intersecting path - unknown	0.1%
Play vehicle (big wheel, tricycle, bicycle with training wheels)	0.1%
Cyclist swings wide when turning right: crossing paths	0.1%
Total	100.0%

6. CONCLUSIONS

A detailed analysis of crossing path crashes was conducted using the 1998 GES and FARS to gain a better understanding of crash avoidance opportunities using intelligent vehicle safety systems. This analysis provides background information that will enable researchers to devise appropriate countermeasure concepts for crossing path crashes and to determine the size of applicable crash populations.

Approximately 1.72 million police-reported crossing path crashes occurred in 1998, which accounted for 27.3 percent of all police-reported crashes in the United States. This crash type resulted in at least two vehicles colliding at an angle in 95.9 percent of the crashes. Five crash scenarios were identified based on vehicle movements that happened immediately prior to a crossing path collision. These five scenarios constituted 88.7 percent of all crossing path crashes, including three most dominant scenarios in terms of crash frequency. The SCP crash scenario was the most prevalent at 29.9 percent, followed closely by the LTAP/OD crash scenario at 27.5 percent, and trailing third was the LTAP/LD crash scenario amounting to 19.7 percent of all crossing path crashes.

Intersections and driveways accounted respectively for 78.1 percent and 21.0 percent of all the locations where crossing path crashes occurred in 1998. Approximately 42 percent of all crossing path crashes at intersections happened in the presence of signals, which was the most frequent among traffic control devices. The LTAP/OD crash scenario accounted for 41 percent of these crashes at signalized intersections. The analysis of 1998 GES revealed, however, that crossing path crashes at intersections with no controls had the highest fatality rates. This finding was based on a sample of crashes in the GES which was difficult to verify against FARS data because the FARS does not contain the "*Accident Type*" variable that enables the unambiguous identification of crossing path crashes. At driveways, the vast majority of crossing path crashes (82.4 percent) occurred at junctions coded in the GES for no controls. Therefore, while it is easy to conceive of the crossing path crash problem as being mainly at signalized intersections, in fact, the GES estimated that more crossing path crashes occurred at unsignalized intersections and driveways in 1998. In addition, unsignalized junction crossing path crashes generally resulted in a higher number of fatalities.

Three 1998 GES variables from the "Vehicle/Driver File" were examined to identify factors that may have contributed to the cause of the crash, including violations charged, vision obstruction, and driver distraction. Both LTAP/OD and SCP crashes had the most violations among crossing path crash scenarios at intersections, while LTAP/OD and LTAP/LD crashes had the most violations at driveways. "Failure to Yield Right-of-Way" was the most dominant violation in all crossing path crash scenarios at intersections and driveways controlled by stop signs or with no controls. This violation was cited especially to drivers attempting to turn either left or right through the intersection in LTAP/OD, LTAP/LD, LTIP, and RTIP crashes. "Running a Traffic Signal" violation was mostly charged to drivers in SCP crashes at signalized intersections, as well as in LTAP/LD and LTIP crashes especially to vehicles going straight through the intersection. Alcohol and drug violations were charged to fewer than 2 percent of the vehicles involved in crossing path crashes at intersections and driveways. High rates of vision obstruction were reported in crossing path crash scenarios that involved mostly turning

maneuvers at unsignalized intersections and driveways. About 9 percent of drivers attributed vision obstruction as a contributing factor in LTAP/LD crashes at intersections with either no controls or stop signs. Similarly, vision obstruction was reported by about 16 percent and 10 percent of drivers involved in LTAP/LD crashes at driveways with stop signs and no controls, respectively. The citation of driver distraction as a crash contributing factor was rarely reported in crossing path crashes according to the 1998 GES. It should be noted that the GES generally underestimates driver distraction. This factor was linked to over 2.5 percent of the drivers in few scenarios including RTIP crashes at signalized intersections, LTAP/LD and SCP crashes at signalized and stop sign-controlled intersections, and LTAP/LD crashes at driveways with no controls.

This report also analyzed pedestrian and pedalcyclist collisions to obtain estimates of their crash counts and to describe their pre-crash events using the 1998 GES. In addition, the actual number of *fatal* crashes with pedestrians and pedalcyclists was found from the 1998 FARS at intersections with different traffic control devices. These results showed that crashes of these types at intersections were of a similar count size to those not at intersections, but that the non-intersection crashes resulted in a higher number of fatalities. Further, *fatal* crash counts for this type were about the same between signalized intersections and uncontrolled intersections, with stop sign-controlled intersections showing the least number of fatalities. Generally, pedestrian and pedalcyclist collisions are more fatal at non-junction locations than at intersections and more fatal at intersections than at driveways. Moreover, pedestrian collisions are more fatal than pedalcyclist collisions. Finally, the most dominant pre-crash event of pedestrian and pedalcyclist collisions involved a vehicle that was in the process of turning/merging, was preparing to turn/merge, or had just completed a turning/merging maneuver.

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APPENDIX A. GES *ACCIDENT TYPE* DIAGRAM

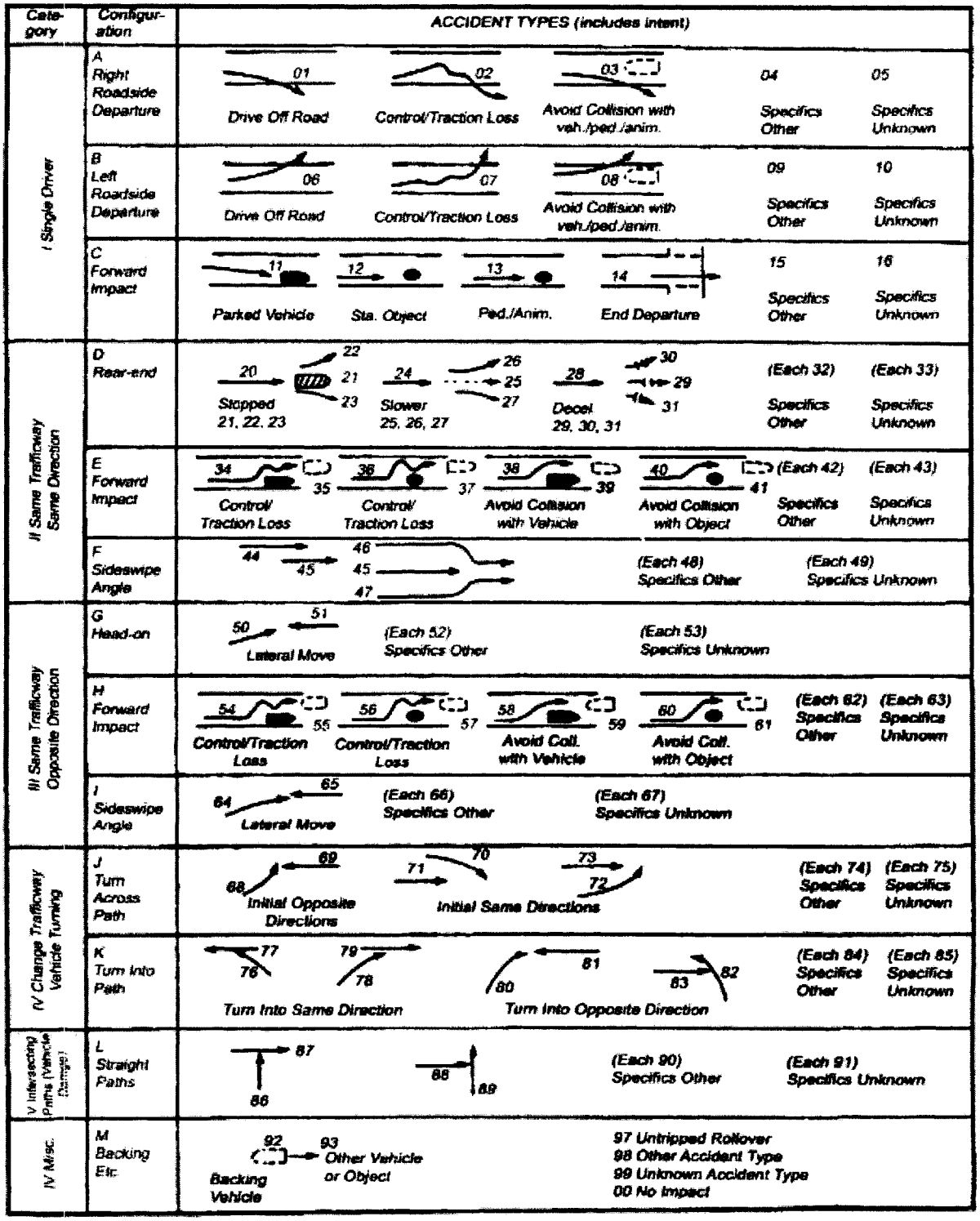

Figure A-1. Diagram of GES Accident Type Variable Code

APPENDIX B. CROSSING PATH CRASHES BY VEHICLE PLATFORM

The *Hotdeck Imputed Body Type*, *Special Use*, and *Emergency Use* variables in the GES "Vehicle/Driver File" were utilized to identify light, commercial, transit, and emergency vehicles. The *Hotdeck Imputed Body Type* variable contains the following categories:

Codes 01-09: Automobiles
Codes 10-13: Automobile derivatives
Codes 14-19: Utility vehicles
Codes 20-29: Van-based light large trucks
Codes 30-39: Light conventional large trucks less than or equal to 4,500 Kg in Gross Vehicle Weight Ratio (GVWR)
Codes 40-48: Other light large trucks less than 4,500 Kg GVWR
Codes 50-59: Buses excluding van-based
Codes 60-78: Medium/heavy large trucks greater than 4,500 Kg GVWR
Codes 80-89: Motored cycles excluding all terrain vehicles/cycles
Codes 90-97: Other vehicles

The relevant codes of the *Special Use* variable are:

Code 00: No special use
Code 03: Vehicle used as "other" bus
Code 05: Police
Code 06: Ambulance
Code 07: Fire truck and car

The *Emergency Use* variable indicates if a code 05 through 07 *Special Use* vehicle is on an emergency run:

Code 0: No
Code 1: Yes
Code 9: Unknown

B.1 Light Vehicles

Crashes that involved at least one light vehicle were identified by selecting codes 01-22, 28-41, or 45-48 from the *Hotdeck Imputed Body Type* variable and code 00 from the *Special Use* variable. There were about 1.66 million police-reported crossing path crashes that involved at least one light vehicle based on 1998 GES statistics. The distribution of these crashes is illustrated in Figure B-1. The most dominant scenario was the SCP crash that accounted for about 29.8 percent of these crashes. The LTAP/OD and LTAP/LD crash scenarios followed with 26.9 percent and 20.0 percent, respectively. The "other" crossing path crash scenario refers to right turn across path (RTAP) crashes, coded as 80-81, and crashes that were coded as crossing path crashes with *other* or *unknown* specifics based on the GES *Accident Type* variable. The RTAP crash scenario involves one vehicle turning right into the opposite direction of another,

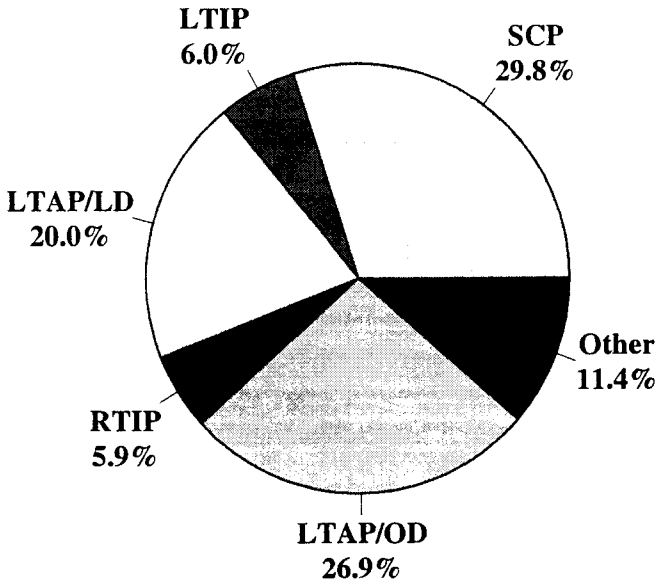

Figure B-1. Distribution of Crossing Path Crash Scenarios for *Light* Vehicles (Based on 1998 GES)

both initially traveling in perpendicular directions. This particular scenario accounted for about 17 percent of all "other" crossing path crashes or about 2 percent of all crossing path crashes. It should be noted that "other" crossing path crashes coded as *other* or *unknown* might include crashes that involve two vehicles initially traveling in the same direction, in adjacent lanes. Generally, the profile of light vehicle crashes resembles that of *all* vehicle crashes since light vehicles constitute over 95 percent of the vehicle fleet in the United States.

B.2 Commercial Vehicles

Crashes that involved at least one commercial vehicle (large truck) were identified by selecting codes 60, 64, 66, or 78 from the *Hotdeck Imputed Body Type* variable and not codes 05-07 from the *Special Use* variable. Based on 1998 GES statistics, crossing path crashes that involved at least one commercial vehicle amounted to approximately 60 thousand police-reported crashes. The distribution of these crashes is illustrated in Figure B-2. A new dominant parallel turning path (PTP) crash scenario appeared in our analyses of commercial vehicle crashes. The PTP crash scenario was identified by analyzing a combination of codes from the *Manner of Collision*, *Accident Type*, *Movement Prior to Critical Event*, and *Critical Event* variables in the GES. This crash scenario refers to two vehicles traveling in the same direction, in adjacent lanes, and both turning either right or left simultaneously as illustrated in Figure B-3. Note that crash scenarios that involved two vehicles traveling in the same direction, in adjacent lanes, other than PTP crash scenario, were excluded from Figure B-2, since these were deemed more appropriate for lane change crash countermeasures.

The SCP crash scenario was the most dominant in terms of crash frequency with 25.5 percent of all crossing path crashes that involved at least one commercial vehicle. The LTAP/LD and LTAP/OD crash scenarios followed respectively with 18.0 percent and 14.7 percent. It is

noteworthy that the PTP crash scenario ranked fourth in terms of the frequency of occurrence at 13.7 percent of all these crashes. The RTAP crash scenario accounted for 3.2 percent of the crashes, in which the commercial vehicle is turning right and swings wide into the path of a vehicle approaching from the right direction.

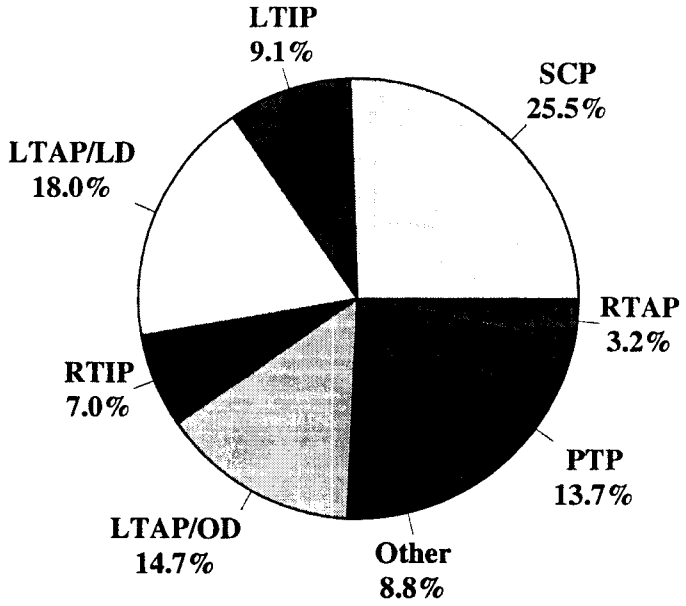

Figure B-2. Distribution of Crossing Path Crash Scenarios for *Commercial* Vehicles (Based on 1998 GES)

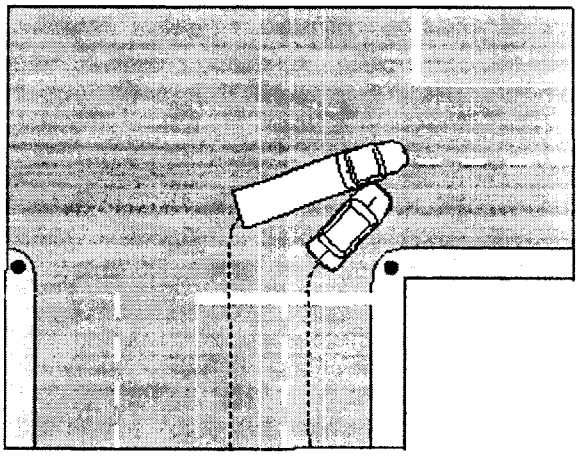

Figure B-3. PTP Crossing Path Crash Scenario

B.3 Transit Vehicles

Codes 25, 58, or 59 from the *Hotdeck Imputed Body Type* variable and codes 00 or 03 from the *Special Use* variable were chosen to identify crashes that involved at least one transit vehicle. There were about 7,000 police-reported crossing path crashes that involved at least one transit vehicle (bus) based on 1998 GES statistics. Figure B-4 illustrates the distribution of these crashes. Similar to light and commercial vehicle crash statistics, the most frequently occurring scenario was the SCP crash scenario at 20.7 percent of these crossing path crashes. The PTP crash scenario ranked a very close second with a relative frequency of 20.6 percent. Note that transit vehicles were more involved in the RTIP crash scenario than light and commercial vehicles, accounting for 17.6 percent of transit vehicle-involved crossing path crashes. As with commercial vehicle crash statistics, Figure B-4 did not include crash scenarios that involved two vehicles traveling in the same direction, in adjacent lanes, other than the PTP crash scenario.

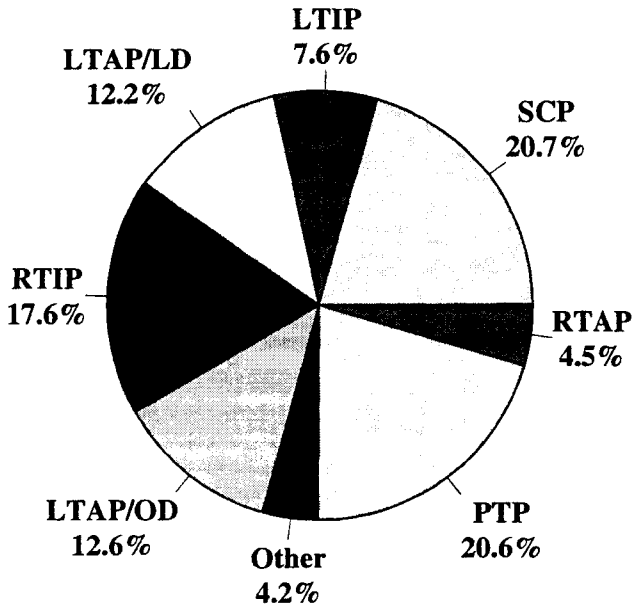

Figure B-4. Distribution of Crossing Path Crash Scenarios for *Transit* Vehicles (Based on 1998 GES)

B.4 Emergency Vehicles

GES codes 05-07 from the *Special Use* variable and code 1 from the *Emergency Use* variable were used to identify crashes that involved emergency vehicles. Based on 1998 GES statistics, emergency vehicles were involved in about 5,000 police-reported crossing path crashes. These crashes consisted of four scenarios as shown in Figure B-5. Both SCP and LTAP/LD crash scenarios collectively accounted for 89.3 percent of these crashes. The SCP crash scenario dominated at 64.4 percent of all emergency vehicle-involved crossing path crashes.

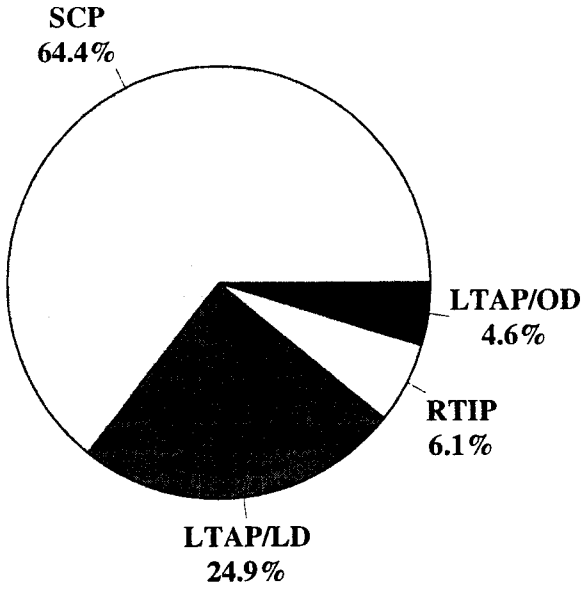

Figure B-5. Distribution of Crossing Path Crash Scenarios for *Emergency* Vehicles (Based on 1998 GES)

APPENDIX C. CROSSING PATH CRASHES IN RELATION TO JUNCTION BY VEHICLE PLATFORM

C.1 Light Vehicles

Table C-1 shows that 98.7 percent of crossing path crashes that involved at least 1 light vehicle occurred at non-interchange locations based on 1998 GES statistics. In addition, 77.8 percent and 21.3 percent of these crashes were reported to occur respectively at intersections and driveways.

Table C-1. Distribution of Crossing Path Crashes vs. Relation to Junction for *Light* Vehicles (Based on 1998 GES)

Relation to Junction		Crossing Path (CP) Crash Scenarios							
		LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Non-Interchange	Non-Junction	4,000	*	1,000		1,000	2,000	8,000	0.5%
	Intersection	335,000	200,000	55,000	57,000	466,000	110,000	1,223,000	73.8%
	Intersection-Related	4,000	5,000	4,000	4,000	2,000	30,000	49,000	2.9%
	Driveway	97,000	121,000	35,000	33,000	20,000	46,000	352,000	21.2%
	Ramp	*		*	*	*		1,000	0.0%
	Grade Crossing	*					*	*	0.0%
	Bridge	*	*		*	*		1,000	0.0%
	Other	1,000		1,000	1,000		1,000	3,000	0.2%
Interchange	Non-Junction								
	Intersection	4,000	4,000	2,000	1,000	3,000	2,000	17,000	1.0%
	Intersection-Related	1,000	*	*	*	*	*	2,000	0.1%
	Driveway				1,000	*	*	1,000	0.1%
	Ramp	*	*	1,000	*	*	*	2,000	0.1%
	Bridge	*						*	0.0%
	Other				*		*	*	0.0%
	Total	446,000	332,000	99,000	98,000	493,000	190,000	1,658,000	100.0%
	% Total	26.9%	20.0%	6.0%	5.9%	29.8%	11.4%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

C.2 Commercial Vehicles

Approximately 96 percent of police-reported crossing path crashes that involved at least one commercial vehicle occurred at non-interchange locations based on 1998 GES statistics. Table C-2 provides the distribution of these crashes in relation to junction. Similar to light vehicle crash statistics, about 77.6 percent and 21.5 percent of these crashes were reported to occur respectively at intersections and driveways.

Table C-2. Distribution of Crossing Path Crashes vs. Relation to Junction for *Commercial* Vehicles (Based on 1998 GES)

Relation to Junction		Crossing Path (CP) Crash Scenarios									
		LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Non-Interchange	Non-Junction					*					0.6%
	Intersection	7,000	7,000	2,000	2,000	14,000	6,000	2,000	2,000	42,000	69.1%
	Intersection-Related	*	1,000	*	*	*	1,000	*	*	3,000	4.7%
	Driveway	2,000	3,000	3,000	2,000	1,000	*	*	2,000	13,000	21.5%
	Ramp				*					*	0.0%
	Grade Crossing										0.0%
	Bridge					*				*	0.0%
	Other			*						*	0.0%
Interchange	Non-Junction										
	Intersection	*	*	*	*	*	1,000		*	2,000	3.7%
	Intersection-Related	*	*			*	*			*	0.0%
	Driveway				*	*				*	0.1%
	Ramp		*	*	*	*	*			*	0.3%
	Bridge										
	Other				*					*	0.0%
	Total	9,000	11,000	6,000	4,000	15,000	8,000	2,000	5,000	60,000	100.0%
	% Total	14.7%	18.0%	9.1%	7.0%	25.5%	13.7%	3.2%	8.8%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

C.3 Transit Vehicles

Based on 1998 GES statistics, crossing path crashes that involved at least one transit vehicle occurred mostly at non-interchange locations with a relative frequency of 98.6 percent as seen in Table C-3. The majority of these crashes happened at intersections with a relative frequency of 91.6 percent, which were more dominant than light and commercial vehicles. Only 8.4 percent of these crashes were reported to occur at driveways.

C.4 Emergency Vehicles

Table C-4 shows that crossing path crashes that involved an emergency vehicle occurred totally at non-interchange locations as estimated by 1998 GES statistics. Intersection and driveway locations were reported in 84.6 percent and 15.4 percent of these crashes, respectively.

Table C-3. Distribution of Crossing Path Crashes vs. Relation to Junction for *Transit* Vehicles (Based on 1998 GES)

Relation to Junction		Crossing Path (CP) Crash Scenarios									
		LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Non-Interchange	Non-Junction										0.0%
	Intersection	1,000	1,000	*	1,000	1,000	1,000	*	*	6,000	85.7%
	Intersection-Related						*	*		*	4.5%
	Driveway		*	*	*	*				1,000	8.4%
	Ramp										
	Grade Crossing										
	Bridge										
	Other										
Interchange	Non-Junction										
	Intersection	*				*				*	1.4%
	Intersection-Related										
	Driveway										
	Ramp										
	Bridge										
	Other										
	Total	1,000	1,000	1,000	1,000	2,000	2,000	*	*	7,000	100.0%
	% Total	12.6%	12.2%	7.6%	17.6%	20.7%	20.6%	4.5%	4.2%	100.0%	

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

Table C-4. Distribution of Crossing Path Crashes vs. Relation to Junction for *Emergency* Vehicles (Based on 1998 GES)

Relation to Junction		Crossing Path (CP) Crash Scenarios							
		LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Non-Interchange	Non-Junction								
	Intersection	*	1,000			3,000		4,000	84.6%
	Intersection-Related								
	Driveway	*	*		*	*		1,000	15.4%
	Ramp								
	Grade Crossing								
	Bridge								
	Other								
Interchange	Non-Junction								
	Intersection								
	Intersection-Related								
	Driveway								
	Ramp								
	Bridge								
	Other								
	Total	*	1,000		*	3,000		4,000	100.0%
	% Total	4.6%	24.9%		6.1%	64.3%		100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

APPENDIX D. CROSSING PATH CRASHES VERSUS TRAFFIC CONTROL DEVICE BY VEHICLE PLATFORM

D.1 Light Vehicles

About 1.64 million police-reported crossing path crashes that involved at least one light vehicle were reported at intersections and driveways based on 1998 GES statistics. Tables D-1 and D-2 provide their frequency counts respectively at intersections and driveways by traffic control device. Approximately 35.0 percent of these crashes occurred at signalized intersections and driveways. Moreover, a stop sign was the traffic control device at intersections and driveways in 31.2 percent of these crashes. Note that intersections and driveways with no controls were associated with 30.8 percent of light vehicle-involved crossing path crashes.

Table D-1. Distribution of Crossing Path Crashes by Traffic Control Device for *Light* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	228,000	52,000	15,000	20,000	181,000	58,000	555,000	43.1%
Stop Sign	16,000	128,000	33,000	29,000	236,000	45,000	487,000	37.7%
No Controls	93,000	26,000	10,000	11,000	35,000	33,000	208,000	16.1%
Other	6,000	4,000	2,000	3,000	20,000	5,000	39,000	3.1%
Total	344,000	210,000	61,000	62,000	472,000	141,000	1,290,000	100.0%
% Total	26.7%	16.3%	4.7%	4.8%	36.6%	11.0%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.

Table D-2. Distribution of Crossing Path Crashes by Traffic Control Device for *Light* Vehicles at Driveways (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	7,000	5,000	1,000	3,000	1,000	2,000	19,000	5.5%
Stop Sign	1,000	12,000	4,000	3,000	3,000	4,000	26,000	7.5%
No Controls	86,000	101,000	29,000	28,000	16,000	38,000	297,000	84.1%
Other	3,000	3,000	1,000	1,000	1,000	2,000	10,000	3.0%
Total	97,000	121,000	35,000	34,000	20,000	46,000	353,000	100.0%
% Total	27.4%	34.4%	9.8%	9.7%	5.7%	12.9%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.

D.2 Commercial Vehicles

About 60,000 police-reported crossing path crashes that involved at least one commercial vehicle were reported at intersections and driveways based on 1998 GES statistics. Tables D-3 and D-4 provide their frequency counts respectively at intersections and driveways by traffic control

device. Approximately 40.2 percent of these crashes occurred at signalized intersections and driveways. Moreover, a stop sign was the traffic control device at intersections and driveways in 28.2 percent of these crashes. Intersections and driveways with no controls were associated with 27.8 percent of commercial vehicle-involved crossing path crashes. It should be noted that the 1998 GES contains very few cases of crossing path crashes that involve commercial vehicles, especially at driveways. In fact, Table D-4 indicates that the five major scenarios had a frequency of at least 1,000 crashes only at driveways with no controls.

Table D-3. Distribution of Crossing Path Crashes by Traffic Control Device for *Commercial* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios									
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Signal	5,000	3,000	1,000	1,000	7,000	5,000	1,000	1,000	23,000	48.8%
Stop Sign	1,000	3,000	2,000	1,000	6,000	1,000	1,000	1,000	16,000	33.5%
No Controls	2,000	1,000	*	*	1,000	2,000	*	1,000	7,000	14.6%
Other	*	*	*	*	*	1,000		*	1,000	3.2%
Total	7,000	7,000	3,000	2,000	14,000	8,000	2,000	3,000	47,000	100.0%
% Total	15.3%	15.8%	6.3%	5.1%	30.5%	16.9%	4.0%	6.2%	100.0%	

- The symbol * represents crash frequencies below 500.

Table D-4. Distribution of Crossing Path Crashes by Traffic Control Device for *Commercial* Vehicles at Driveways (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios									
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Signal	*	*	*	*	*	*		1,000	1,000	9.5%
Stop Sign		*	*	*	*			*	1,000	9.1%
No Controls	1,000	3,000	2,000	1,000	1,000	*	*	1,000	10,000	75.6%
Other	*	*	*	*		*		*	1,000	5.8%
Total	2,000	3,000	3,000	2,000	1,000	*	*	2,000	13,000	100.0%
% Total	12.9%	26.5%	19.4%	13.6%	5.8%	2.6%	0.3%	18.9%	100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

D.3 Transit Vehicles

About 8,000 police-reported crossing path crashes that involved at least one transit vehicle were reported at intersections and driveways based on 1998 GES statistics. Tables D-5 and D-6 provide their frequency counts respectively at intersections and driveways by traffic control device. Signalized intersections and driveways were reported in 59.4 percent of these crashes. These locations had higher relative frequencies of crossing path crashes related to transit vehicle than both light and commercial vehicles. Moreover, a stop sign was the traffic control device at intersections and driveways in 26.5 percent of these crashes. Intersections and driveways with no controls experienced 12.8 percent of these crashes, which was at a lower relative frequency than light and commercial vehicles. As seen in Table D-5, only five crossing path crash

scenarios had a frequency of at least 1,000 transit vehicle crashes at intersections, four of them at signalized intersections. Table D-6 shows that reported crossing path crash frequencies at driveways were below 500 transit vehicle crashes.

Table D-5. Distribution of Crossing Path Crashes by Traffic Control Device for *Transit* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios									
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Signal	1,000	*	*	1,000	1,000	2,000	*		4,000	64.8%
Stop Sign		*		*	1,000		*	*	2,000	28.9%
No Controls		*	*						*	4.9%
Other					*				*	1.5%
Total	1,000	1,000	*	1,000	1,000	2,000	*	*	7,000	100.0%
% Total	13.7%	12.3%	4.7%	15.8%	21.6%	22.5%	4.9%	4.6%	100.0%	

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

Table D-6. Distribution of Crossing Path Crashes by Traffic Control Device for *Transit* Vehicles at Driveways (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios									
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	PTP	RTAP	Other	All CP	% All CP
Signal										
Stop Sign										
No Controls		*	*	*	*				1,000	100.0%
Other										
Total		*	*	*	*				1,000	100.0%
% Total		11.4%	40.2%	37.4%	11.1%				100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

D-4 Emergency Vehicles

About 5,000 police-reported crossing path crashes that involved at least 1 emergency vehicle were reported at intersections and driveways based on 1998 GES statistics. Tables D-7 and D-8 provide their frequency counts respectively at intersections and driveways by traffic control device. Close to transit vehicle crash statistics, signalized intersections and driveways experienced about 63.0 percent of these crashes. Moreover, only 10.0 percent of these crashes were reported at stop sign-controlled intersections and driveways. Uncontrolled intersections and driveways were associated with 26.9 percent of emergency vehicle-involved crossing path crashes. Only two crossing path crash scenarios had a frequency of at least 1,000 emergency vehicle crashes at both driveways and intersections, as seen in Tables D-7 and D-8.

Table D-7. Distribution of Crossing Path Crashes by Traffic Control Device for *Emergency* Vehicles at Intersections (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	*	1,000			2,000		3,000	73.1%
Stop Sign					*		*	11.9%
No Control	*	*			*		1,000	15.0%
Other								
Total	*	1,000			3,000		4,000	100.0%
% Total	4.9%	21.9%			73.2%		100.0%	

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

Table D-8. Distribution of Crossing Path Crashes by Traffic Control Device for *Emergency* Vehicles at Driveways (Based on 1998 GES)

Traffic Control Device	Crossing Path (CP) Crash Scenarios							
	LTAP/OD	LTAP/LD	LTIP	RTIP	SCP	Other	All CP	% All CP
Signal	*	*					*	7.4%
Stop Sign								
No Controls		*		*	*		1,000	92.6%
Other								
Total	*	*		*	*		1,000	100.0%
% Total	2.9%	41.6%		39.8%	15.6%		100.0%	

- Numbers in cells were rounded to the nearest 1,000.
- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.
- The symbol * represents crash frequencies below 500.

APPENDIX E. VEHICLE MOVEMENTS IN CROSSING PATH CRASH SCENARIOS BY VEHICLE PLATFORM

The 1998 GES was queried to obtain statistics on vehicle movements in crossing path crash scenarios that involved at least one vehicle turning either left or right through the intersection. The LTAP/OD, LTAP/LD, LTIP, and RTIP crash scenarios were specifically considered.

E.1 Light Vehicles

Tables E-1 and E-2 present the distribution of light vehicle movements in turning scenarios at intersections and driveways based on 1998 GES statistics. As seen in both tables, the percentages of light vehicle movements were almost even between going straight and turning through the intersection. This is due to the 95 percent composition rate of light vehicles in the U.S. vehicle fleet and, thus, a light vehicle is most likely to strike another light vehicle in a crash.

Table E-1. *Light* Vehicle Movements in Crossing Path Crash Scenarios at Intersections (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	49.9%	50.1%	49.9%	50.1%	49.7%	50.3%	49.2%	50.8%
Stop Sign	49.9%	50.1%	49.7%	50.3%	50.7%	49.3%	49.7%	50.3%
No Controls	50.1%	49.9%	49.3%	50.7%	50.7%	49.3%	51.6%	48.4%
Other	51.5%	48.5%	50.6%	49.4%	53.9%	46.1%	50.0%	50.0%

Table E-2. *Light* Vehicle Movements in Crossing Path Crash Scenarios at Driveways (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	49.3%	50.7%	50.1%	49.9%	50.4%	49.6%	50.2%	49.8%
Stop Sign	50.0%	50.0%	49.5%	50.5%	51.7%	48.3%	51.4%	48.6%
No Controls	50.3%	49.7%	50.0%	50.0%	50.4%	49.6%	50.8%	49.2%
Other	51.3%	48.7%	49.2%	50.8%	49.2%	50.8%	40.7%	59.3%

E.2 Commercial Vehicles

Commercial vehicles were mostly turning left in LTAP/OD and LTAP/LD crashes at intersections controlled with signals, stop signs, or no controls as indicated in Table E-3. These vehicles were mostly traveling straight through intersections controlled by either signals or stop signs in LTIP crashes. Conversely, these vehicles were mostly turning right in RTIP crashes at intersections controlled by either signals or stop signs. Table E-4 shows that commercial vehicles were mostly turning left in LTAP/OD and LTAP/LD crashes while mostly going straight in LTIP and RTIP crashes at driveways.

Table E-3. *Commercial* Vehicle Movements in Crossing Path Crash Scenarios at Intersections (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	57.7%	42.3%	58.8%	41.2%	43.5%	56.5%	56.7%	43.3%
Stop Sign	92.5%	7.5%	63.3%	36.7%	38.0%	62.0%	73.2%	26.8%
No Controls	71.4%	28.6%	72.0%	28.0%	71.4%	28.6%	2.8%	97.2%
Other	5.6%	94.4%	62.8%	37.2%	0.0%	100.0%	51.9%	48.1%

Table E-4. *Commercial* Vehicle Movements in Crossing Path Crash Scenarios at Driveways (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	71.8%	28.2%	69.0%	31.0%	30.9%	69.1%	49.2%	50.8%
Stop Sign			68.7%	31.3%	0.0%	100.0%	34.2%	65.8%
No Controls	77.1%	22.9%	64.9%	35.1%	49.6%	50.4%	32.7%	67.3%
Other	31.6%	68.4%	100.0%	0.0%	100.0%	0.0%	100.0%	0.0%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

E.3 Transit Vehicles

Table E-5 indicates that transit vehicles were mostly turning in LTAP/OD and LTAP/LD crashes at intersections controlled by either signals or stop signs, and in RTIP crashes at signalized intersections. Moreover, transit vehicles were going straight in LTIP crashes at intersections and in RTIP crashes at stop sign-controlled intersections. Table E-6 presents statistics on transit vehicle movements at driveways. The reader is cautioned that the statistics in Tables E-5 and E-6 are not reliable since they were derived from a very small sample from the 1998 GES. Multiple years of GES data must be examined in order to obtain reliable crash statistics on transit vehicles.

E.4 Emergency Vehicles

Tables E-7 and E-8 show that emergency vehicles were mostly turning left in LTAP/OD crashes at intersections and driveways, and in LTAP/LD crashes at uncontrolled intersections. Moreover, these vehicles were mostly traveling straight in LTAP/LD crashes at signalized intersections. The reader is cautioned that the statistics in Tables E-7 and E-8 are not reliable since they were derived from a very small sample from the 1998 GES. Multiple years of GES data must be examined in order to obtain reliable crash statistics on emergency vehicles.

Table E-5. *Transit* Vehicle Movements in Crossing Path Crash Scenarios at Intersections (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	90.2%	9.8%	64.0%	36.0%	0.0%	100.0%	69.0%	31.0%
Stop Sign			100.0%	0.0%			0.0%	100.0%
No Controls			0.0%	100.0%	0.0%	100.0%		
Other								

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table E-6. *Transit* Vehicle Movements in Crossing Path Crash Scenarios at Driveways (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal								
Stop Sign								
No Controls			0.0%	100.0%	0.0%	100.0%	0.0%	100.0%
Other								

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table E-7. *Emergency* Vehicle Movements in Crossing Path Crash Scenarios at Intersections (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	100.0%	0.0%	39.4%	60.6%				
Stop Sign								
No Controls	100.0%	0.0%	100.0%	0.0%				
Other								

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table E-8. *Emergency* Vehicle Movements in Crossing Path Crash Scenarios at Driveways (Based on 1998 GES)

Traffic Control Device	LTAP/OD		LTAP/LD		LTIP		RTIP	
	Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight
Signal	100.0%	0.0%	11.0%	89.0%				
Stop Sign								
No Controls			0.0%	100.0%			0.0%	100.0%
Other								

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

APPENDIX F. CONTRIBUTING FACTORS IN CROSSING PATH CRASHES BY VEHICLE PLATFORM

Tables F-1 – F-6 present statistics on violations charged to vehicles involved in crossing path crashes respectively at intersections and driveways for light, commercial, transit, and emergency vehicles based on 1998 GES. Tables F-7 – F-13 provide statistics on vision obstruction and driver distraction in crossing path crashes respectively at intersections and driveways for light, commercial, transit, and emergency vehicles based on 1998 GES. Statistics related to emergency vehicle crashes were obtained for the "other" vehicle that collided with the emergency vehicle. This appendix does not include statistics on violations charged to vehicles involved in transit or emergency vehicle crashes at driveways, or statistics on vision obstruction and driver distraction in transit vehicle crashes at driveways, because the 1998 GES did not contain any relevant data about these crashes. It should be noted that the statistical description of contributing factors is not reliable in commercial vehicle crashes at driveways, and in transit and emergency vehicle crashes at both intersection and driveways, due to very small representative samples in the 1998 GES. Multiple years of GES data must be examined in order to obtain reliable statistics for these crashes.

Table F-1. Violations Charged to *Light* Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol/Drug	1.7%	0.3%	0.2%	0.7%	0.5%		2.8%		1.0%	1.0%
	Speeding	0.2%	0.5%	1.4%	0.7%			0.8%	0.4%	0.4%	1.0%
	Reckless Driving	0.2%	0.1%	0.2%	0.8%					0.2%	0.5%
	Failure to Yield Right-of-Way	29.7%	0.8%	4.4%	1.1%	3.8%	2.1%	20.3%		1.5%	1.7%
	Running a Signal/Stop Sign	1.3%	3.6%	3.7%	23.8%	5.4%	11.1%	4.4%	4.2%	14.9%	1.0%
	Other Violations	16.3%	9.4%	10.9%	12.2%	14.0%	12.2%	15.3%	4.5%	13.9%	16.9%
Stop Sign	Alcohol/Drug		1.5%	1.2%	0.3%	0.8%		0.3%		0.3%	1.5%
	Speeding			0.2%	0.4%			0.3%		0.5%	0.6%
	Alcohol/Drug and Speeding				0.1%						
	Reckless Driving			0.1%		0.4%	0.4%			0.2%	0.4%
	Failure to Yield Right-of-Way	38.8%	5.1%	36.7%	0.4%	35.9%	0.8%	32.4%	2.0%	17.2%	9.0%
	Running a Signal/Stop Sign		2.7%	3.1%	1.0%	9.9%	0.3%	4.3%	0.3%	6.1%	0.6%
	Other Violations	12.0%	7.6%	11.1%	7.8%	11.9%	6.3%	14.5%	7.9%	11.1%	15.8%
No Controls	Alcohol/Drug	1.0%		1.5%	0.5%	0.9%	3.1%			0.6%	1.6%
	Speeding	0.4%	0.3%		2.0%		2.6%		3.1%	1.3%	1.3%
	Alcohol/Drug and Speeding		0.3%								
	Reckless Driving	0.2%						0.9%			0.2%
	Failure to Yield Right-of-Way	38.0%	0.9%	22.2%	0.4%	15.3%		12.7%	0.2%	17.2%	0.5%
	Running a Signal/Stop Sign		0.1%							0.1%	
	Other Violations	16.6%	9.8%	23.0%	3.6%	9.0%	2.5%	18.2%	8.6%	11.9%	17.6%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-2. Violations Charged to *Light* Vehicles in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol/Drug			4.8%		24.4%		7.5%			
	Failure to Yield Right-of-Way	27.6%	1.3%	10.9%	1.8%		8.1%	15.7%		4.1%	3.6%
	Running a Signal		3.9%		8.3%					16.6%	1.5%
	Other Violations	7.6%	13.9%	21.1%	3.5%		11.3%	30.4%	0.1%	0.2%	10.6%
Stop Sign	Failure to Yield Right-of-Way	63.3%		31.5%	0.7%	40.2%		38.9%		18.7%	13.1%
	Running a Stop Sign			4.0%		2.7%		5.4%			
	Other Violations			15.0%	2.2%	14.6%		21.2%		5.0%	6.9%
No Controls	Alcohol/Drug	0.9%		0.7%						0.2%	0.4%
	Speeding		0.7%	0.1%		1.1%			0.3%		1.3%
	Alcohol/Drug and Speeding								0.3%		
	Reckless Driving	0.6%			0.1%			0.5%			
	Failure to Yield Right-of-Way	31.6%	0.1%	38.8%	0.1%	37.7%	0.3%	28.5%		14.2%	6.1%
	Running a Sign			0.1%							
	Other Violations	16.9%	7.2%	17.5%	5.9%	9.8%	5.5%	26.3%	10.7%	10.7%	17.3%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-3. Violations Charged to *Commercial* Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs			0.1%						0.1%	
	Speeding	0.3%	2.1%							0.7%	
	Alcohol or Drugs and Speeding										
	Reckless Driving	0.3%	0.4%							0.3%	0.1%
	Failure to Yield Right-of-Way	19.8%	0.2%	13.9%				11.4%			
	Running a Traffic Signal or Stop Sign	1.0%	6.4%	1.3%	13.6%	1.7%	1.8%		9.8%	14.7%	1.1%
	Other Violation	19.1%	4.1%	27.5%	0.8%	2.1%		5.1%		11.1%	23.2%
Stop Sign	Alcohol or Drugs										
	Speeding				6.9%						
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	3.8%		13.4%		0.9%		11.5%		15.4%	1.2%
	Running a Traffic Signal or Stop Sign			1.0%	0.3%			3.5%		10.3%	
	Other Violation	35.1%	15.8%	23.6%	2.2%	28.6%		1.5%	3.1%	8.7%	36.5%
No Controls	Alcohol or Drugs	0.3%									0.1%
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	35.4%							22.0%	13.8%	2.1%
	Running a Traffic Signal or Stop Sign										
	Other Violation	9.2%	3.0%	48.6%	3.2%	79.1%				15.0%	15.8%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-4. Violations Charged to *Commercial* Vehicles in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs										
	Speeding										0.5%
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	5.9%		31.8%				47.4%			
	Running a Traffic Signal or Stop Sign										
	Other Violation	94.1%					100.0%	52.6%			48.8%
Stop Sign	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way			59.3%				97.4%		52.5%	0.9%
	Running a Traffic Signal or Stop Sign										
	Other Violation			12.8%			1.6%				60.7%
No Controls	Alcohol or Drugs					13.8%					
	Speeding										0.1%
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way	6.6%		27.5%		3.7%		52.9%		2.9%	2.1%
	Running a Traffic Signal or Stop Sign										
	Other Violation	37.5%	76.5%	5.2%	3.2%	31.7%		25.2%		7.2%	31.4%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-5. Violations Charged to *Transit* Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way										
	Running a Traffic Signal or Stop Sign									13.0%	
	Other Violation	39.8%						45.2%	100.0%		26.8%
Stop Sign	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way			22.4%							
	Running a Traffic Signal or Stop Sign										
	Other Violation										
No Controls	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way										
	Running a Traffic Signal or Stop Sign										
	Other Violation										

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-6. Violations Charged to *Other* Vehicles Involved with *Emergency* Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Violations Charged	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way		84.1%	6.9%						7.5%	
	Running a Traffic Signal or Stop Sign										
	Other Violation			93.1%	4.0%					28.5%	
Stop Sign	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way										
	Running a Traffic Signal or Stop Sign										
	Other Violation									36.1%	
No Controls	Alcohol or Drugs										
	Speeding										
	Alcohol or Drugs and Speeding										
	Reckless Driving										
	Failure to Yield Right-of-Way										
	Running a Traffic Signal or Stop Sign										
	Other Violation									57.9%	

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-7. Vision Obstruction and Driver Distraction Statistics for *Light* Vehicles Involved in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed	2.8%	1.0%	3.6%	3.4%				0.4%	1.7%	1.2%
	Driver Distracted	3.2%	1.5%	1.5%	4.2%	0.5%	3.5%	5.8%	5.3%	2.8%	0.9%
Stop Sign	Vision Obstructed	5.5%	3.6%	12.3%	4.4%	7.4%	2.7%	4.2%	1.1%	3.4%	1.7%
	Driver Distracted	2.7%	0.5%	4.8%	0.4%	1.8%		2.7%	1.1%	2.9%	2.1%
No Controls	Vision Obstructed	8.4%	2.7%	12.6%	4.4%	6.7%	2.6%	10.2%	5.0%	6.4%	3.7%
	Driver Distracted	3.9%	0.7%	3.6%	0.3%	5.7%		3.4%		1.4%	3.6%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-8. Vision Obstruction and Driver Distraction Statistics for *Light* Vehicles Involved in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed	12.6%	1.3%	9.9%	4.8%					12.4%	0.6%
	Driver Distracted	5.4%		5.6%	7.4%						
Stop Sign	Vision Obstructed			23.3%	8.8%	20.0%	15.7%			5.2%	3.6%
	Driver Distracted			0.7%		7.3%				1.5%	6.2%
No Controls	Vision Obstructed	8.2%	3.2%	15.8%	5.1%	1.8%	0.7%	7.1%	1.1%	4.2%	6.3%
	Driver Distracted	4.5%	0.1%	4.5%	0.3%	2.5%		1.2%	0.9%	2.6%	0.7%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-9. Vision Obstruction and Driver Distraction Statistics for *Commercial* Vehicles Involved in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed		0.4%							0.5%	2.6%
	Driver Distracted	0.2%		0.2%	3.4%					0.4%	3.3%
Stop Sign	Vision Obstructed	1.9%		13.2%	1.6%	33.5%	0.6%	0.6%		1.9%	0.5%
	Driver Distracted	1.9%		0.4%					0.9%	1.3%	0.8%
No Controls	Vision Obstructed			38.9%	7.1%					39.7%	6.2%
	Driver Distracted	0.3%			8.3%						0.5%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-10. Vision Obstruction and Driver Distraction Statistics for *Commercial* Vehicles Involved in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed										
	Driver Distracted										
Stop Sign	Vision Obstructed										
	Driver Distracted										
No Controls	Vision Obstructed	11.2%	0.8%	12.1%		0.8%		3.0%		2.4%	
	Driver Distracted	0.6%		12.0%		13.8%					0.2%

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-11. Vision Obstruction and Driver Distraction Statistics for *Transit* Vehicles Involved in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed										15.2%
	Driver Distracted										
Stop Sign	Vision Obstructed			77.6%							
	Driver Distracted										
No Controls	Vision Obstructed										
	Driver Distracted										

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-12. Vision Obstruction and Driver Distraction Statistics for *Other* Vehicles Involved with *Emergency* Vehicles in Crossing Path Crashes at Intersections (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed										
	Driver Distracted										
Stop Sign	Vision Obstructed									100.0%	
	Driver Distracted										
No Controls	Vision Obstructed										
	Driver Distracted		100.0%								

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

Table F-13. Vision Obstruction and Driver Distraction Statistics for *Other* Vehicles Involved with *Emergency* Vehicles in Crossing Path Crashes at Driveways (Based on 1998 GES)

TCD	Factor	LTAP/OD		LTAP/LD		LTIP		RTIP		SCP	Other
		Turning	Straight	Turning	Straight	Turning	Straight	Turning	Straight		
Signal	Vision Obstructed										
	Driver Distracted										
Stop Sign	Vision Obstructed										
	Driver Distracted										
No Controls	Vision Obstructed			100.0%							
	Driver Distracted										

- Empty cells refer to scenarios that had no crashes in the 1998 GES sample.

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