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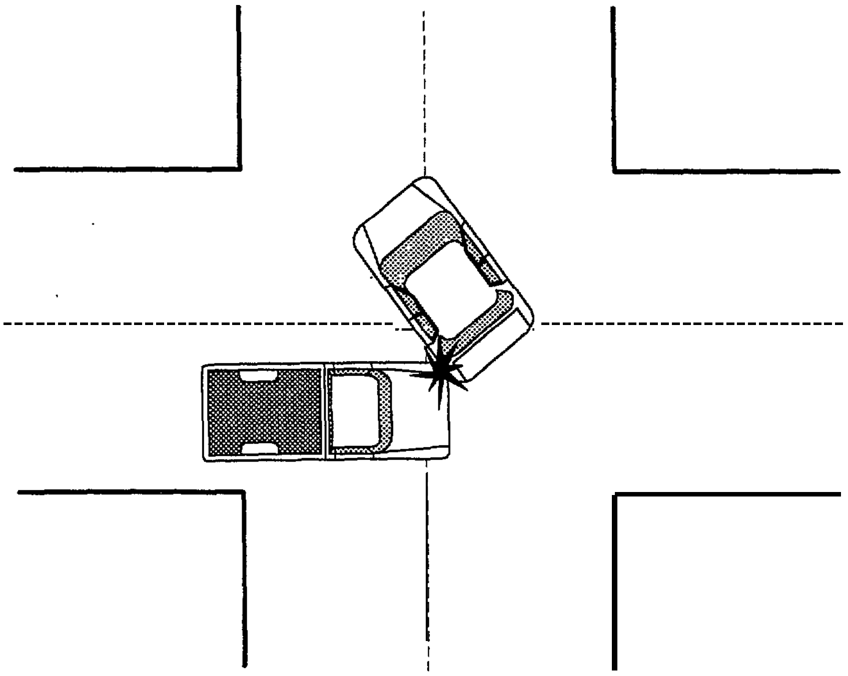
Intersection Crossing Path Crashes: Problem Size Assessment and Statistical Description



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16. Abstract

This document presents problem size assessments and statistical crash descriptions for intersection crossing path (ICP) crashes and three key subtypes of the ICP crashes. The ICP crashes are potential "target crashes" of high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. To elucidate potential countermeasure applicability, the ICP crash is divided into three types: signalized intersection perpendicular crossing path (SI/PCP), unsignalized intersection perpendicular crossing path (UI/PCP) and left turn across path (LTAP) crashes. The principal data source is the 1991 General Estimates System (GES). ICP crash problem size is assessed using such measures as number of crashes, number and severity of injuries, crash involvement rate, and crash involvement likelihood. Problem size statistics are provided for five vehicle type categories: all vehicles, passenger vehicles (i.e., cars, light trucks, light vans), combination-unit trucks, medium/heavy single-unit tricks and motorcycle. Descriptive statistics are provided for all vehicles only. ICP crashes and the three crash subtypes are described statistically primarily in terms of the conditions under which they occur (e.g., time of day, weather, roadway type, relation to junction) and, when data are available, in terms of possible contributing factors.

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EXECUTIVE SUMMARY .

This document presents problem size assessments and statistical crash descriptions for intersection crossing path **(ICP)** crashes. The principal data source is the 1991 General Estimates System (GES). ICP crashes are potential "target crashes" of various conventional and high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. For example, countermeasure concepts incorporating communication among vehicles, drivers and upcoming intersections (e.g., to inform drivers of a hazardous situation at an intersection through the use of alerting devices or similar technologies) appear to be especially applicable to this crash type.

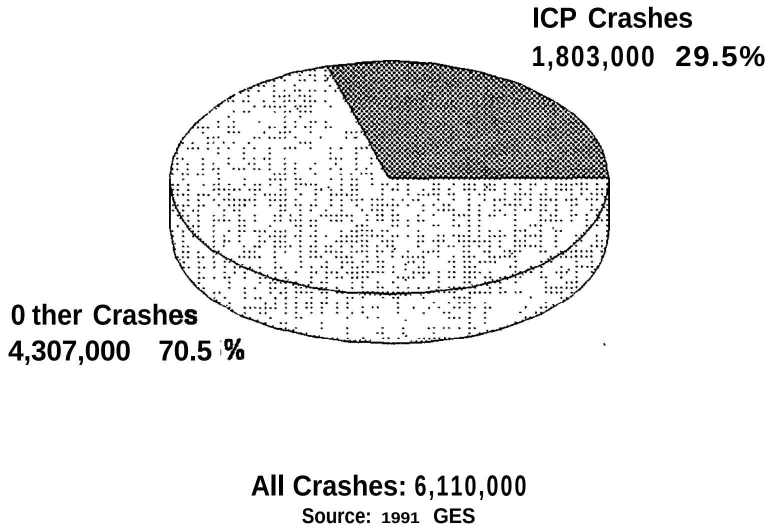
In this report, the ICP crash problem size is assessed using such measures as number of crashes, number and severity of injuries, number of fatalities, crash involvement rate, and crash involvement likelihood. Problem size statistics are provided for five vehicle type categories: all vehicles combined, passenger vehicles (i.e., cars, light trucks, light vans), combination-kit trucks, medium/heavy single-unit trucks, and motorcycles.

Overall Problem Size

Principal statistical findings regarding the ICP crash problem size include the following:

- In 1991, there were 1,803,000 ICP crashes, constituting 29.5 percent of all police-reported crashes. **See Figure ES-l.** These crashes resulted in 1,082,000 injuries, including 144,000 fatal or incapacitating (WA") injuries.

Figure ES-1. Intersection Crossing Path (ICP) Crashes



During its operational life, a vehicle can be expected to be involved in 0.25 police-reported ICP crashes.

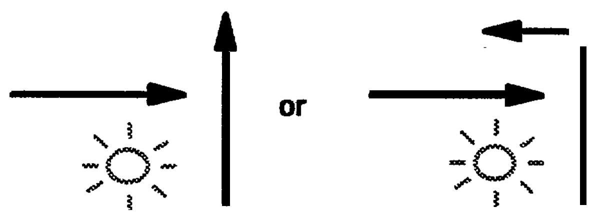
- The above statistics relate to police-reported crashes. This report presents a method for estimating annual ***non-police reported*** ICP crashes, which yielded an estimate of approximately 2,224,000 for 1991.

- The report also presents a method for estimating crash-caused delay in vehicle-hours. Based on the estimation algorithm described in .the report, ICP crashes cause about 26.7 percent of all crash-caused delay.

ICP Crash Type Taxonomy

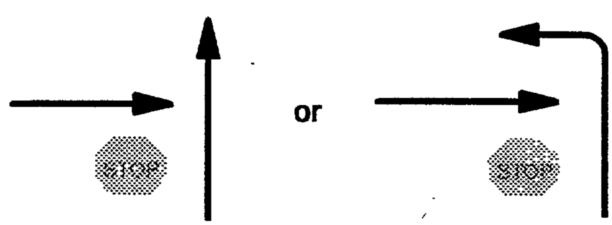
Following the overall problem size assessment, this report disaggregates the overall problem into the following three subtypes:

1) Signalized intersection perpendicular crossing path (SI/PCP) crashes.



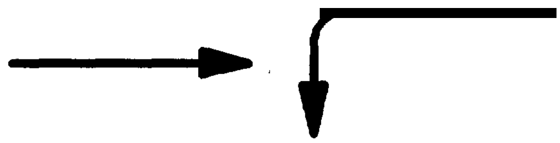
SI/PCP crashes include those crashes occurring at intersections with signal lights where the two involved vehicles approached the intersection from perpendicular paths.

2) Un-signalized intersection perpendicular crossing path (UI/PCP)' crashes.



UI/PCP crashes include those crashes occurring at intersections either with traffic control signs or without any control device and where the two involved vehicles approached the intersection from perpendicular paths.

3) Left Turn Across Path (LTAP) crashes.



LTAP crashes involve two vehicles traveling in opposite directions where one makes a left turn maneuver across the path of the other. These crashes may occur both at signalized and un-signalized intersections.

Figure ES-2 shows the relative crash problem sizes of these crash subtypes.

Figure ES-2 Various ICP Crash Subtypes as a Portion of All Crashes

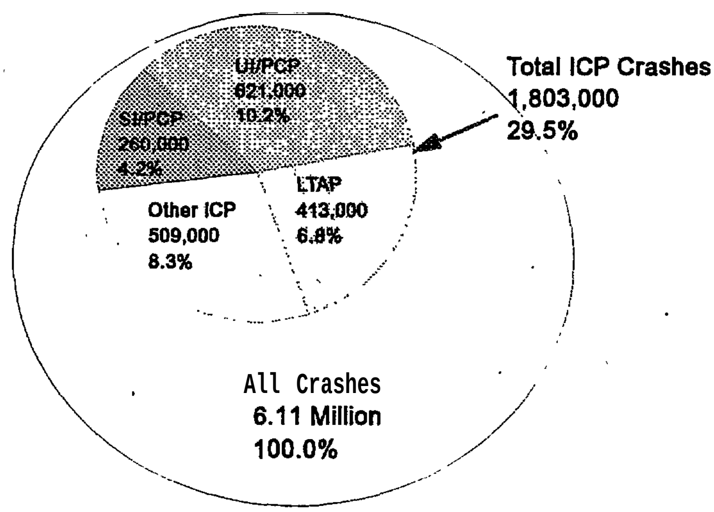


Figure ES-2 shows that of the estimated 1,803,000 crashes in 1991, 260,000 were SI/PCP crashes (4.2 percent of all crashes), 621,000 were UI/PCP crashes (10.2%) and 413,000 were LTAP crashes (6.8 %). Other ICP crashes (e.g., Turn Across Path, Initial Same Direction) accounted for 509,000 crashes.

Vehicle Type Comparisons

The above statistics relate'to all vehicle types combined. The report presents problem size statistics on ICP crashes for several major vehicle type categories, including passenger vehicles (here defined as cars, utility vehicles, light trucks, and vans), combination-unit trucks (i.e., tractor-trailers), single-unit medium/heavy trucks, and motorcycles. In 1991, ICP crashes constituted 30.2 percent of passenger vehicle crashes, 17.4 percent of combination-unit crashes, 25.3 percent of single-unit truck crashes and 31.0 percent of motorcycle crashes.

Not surprisingly, the vast majority of ICP crashes (99.8 percent) involve at least one passenger vehicle. However, motorcycles have a crash involvement rate per 100 million vehicle miles traveled (VMT) that is about twice that of passenger vehicles. Combination-unit trucks have a low rate of involvement, but, due to their high mileage exposure and long operational life, have the highest likelihood of involvement over vehicle life. Motorcycles show a diametrically-opposite picture; i.e., very high crash involvement rates but relatively low likelihoods over vehicle life.

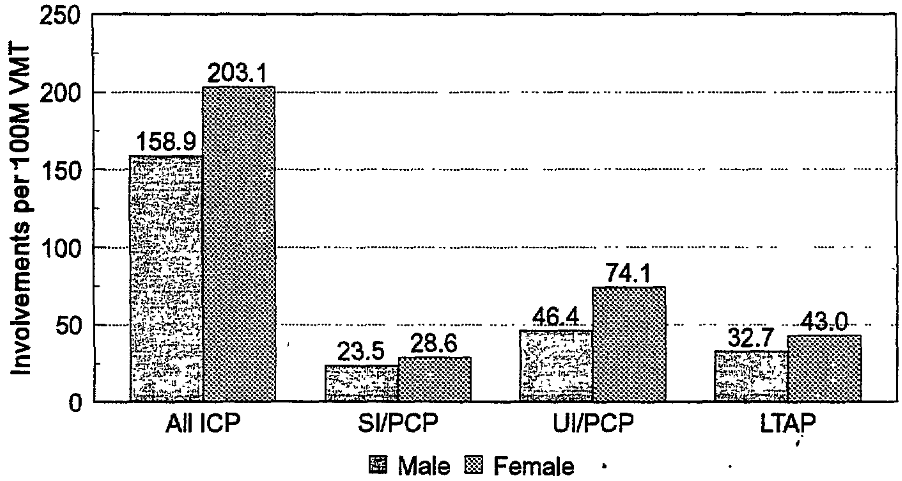
Crash Characteristics

Descriptive statistics are provided for ICP, SI/PCP, UI/PCP and LTAP crashes. As stated above, 99.8 percent of ICP crashes involved at least one passenger vehicle. Thus, all descriptive statistics presented here are for all vehicles combined. In addition, certain vehicle/driver characteristics are presented separately based on the vehicle roles (e-g, left turning vehicle versus the other vehicle).

Most of the ICP crashes occurred largely during daytime with no adverse weather conditions or other major environmental contributing factors. There were few differences among the three subtypes.

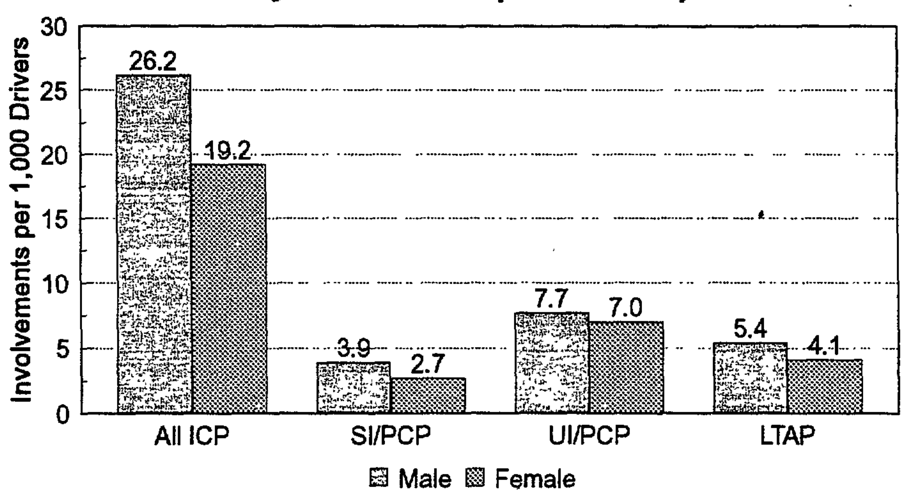
Driver age and sex involvement patterns were calculated using two different statistical metrics: rate (per 100 million VMT) and likelihood (involvements per 1,000 registered drivers). Unlike most other descriptive statistics, the age/sex statistics were calculated for 1990 rather than 1991. ICP crash involvement rates per 100 million VMT were highest for younger drivers and lowest for middle-aged drivers. Drivers aged 75 and older had the next highest involvement rate. SI/PCP, UI/PCP and LTAP crash subtypes followed similar patterns. Overall, females had a higher involvement rate. **Figure ES-3** depicts the comparable involvement rates by sex for all ICP crashes and the three subtypes.

Figure ES-3. Crash Involvement Rate by Driver Sex (1990 Data)



The ICP crash involvement likelihood (involvements per 1,000 licensed drivers) shows a different pattern by sex than that based on the VMT. Overall, the likelihood of involvement for male drivers was higher than for female drivers (26.2 ICP crash involvement/per 1,000 male drivers compared to 19.2 ICP crash involvements per 1,000 female drivers). **Figure ES-4** shows the likelihood of involvement for all ICP crashes and the three subtypes.

Figure ES-4. Crash Involvement Likelihood by Driver Sex (1990 Data)



The most common violations charged were failure to yield, running a traffic light, and impairment by alcohol/drugs. Compared to younger and'middle-aged drivers, relatively more older drivers were charged with failure to yield, and fewer were charged with alcohol/drugs.

Appendices

Appendices to the report provide detailed definitions and explanations of all statistics used, statistics on all crashes (i.e., the "universe" of crashes), generalized estimated sampling errors for the 1991 GES, and reference citations.

1. INTRODUCTION

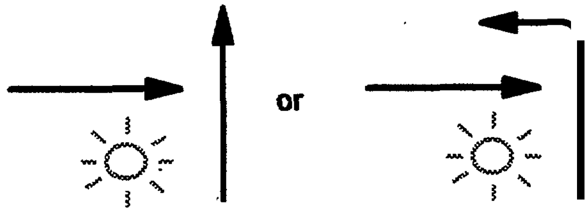
This report is the fifth in a series of reports on target crash problem sizes and statistical descriptions produced by the NHTSA Office of Crash Avoidance Research in conjunction with countermeasure assessment/problem definition efforts. Previous reports have addressed rear-end crashes Knipling, Wang, and Yin, 1993), backing crashes (Wang and Knipling, 1994a), lane change/merge crashes (Wang and Knipling,' 1994b), and single vehicle roadway departure crashes (Wang and Knipling, 1994c). Future planned reports will examine opposite direction (e.g., head-on) crashes, fatigued/drowsy driver crashes, and other crash types as needed to support agency crash analyses.

This document presents problem size assessments and statistical crash descriptions for intersection crossing path (ICP) crashes. ICP crashes are potential "target crashes" of high-technology Intelligent Vehicle Highway System (IVHS) crash avoidance countermeasures. For example, countermeasure concepts incorporating communication between vehicles, drivers and upcoming intersections (to inform drivers of hazards at intersections through the use of intersection alerting devices, or similar technologies) appear to be especially applicable to this crash'type. In this report, the ICP crash problem size is assessed using such measures as number of crashes, number and severity of injuries, number of fatalities, crash involvement rate (per 100 million vehicle miles of travel), and crash involvement likelihood (e.g., annual number of involvements per ~1,000 vehicles). ICP crashes are described statistically primarily in terms of the conditions under which they occur and, when data are available, in terms of possible contributing factors.

Most statistics provided in this report are estimates based on national crash databases, such as the 1991 NHTSA General Estimates System (GES). Due to the lack of similar defining variables in the Fatal Accident Reporting System (FARS), definitive data on fatalities resulting from ICP crashes are not available. Instead, 'aggregated GES data on fatalities and incapacitating injuries are provided for ICP crashes and the three subjects. Statistics address ***only police-reported*** crashes, although a rough estimate of the non-police-reported ICP crash population is provided based on a new estimation procedure for these crashes.

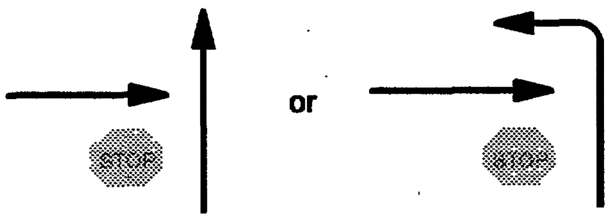
The provision-of crash statistics for ICP crashes and other topics implies that the crash problem in question can be stated and quantified in terms of existing database variables/elements to an acceptable degree of accuracy. In practice, accuracy will vary, based primarily on how well crash database variables and definitions correspond to the ICP crash type of the conceived countermeasure. In some cases, a problem size assessment may represent a target crash type that is broader, narrower, or otherwise different than that conceptualized according to the action of the countermeasure on driver or vehicle response. Thus, baseline problem size assessments may be modified based on additional information as part of the problem definition/countermeasure technology assessment process. In the case of' ICP crashes, other than describing ICP crash population as a whole, three subtype crashes are studied:

1) Signalized intersection perpendicular crossing path (SI/PCP) crashes.



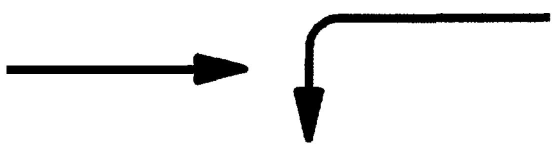
SI/PCP crashes include those crashes occurring at intersections with signal lights where the two involved vehicles approached the intersection from perpendicular paths.

2) Un-signalized intersection perpendicular crossing path (UI/PCP) crashes.



UI/PCP crashes include those crashes occurring at intersections either with traffic control signs or without any control device and where the two involved vehicles approached the intersection from perpendicular paths.

3) Left Turn Across Path (LTAP) crashes.



LTAP crashes involve two vehicles traveling in opposite directions where one makes a left turn maneuver across the path of the other. These crashes may occur both at signalized and un-signalized intersections.

This report will initially present the entire ICP crash population and then disaggregate the overall problem into three subtypes: SYPCP, UI/PCP and LTAP. The countermeasure analytical modeling work described above addresses these three subtypes separately, thus necessitating separate statistical analyses.

This problem size assessment and statistical description of ICP crashes has been prepared in conjunction with an ongoing analytical process intended to determine the extent to which high-technology IVHS countermeasures can be employed effectively to prevent (and lessen the severity of) crashes. The ICP crash-related countermeasure modeling work is described in the three different technical reports, each emphasizing one specific subtype. SYPCP crash related technical report is by Tijerina et al (1994), UI/PCP by Chovan et ***al*** (1994a) and LTAP by Chovan et al (1994b).

In summary, the crash problem statistics presented in this report are intended to be compatible with ongoing countermeasure modeling/effectiveness estimation efforts. This information supports the assessment of potential safety benefits of crash prevention approaches and also helps to defme the conditions under which countermeasures must operate in order to be effective.

The remainder of this report is organized as follows:

- Chapter 2 classifies ICP crashes, presents data on crash problem size, and disaggregates the ICP crash problem size into subtypes relevant to countermeasure applicability.
- Chapter 3 provides descriptive statistics regarding ICP crashes and three major subtypes. This includes crash involvement rates for various driver age and gender groups.
- Chapter 4 recounts statistics from the Indiana Tri-Level study on the causes of ICP crashes.
- Appendix A describes the statistics used to quantify and describe the ICP and other target crash problems.
- Appendix B provides a problem size assessment for ***all*** crashes, the “universe“ of the U.S. crash problem, in accordance with the above statistical measures.
- Appendix C is a technical note explaining GES sampling errors and providing tables of GES standard errors.
- Appendix D is a reference section listing publications cited or otherwise relevant to this report.,

2 . CRASH PROBLEM SIZE ESTIMATES

This chapter presents problem size estimates for intersection crossing path (ICP) crashes and their subtypes. All estimates of the number of crashes and injuries were obtained from the 1991 General Estimates System (GES). GES is a probability sample of police-reported crashes in the United States. GES provides information on all severities of crashes and all vehicle types. GES is the best available data source for overall crash size estimates but does not provide highly accurate estimates. of fatal crashes and fatalities. The Fatal Accident Reporting System (FARS) is a census of all fatal crashes in the U.S., and is ordinarily used for fatal crash and fatality statistics. However, the 1991 FARS does not contain data variables to support the disaggregation of crossing path subtypes. Therefore, all problem size estimates provided here are from GES, with the exception of some GES vs. FARS comparative fatality statistics on ICP crashes provided at the end of Section 2.1. To ensure adequate reliability, the crash problem size tables for ICP crashes and specific subtypes provide a combined estimate for fatalities + incapacitating (serious) injuries (K/A) instead of separate "K" and " A" estimates. The report does provide "fatal crash equivalent" estimates for ICP crashes and the subtypes based entirely on GES data using the calculation algorithm described in Appendix A.

Unless otherwise noted, all GES statistics on crashes and injuries presented here are rounded to the nearest 100 if the unrounded number is less than 2,000, and rounded to the nearest 1,000 if the number is 2,000 or greater. As a result of rounding, some table entries may not sum to the posted totals. In addition, percentage estimates and the derived statistics in the tables were calculated before numbers were rounded.

The ICP crash type is a large subset of the "universal" category of crossing path (CP) crashes. In 1991, there were approximately 1,830,000 police-reported CP crashes, which constituted 30 percent of all police-reported crashes.

Table 2-1 shows the numeric distribution of all CP crashes by subtype and relation to junction based on 1991 GES data. Four principal subtypes of CP crashes are derived based on the vehicle accident type (V23, ACC-TYPE) variable in GES. These four configurations and their data retrieval specifications are listed below:

- Perpendicular Crossing Path (PCP) crashes (ACC-TYPE = 82-83, 86-91)
  - Straight Crossing Path (ACC-TYPE = 86-91)
  - Left Turn Across Path/Initial Perpendicular Direction (ACC-TYPE = 82-83)

- Left Turn Across Path/Initial Opposite Direction (LTAP) (ACC-TYPE = 68-69)

- Turn Across Path/Initial Same Direction (ACC-TYPE = 70-73)

- Turn Into Path and Turn Across Path (Other/Unknown) (ACC-TYPE = 74-79, 80-81, **84-85)**

Table 2-l. Crossing Path (CP) Crashes by Subtype and Relation to Junction (Shaded Areas = Intersection Crossing Path Crashes)

Relation to Junction	Perpendicular Crossing Path		Left Torn Across Path/Initial Opposite Direction	Turn Across Path/Initial Same Direction	Turn Into Path or Turn Across Path/ Other	Total
	straight Crossing Path	Left Turn Across Path/ Initial Perpedicular Directions				
Non-Junction	1,000	l,000	4,000	5,000	1,000	12,000
Intersection	554,000	177,000	336,000	99,000	183,000	1,349,000
Intersection-Related	8,000	7,000	6,000	13,000	25,000	59,000
Interchange Area	0	0	1,000	0	2,000	3,000
Drive/Alley	48,000	97,000	85,000	64,000	102,000	396,000
Entrance/Exit	0	1,000	0	0	1,000	2,000
Railroad Crossing	0	0	0	0	0	0
Other	1,000	l,000	2,000	2,000	3,000	9,00
Total	612,000	284,000	434,000	183,000	317,000	1,830,000

Source: 1991 General E&mates System (GES)

Of the total of 1,830,OOO CP crashes, 896,000 were PCP crashes, 434,000 were LTAP crashes, 183,000 were turn across path/initial same direction crashes and 317,000 were other/unknown/turn into path/turn across path crashes.

As stated previously, the emphasis of this chapter is on CP crashes occurring at intersections, i.e. ICP crashes. ICP crashes are indicated by the shaded areas in Table 2-l. For the purpose of the report, ICP crashes are further categorized by type of traffic control device deployed at the intersection. Of particular interest are: perpendicular crossing path crashes at signalized intersection (SI/PCP), perpendicular crossing path crashes at un-signalized intersection (UI/PCP), and left. turn across path/initial opposite direction (LTAP) crashes, signalized and un-signalized combined. These three subtypes were selected for **analysis** because they represent important and distinct crash subtypes of the overall ICP category.

The next four sections of this chapter provide ICP crash problem size statistics, first on the overall ICP category and then on the three principal subtypes described above. Each section provides problem size estimates for the target crash subtype for five involved vehicle type categories: all vehicles, passenger vehicles, combination-unit trucks, single-unit trucks and motorcycles. These four sections are:

2.1 Intersection Crossing Path (ICP) Crashes.
2.2 Signalized Intersection/Perpendicular Crossing Path (SI/PCP) Subtype.
2.3 Unsignalized Intersection/Perpendicular Crossing Path (UI/PCP) Subtype.
2.4 Left Turn Across Path (LTAP) Subtype.

Finally, Section 2.5 summaries comparative statistics for the ICP subtypes for all vehicles.

2.1 Intersection Crossing Path (ICP) Crashes

This section presents an overall problem size assessment for all ICP crashes. ICP crashes are a large subset of CP crashes. ICP crashes include crossing path crashes occurring in an intersection, are intersection-related, or are driveway/alley-related. **Table 2-2** shows all ICP crashes by traffic control device and subtype. The Table 2-2 statistics correspond to the total of the shaded areas in Table 2-l.

Table 2-2. Intersection Crossing Path (ICP) Crashes by Subtype and Traffic Control Device

	Perpendicular Crossing Path (PCP)					
Traffic Control Device	straight Crossing Path	**Left Turn Across Path/ Initial Perpendicular Direction**	Left Turn Across Path/ Initial Opposite Direction	Turn Across Path/ Initial Same Direction	Other/Unknown Turn Into Path or Turn Across Path	Total'
Signalized	210,000	49,ooo	212,000	40,000	78,000	589,000
Unsignalized	392,000	229,000	202,000	134,000	229,000	1,186,000
Other	7,000	2,000	13,000	2,000	4,000	28,000
Total	609,000	280,000	427,000	176,000	311,000	1,803,000

The ICP crash- data retrieval specification for the 1991 GES is provided below; see the GES User's Manual for a detailed description of variables.

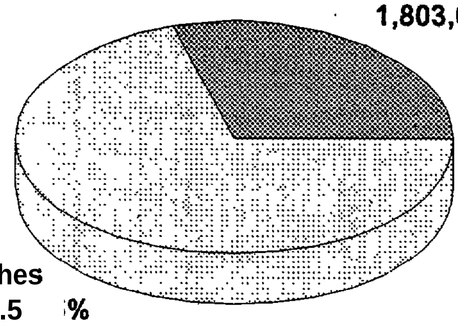
Vehicle Accident Type = 68/69 (Turn Across Path, Initial Opposite Direction)
(V23, VEH_TYPE)
70/71 (Turn Across Path to Right, Initial Same Direction)
72/73 (Turn Across Path to Left, Initial Same Direction)
76/77 (Turn Left into Same Direction)
78/79 (Turn Right into Same Direction)
80/81 (Turn Right Into Opposite Direction)
82/83 (Turn Left Into Opposite Direction).
86/87 (Straight Path, Striking Vehicle From 90" Right)
88/89 (Straight Path, Striking Vehicle From 90" Left)
90/91 (Straight Path, Vehicle Maneuver Unknown)

Imputed Relation to Junction = 1 (intersection)
(V91, RELJCT_I)
2 (intersection-related)
4 (driveway/alley).

Table 2-3 presents 1991 statistics for ICP crashes for five vehicle types. Table 2-3 shows the following:

- There were 1,803,000 ICP crashes, constituting 29.5 percent of all police-reported crashes. **See Figure 2-l.** These crashes resulted in 1,082,000 injuries, including 144,000 fatal or incapacitating (WA") injuries.

Figure 2-1. Intersection Crossing Path (ICP) Crashes



All Crashes: 6,110,000
Source: 1991 GES

- There were 3,607,00 ICP vehicle crash involvements (Note: A two-vehicle crash is one crash but two vehicle involvements). This represents 33.7 percent of all vehicle crash involvements.

- ICP crashes were associated with approximately 21,162 fatal crash equivalents (see Appendix A for definition and discussion).

- ICP crashes caused an estimated 26.7 percent of all crash-caused delay. Total delay due to ICP crashes was approximately 120.3 million vehicle hours.

- The involvement rate was 166.0 involvements per 100 million vehicle miles traveled.

- Based on these 1991 involvement statistics, the expected number of involvements during a vehicle's operational life would be 0.2460. This includes all involvement roles (e.g. striking and struck vehicle, vehicle turning and going straight, etc).

TABLE 2-3
PROBLEM SIZE ESTIMATE - INTERSECTION CROSSING PATH (ICP) CRASHES

GES/FARS-Based Statistics **(1991)**

		All Vehicles	Passenger Vehicles	C.U.T.	S.U.T.	Motorcycles
Annual # PR Crashes (GES)	Total:	1,803,000	1,800,000	33,000	33,000	32,000
	Injury:	632,000	631,000	8,000	10,000	25,000
	PDO:	1,171,000	1,169,000	25,000	23,009	7,000
Annual # Vehicle Involvements (GES)		3,607,000	3,487,000	34,000	33,000	32,000
Ann. # PR Injuries (GES)	Total:	1,082,000	1,081,000	12,000	15,000	31,000
	WA:	144,000	144,000	4,000	3,000	8,000
	B:	297,000	297,000	3,000	5,000	13,000
	C:	641,000	640,000	5,000	7,000	10,000
Fatal Crash Equivalents (FCEs)		21,162	21,123	787	458	1,208
Percentage of All PR Crashes		29.52%	30.17%	17.44%	25.26%	0.52%
Percentage of All FCE		25.07%	26.07%	20.49%	26.87%	31.84%
Annual Involvements (all roles):						
Involvement Rate Per 100 Million VMT		166.0	173.8	34.8	61.5	351.3
Annual Involvements Per 1,000 Registered Vehicles		18.73	19.17	21.04	7.78	7.72
Expected # Involvements During Vehicle Life		0.2460	0.2494	0.3093	0.1144	0.0579
Estimated Annual # NPR Crashes	Total:	2,234,000	2,230,000	47,000	44,000	14,000
	Injury:	264,000	263,000	6,000	5,000	1,700
	PDO:	1,970,000	1,967,000	42,000	39,000	13,000
Estimated Total Annual Target Crashes (PR + NPR)	Total:	4,037,000	4,030,000	80,000	77,000	46,000
	UDH:	585,000	584,000	16,000	9,000	4,000
	Non-UDH:	3,453,000	3,447,000	64,000	67,000	42,000
Crash-Caused Congestion (Delay)	Veh-Hours:	120.3 M	120.2 M	3.2 M	1.9 M	1.2 M
Percentage of All Crash-Caused Delay		26.72%	26.70%	0.17%	0.42%	0.27%

Legend:

WA	Fatalities + Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
C.U.T.	Combination-Unit Truck	PR	Police Reported
FARS	Fatal Accident Reporting System	S.U.T.	Single-Unit Truck
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

As noted previously, the 1991 FARS does not contain variables to support a disaggregation of fatalities due to specific ICP subtypes, and GES does not provide highly reliable estimates of fatalities. To provide a general picture of the number of fatalities resulting from ICP crashes, data retrievals were performed using both the 1991 FARS and GES using the Manner of Collision "angle'K and the same three Relation to Junction values specified on page 2-3. The 199 1 FARS indicated 5,630 fatalities resulting from such crashes, whereas GES indicated 5,437 such fatalities (unrounded estimate). Using the somewhat more restrictive GES ICP crash specification described on the previous page, the 1991 GES indicated 4,690 such fatalities (unrounded). Following the rounding rules stated earlier, a realistic estimate of 1991 ICP crash fatalities is 5,000. This 5,000 estimate is based on GES and supported by the concordance between the FARS and GES statistics for fatalities due to intersection/angle crashes (i.e., 5,630 vs. 5,437).

In comparing the different vehicle types, the following problem size statistics are notable:

- Passenger vehicles represent 96.7 percent of all ICP vehicle crash involvements.

- Based on vehicle miles of travel, motorcycles had the highest ICP crash involvement rate (351.3 per 100 million VMT), compared to 173.8 for passenger vehicles, 61.5 for single-unit trucks and 34.8 for combination-unit trucks.

- Per 1,000 combination-unit trucks during 1991, there were 21.0 ICP involvements, versus 19.2 per 1,000 passenger vehicles, 7.8 per 1,000 single-unit trucks and 7.7 per 1,000 motorcycles.

- Based on an extrapolation of these 1991 statistics, the expected number of ICP crash involvements during a combination-unit truck's operational life is 0.3093, compared to 0.2494 for passenger vehicles, 0.1144 for single-unit trucks, and 0.0579 for motorcycles.

Note in Table 2-3 that combination-unit trucks have much lower involvement rates (per 100 million VMT) than do passenger vehicles, but their involvements per 1,000 vehicles and expected numbers of involvements over vehicle life are much higher. These paradoxical fmdings are due primarily to the fact that combination-unit trucks have much greater mileage exposure (on average, six times greater than passenger vehicles) and, secondarily, their operational lives are somewhat longer. Appendix A provides a fuller explanation of these measures and the differences in exposure and operational vehicle life between heavy trucks and passenger vehicles.

The experience of motorcycles is opposite that of combination-unit trucks. The ICP crash involvement rate of motorcycles is very high, but their average annual mileage exposure is relatively small an# their operational lives relatively short. These differences in exposure result in lower values for involvement per 1,000 registered vehicles and expected involvements over vehicle life. Appendix A defines and discusses these parameters in more detail.

2.2 Signalized Intersection Perpendicular Crossing Path (SI/PCP) subtype

This section presents a problem size assessment for the SI/PCP subtype, indicated by the shaded **area in Table 2-4.** Note that this subtype includes both straight crossing path crashes and left turn across path crashes where the vehicles initially approach each other from a 90 angle.

Table 2-4. Signalized Intersection Perpendicular Crossing Path (SI/PCP) Crashes as a Subset of All ICP Crashes

Traffic Control Device	Perpendicular Crossing Path (PCP)		Left Turn Across Path/ Initial Opposite Direction	Turn Across Path/ Initial Same Direction	Other/Unknown Turn Into Path or Turn Across Path	Total
	Straight Crossing Path	Left Turn Across Path/ Initial Perpendicular Direction				
Signalized	210,000	49,000	212,000	40,000	78,000	589,000
Unsignalized	392,000	229,000	202,000	134,000	229,000	1,186,000
Other	7,000	2,000	13,000	2,000	4,000	28,000
Total	609,000	280,000	427,000	178,000	311,000	1,803,000

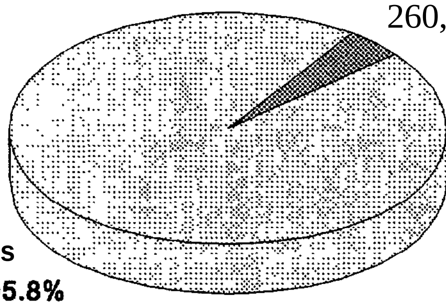
The SI/PCP crash data retrieval specification for the 1991 GES is provided below.

Vehicle Accident Type **(V23, VEH_TYPE)**	=	82/83 (Turn Left Into Opposite Direction) **86/87** (Straight Path, Striking Vehicle From 90” Right) 88/89 (Straight Path, Striking Vehicle From 90” Left) 90/91 (Straight Path, Vehicle Maneuver Unknown)
Imputed Relation to Junction (A91, RELJCT_I)	=	1 (intersection) 2 (intersection-related) 4 (driveway/ alley).
Imputed Traffic Control Device (V16I, TRFCON-I)	=	01 (Traffic Control Signal-on colors) 04 (Flashing Traffic Control Signal or Flashing Beacon) 08 (Other Traffic Signal) 09 (Unknown Traffic Signal)

Table 2-5 presents 1991 statistics for SI/PCP crashes for five vehicle types. Table 2-2 shows the following:

- There were 260,000 SI/PCP crashes, which constituted 4.2 percent of all police-reported crashes. See Figure 2-2. These crashes resulted in 223,000 injuries, including 29,000 fatal or incapacitating (WA”) injuries.

Figure 2-2. Signalized Intersection Perpendicular Crossing Path (SI/PCP) Crashes



All Crashes: 6,110,OOO
Source: 1991 GES

- SI/PCP crashes were associated with approximately 3,732 fatal crash equivalents (see Appendix A for definition).

- The involvement rate was 23.9 involvements per 100 million vehicle miles traveled.

- Based on these statistics, the expected number of involvements during a vehicle’s operational life would be 0.0354.

- SI/PCP crashes caused an estimated 21.5 million vehicle hours delay, which represented 4.8 percent of all crash-caused delay.

TABLE 2-5
PROBLEM SIZE ESTIMATE - SIGNALIZED INTERSECTION PERPENDICULAR CROSSING PATH (SI/PCP) CRASHES.

GES/FARS-Based Statistics (1991)

		All Vehicles	Passenger Vehicles	C.U.T.	S.U.T.	Motorcycles
Annual # PR Crashes (GES)	Total:	260,000	259,000	4,000	5,000	2,000
	Injury:	124,000	124,000	1,100	1,500	1,200
	PDO:	136,000	135,000	3,000	3,000	1,100
Annual # Vehicle involvements (GES)		519,000	506,000	4,000	5,000	2,000
Ann. # PR Injuries (GES)	Total:	223,000	223,000	1,900	3,000	1,600
	K/A:	29,000	29,000	600	400	500
	B:	60,000	60,000	500	1,300	700
	c:	134,000	134,000	800	1,100	400
Fatal Crash Equivalents (FCEs)		3,732	3,728	86	75	54
Percentage of All PR Crashes		4.25%	4.34%	2.18%	3.72%	2.28%
Percentage of All FCE		4.42%	4.60%	2.24%	4.40%	1.42%
Annual Involvements (all roles):						
Involvement Rate Per 100 Million VMT		23.9	25.2	4.4	9.0	25.7
Annual Involvements Per 1,000 Registered Vehicles		2.70	2.78	2.64	1.14	0156
Expected # involvements During Vehicle Life		0.0354	0.0362	0.0388	0.0167	0.0042
Estimated Annual # NPR Crashes	Total:	260,000	258,000	6,000	6,000	4,000
	Injury:	31,000	30,000	700	700	500
	PDO:	229,000	228,000	5,000	6,000	4,000
Estimated Total AnnualTarget Crashes (PR + NPR)	Total:	519,000	517,000	10,000	11,000	7,000
	UDH:	101,000	101,000	1,900	1,700	800
	Non-UDH:	418,000	416,000	8,000	9,000	6,000
Crash-Caused Congestion (Delay)	Veh-Hours:	21.5 M	21.4 M	0.4 M	0.3 M	0.1 M
Percentage of All Crash-Caused Delay		4.78%	4.75%	0.09%	0.07%	0.02%

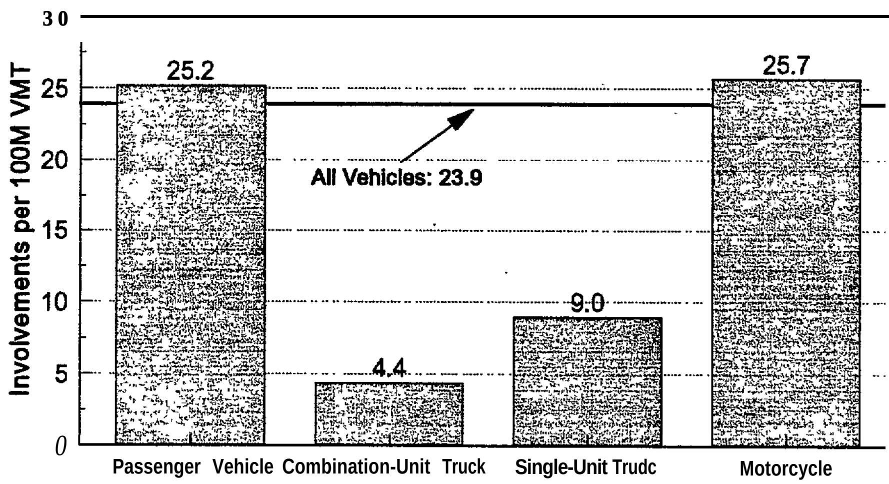
Legend:

WA	Fatalities + Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
c	Possible Injuries	PDO	Property Damage Only
C.U.T.	Combination-Unit Truck	PR	Police Repotted
FAR	Fatal Accident Reporting System	S.U.T.	Single-Unit Truck
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

Table 2-5 also shows comparative statistics on SI/PCP crashes for five vehicle types. It indicates that:

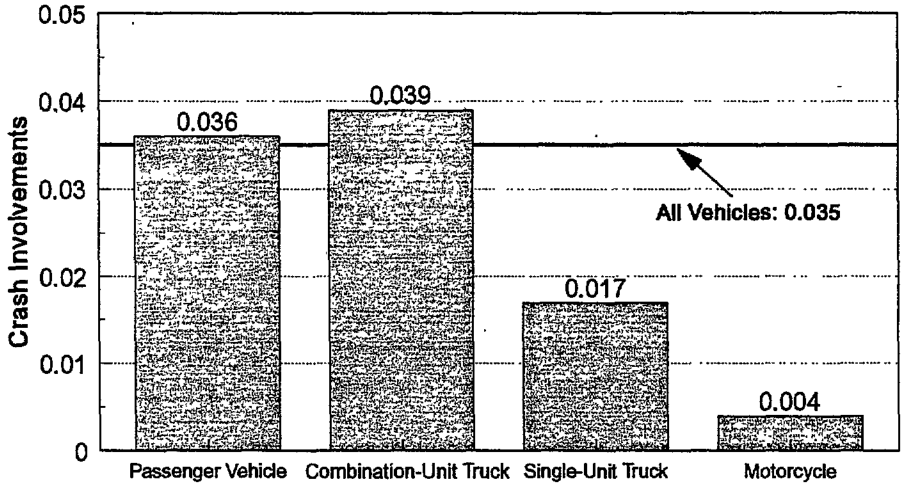
- Based on VMT, motorcycles had the highest target crash involvement rate (25.7 per 100 million VMT). The rate for combination-unit trucks was the lowest (4.4). In between were passenger vehicles (25.2) and single-unit trucks (9.0). **Figure 2-3** compares involvement rates per 100 Million VMT for these vehicle types.

Figure 2-3. SI/PCP Crash Involvement Rate by Vehicle Type



- Even though their involvement rates are low, individual combination-unit trucks are more likely to be involved in this crash subtype, during their operational lives than are other vehicle types. Based on the 1991 statistics, the average combination-unit truck could be expected to be involved in 0.039 SI/PCP crashes during its operational life, compared to a value of 0.036 for passenger vehicles, 0.017 for single-unit trucks and 0.004 for motorcycles. **See Figure 2-4.** As discussed earlier, this reversal for combination-unit trucks (i.e. lower rate but higher likelihood of involvement) is due to the much greater average mileage exposure of combination-unit trucks and the longer operational lives of heavy trucks compared to other vehicle types.

Figure 2-4. Expected Number of SI/PCP Crash Involvements Over Vehicle Operational Life By Vehicle Type



2.3 Unsignalized Intersection Perpendicular Crossing Path (UI/PCP) Subtype

This section provides problem size statistics for UI/PCP crashes; i.e., those indicated in the shaded areas of Table 2-6. Note that this subtype includes both straight crossing path crashes and left turn across path crashes where the vehicles initially approach each other from a 90° angle.

Table 2-6. Unsignalized Intersection Perpendicular Crossing Path (UI/PCP) Crashes As a Subset of All ICP Crashes

	Perpendicular Crossing Path (PCP)					
Traffic Control Device	Straight Crossing Path	Left Turn Across Path/ Initial Perpendicular Direction	Left Turn Across Path/ Initial Opposite Direction	Turn Across Path/ Initial Same Direction	Other/Unknown Turn Into Path or Turn Across Path	Total
Signalized	210,000	49,000	212,000	40,000	78,000	589,000
Unsignalized	392,000	229,000	202,000	134,000	229,000	1,186,000
Other	7,000	2,000	13,000	2,000	4,000	28,000
Total	609,000	280,000	427,000	176,000	311,000	1,803,000

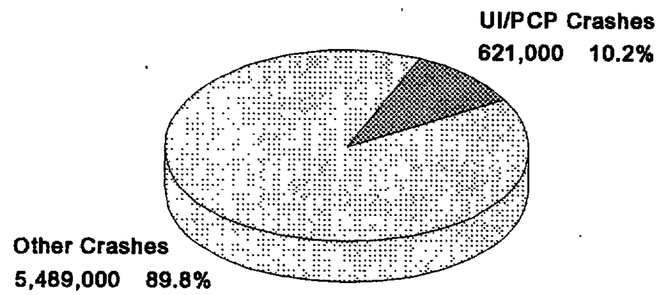
The UI/PCP crash data retrieval specification for the 1991 GES is provided below.

Vehicle Accident Type (V23, VEH_TYPE)	=	82/83 (Turn Left Into Opposite Direction) 86/87 (Straight Path, Striking Vehicle From 90° Right) 88/89 (Straight Path, Striking Vehicle From 90° Left) 90/91 (Straight Path, Vehicle Maneuver Unknown)
Imputed Relation to Junction (A9I, RELJCT_I)	=	1 (intersection) 2 (intersection-related) 4 (driveway/alley).
Imputed Traffic Control Device (V16I, TRFCON_I)	≠	01 (Traffic Control Signal-on colors) 04 (Flashing Traffic Control Signal or Flashing Beacon) 08 (Other Traffic Signal) 09 (Unknown Traffic Signal) 61 (Active Devices at Railroad Crossing) 62 (Passive Devices at Railroad Crossing) 97 (Traffic Device - No Detail) 98 (Other Traffic Device)

Table 2-7 presents 1991 statistics for UI/PCP crashes for five vehicle types. Table 2-7 shows the following:

- There were 621,000 UI/PCP crashes, which constituted 10.2 percent of all police-reported crashes. See **Figure 2-5**. These crashes resulted in 400,000 injuries, including 58,000 fatal or incapacitating ("K/A") injuries.

Figure 2-5. Unsignalized Intersection Perpendicular Crossing Path (UI/PCP) Crashes



All Crashes: 6,110,000
Source: 1991 GES

TABLE 2-7
PROBLEM SIZE ESTIMATE - UNSIGNALIZED INTERSECTION PERPENDICULAR CROSSING PATH (UI/PCP) CRASHES

GES/FARS-Based Statistics (1991)

		All Vehicles	Passenger Vehicles	C.U.T.	S.U.T.	Motorcycles
Annual # PR Crashes (GES)	Total:	621,000	621,000	5,000	9,000	12,000
	Injury:	231,000	231,000	3,000	3,000	9,000
	PDO:	390,000	390,000	2,000	6,000	3,000
Annual # Vehicle Involvements (GES)		1,242,000	1,210,000	5,000	8,000	12,000
Ann. # PR Injuries (GES)	Total:	400,000	400,000	4,000	5,000	11,000
	K/A:	58,000	58,000	1,500	1,200	3,000
	B:	109,000	109,000	1,000	1,700	5,000
	C:	233,000	233,000	1,400	1,800	3,000
Fatal Crash Equivalents (FCEs)		8,300	8,290	379	224	387
Percentage of All PR Crashes		10.16%	10.40%	2.41%	6.57%	11.56%
Percentage of All FCE		9.83%	10.23%	9.86%	13.14%	10.20%
<u>Annual Involvements (all roles):</u>						
Involvement Rate Per 100 Million VMT		57.2	60.3	4.7	16.1	129.9
Annual Involvements Per 1,000 Registered Vehicles		6.45	6.65	2.87	2.04	2.85
Expected # Involvements During Vehicle Life		0.0847	0.0866	0.0422	0.0300	0.0214
Estimated Annual # NPR Crashes	Total:	743,000	743,000	4,000	11,000	23,000
	Injury:	88,000	88,000	400	1,300	3,000
	PDO:	656,000	655,000	3,000	10,000	20,000
Estimated Total Annual Target Crashes (PR + NPR)	Total:	1,364,000	1,364,000	8,000	19,000	35,000
	UDH:	130,000	130,000	800	3,000	3,000
	Non-UDH:	1,234,000	1,234,000	7,000	16,000	32,000
Crash-Caused Congestion (Delay)	Veh-Hours:	28.3 M	28.3 M	0.2 M	0.6 M	0.5 M
Percentage of All Crash-Caused Delay		6.29%	6.29%	0.04%	0.13%	0.11%

Legend:

K/A	Fatalities + Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
C.U.T.	Combination-Unit Truck	PR	Police Reported
FARS	Fatal Accident Reporting System	S.U.T.	Single-Unit Truck
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

- UI/PCP crashes were associated with approximately 8,300 fatal crash equivalents (see Appendix A for definition).

- The involvement rate was 57.2 involvements per 100 million vehicle miles traveled.

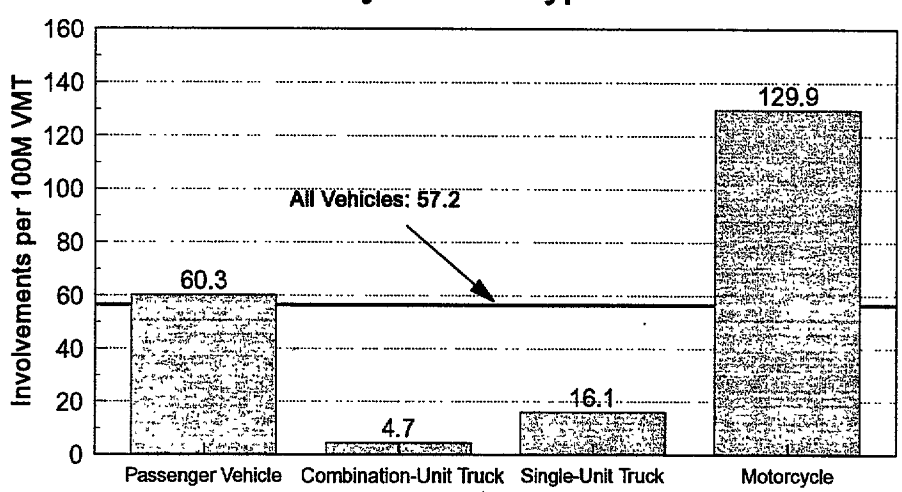
- Based on these 1991 statistics, the expected number of involvements during a vehicle's operational life would be 0.0847.

- UI/PCP crashes caused an estimated 28.3 million vehicle hours of delay, representing 6.3 percent of all crash-caused delay.

Table 2-7 also shows comparative statistics on UI/PCP crashes for five vehicle types. It indicates that:

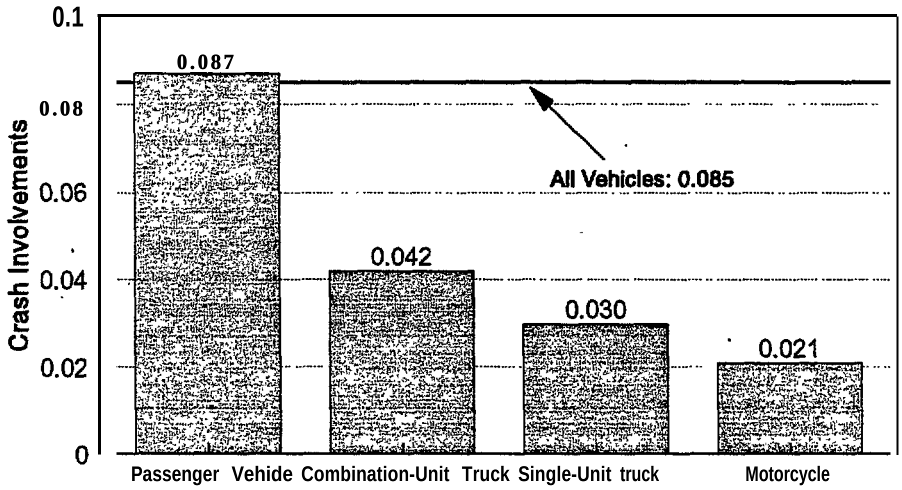
- Based on VMT, motorcycles had a much higher target crash involvement rate (129.9 per 100 million VMT) than did passenger vehicles (60.3), single-unit trucks (16.1) or combination-unit trucks (4.7). **Figure 2-6** compares involvement rates per 100 Million VMT for these vehicle types.

Figure 2-6. UI/PCP Crash Involvement Rate by Vehicle Type



- Based on the 1991 statistics, the average passenger vehicle could be expected to be involved in 0.087 UI/PCP crashes during its operational life, compared to a value of 0.042 for combination-unit trucks, 0.030 for single-unit trucks and 0.021 for motorcycles. See **Figure 2-7.** The extreme differences in UI/PCP crash experience between combination-unit trucks and motorcycles are notable. Motorcycles had an involvement rate (per 100 million VMT) that was nearly 30 times greater than combination-unit trucks, but their expected involvements over vehicle life, projected based on the 1991 statistics, are only one-half those of trucks. This extreme reversal is due to large differences in exposure (i.e., annual VMT) and, secondarily, differences in vehicle operational life.

Figure 2-7. Expected Number of UI/PCP Crash Involvements Over Vehicle Operational Life By Vehicle Type



2.3 Left Turn Across Path (LTAP) Subtype

This section presents problem size statistics for LTAP (initial opposite direction) crashes, represented by the shaded areas in **Table 2-8.** Note that, unlike the previous two subtypes, this subtype combines signalized and unsignalized intersection crashes.

Table 2-8. Left Turn Across Path/Initial Opposite Direction (LTAP) Crashes As a Subset of All ICP Crashes

	Perpendicular Crossing Path (PCP)					
Traffic Control Device	**Straight Crossing Path**	**Left Turn Across Path/ Initial Perpendicular Direction**	**Left Turn Across Path/ Initial Opposite Direction**	**Turn Across Path/ Initial Same Direction**	**Other/Unknown Turn Into Path or Turn Across Path**	**Total**
Signalized	210,000	49,000	212,000	40,000	78,000	589,000
Unsignalized	392,000	229,000	202,000	134,000	229,000	1,186,000
Other	7,000	2,000	13,000	2,000	4,000	28,000
Total	609,000	280,000	427,000	176,000	311,000	1,803,000

The LTAP crash data retrieval specification for the 1991 GES is provided below.

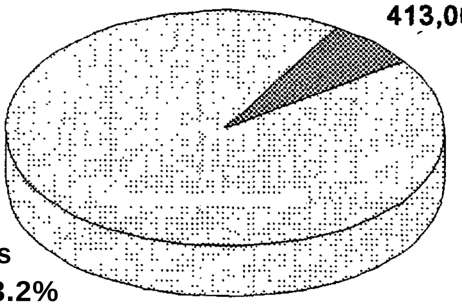
Vehicle Accident Type = 68/69 (Turn Across Path, Initial Opposite Direction)
(V23, VEH_TYPE)

Imputed Relation to Junction = 1 (intersection)
(A9I, RELICT-I) 2 (intersection-related)
4 (driveway/alley).

Table 2-9 presents 1991 statistics for LTAP crashes for five vehicle types. Table 2-9 shows the following:

- There were 413,000 LTAP crashes, which constituted 6.8 percent of all police-reported crashes. See **Figure** 2-8. These crashes resulted in 295,000 injuries, including 41,000 fatal or incapacitating (WA") injuries.

Figure 2-8. Left Turn Across Path/Initial Opposite Direction (LTAP) Crashes



All Crashes: 6,110,OOO
Source: 1991 GES

- LTAP crashes were associated. with approximately 5,520 fatal crash equivalents (see Appendix A for definition).
- The involvement rate was 38.1 involvements per 100 million vehicle miles traveled.
- Based on the 1991 statistics, the expected number of involvements during a vehicle's operational life would be 0.0564.
- LTAP caused an estimated 36.6 million vehicle hours delay, representing 8.1 percent of all crash-caused delay.

TABLE 2-9
PROBLEM SIZE ESTIMATE - LEFT TURN ACROSS PATH (LTAP) CRASHES

GES/FARS-Based Statistics (1991)

		All Vehicles	Passenger Vehicles	C.U.T.	S.U.T.	Motorcycles
Annual # PR Crashes (GES)	Total:	413,000	413,000	3,000	3,000	10,000
	Injury:	171,000	171,000	1,000	1,000	8,000
	PDO:	242,000	242,000	2,000	2,000	2,000
Annual # Vehicle Involvements (GES)		827,000	808,000	4,000	3,000	10,000
Ann. # PR Injuries (GES)	Total:	295,000	295,000	2,000	3,000	11,000
	K/A:	41,000	41,000	1,200	300	3,000
	B:	86,000	86,000	500	700	3,000
	C:	168,000	168,000	700	1,800	4,000
Fatal Crash Equivalents (FCEs)		5,520	5,512	164	44	564
Percentage of All PR Crashes		6.77%	6.92%	1.71%	2.34%	9.91%
Percentage of All FCE		6.54%	6.80%	4.27%	2.58%	14.87%
<u>Annual Involvements (all roles):</u>						
Involvement Rate Per 100 Million VMT		38.1	40.3	3.7	5.7	112.3
Annual Involvements Per 1,000 Registered Vehicles		4.29	4.44	2.26	0.72	2.47
Expected # Involvements During Vehicle Life		0.0564	0.0578	0.0333	0.0106	0.0185
Estimated Annual # NPR Crashes	Total:	462,000	461,000	3,000	3,000	20,000
	Injury:	55,000	54,000	400	400	2,000
	PDO:	407,000	407,000	3,000	3,000	17,000
Estimated Total Annual Target Crashes (PR + NPR)	Total:	875,000	874,000	7,000	6,000	30,000
	UDH:	178,000	177,000	2,000	700	3,000
	Non-UDH:	697,000	697,000	5,000	6,000	27,000
Crash-Caused Congestion (Delay)	Veh-Hours:	36.6 M	36.5 M	0.4 M	0.2 M	0.5 M
Percentage of All Crash-Caused Delay		8.13%	8.11%	0.09%	0.04%	0.11%

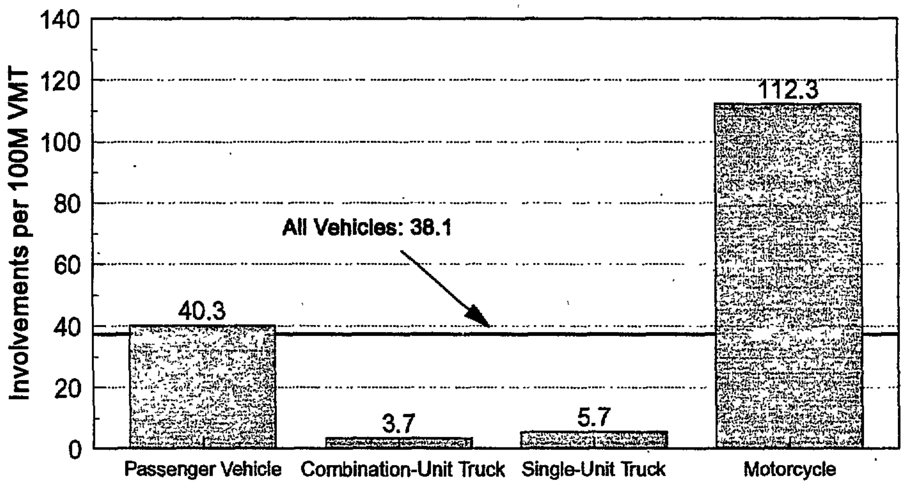
Legend:

K/A	Fatalities + Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
C.U.T.	Combination-Unit Truck	PR	Police Reported
FARS	Fatal Accident Reporting System	S.U.T.	Single-Unit Truck
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMT	Vehicle Miles Traveled

Table 2-9 also shows comparative statistics on LTAP crashes for five vehicle types. It indicates that:

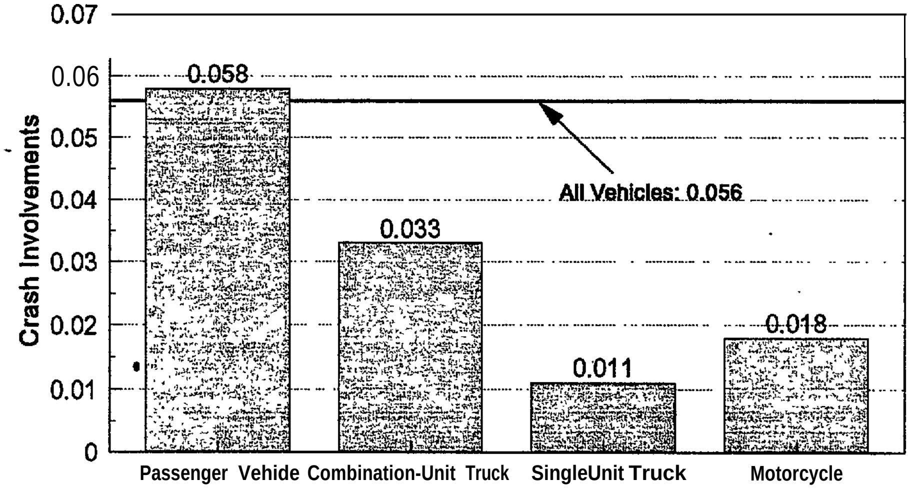
- Based on VMT, motorcycles had a much higher target crash involvement rate (112.3 per 100 million VMT) than did passenger vehicles (40.3), single-unit trucks (5.7) or combination-unit trucks (3.7). **Figure 2-9** compares target crash involvement rates for these vehicle types.

Figure 2-9. LTAP Crash Involvement Rate by Vehicle Type



- Based on the 1991 statistics, the average passenger vehicle could be expected to be involved in 0.058 LTAP crashes during its operational life, compared to a value of 0.033 for combination-unit trucks, 0.011 for single-unit trucks and 0.021 for motorcycles. See **Figure 2-10.**

Figure 2-10. Expected Number of LTAP Crash Involvements Over Vehicle Operational Life By Vehicle Type



Heretofore, all crash involvement statistics presented in this chapter have included all involvements regardless of vehicle role (e.g., striking vs. struck, going straight vs. turning left, etc.). For LTAP crashes it is possible to disaggregate involvements as the left-turning vehicle (Vehicle Accident Type 68) versus involvements as the going-straight vehicle (Vehicle Accident Type 69). These role-specific involvements were as follows for the four principal vehicle type categories (Statistics for trucks and motorcycles are rounded to the nearest 100):

- Passenger Vehicles (808,000 vehicle involvements):
  - Turning Left: 406,000 (50.3 percent)
  - Going Straight: 402,000 (49.7 percent).

- Combination-Unit Trucks (4,000 vehicle involvements):
  - Turning Left: 2,000 (55.9 percent)
  - Going Straight: 1,600 (44.1 percent).

- Single-Unit Trucks (3,000 vehicle involvements):
  - Turning Left: 2,000 (73.4 percent)
  - Going Straight: 800 (26.6 percent).

- Motorcycles (10,000 vehicle involvements):
  - Turning Left: 1,800 (17.4 percent)
  - Going Straight: 9,000 (82.6 percent).

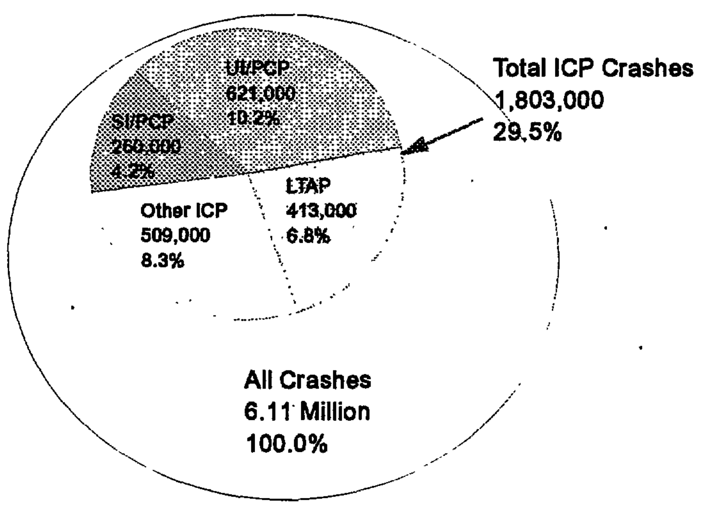
Involvement rate and likelihood statistics for specific LTAP roles by vehicle type can be calculated by multiplying the above percentages by the rate and likelihood statistics in Table 2-9.

2.5 Summary

Figure 2-11 shows the relative sizes of the three specific target crash types (SI/PCP, UI/PCP, and LTAP) in relation to all intersection crossing path (ICP) crashes and all police-reported crashes. Altogether, ICP crashes accounted for 1,803,000 crashes (29.5 percent of all crashes) in 1991 according to GES data. The three principal ICP subtypes under examination in this report each account for sizable portions of the overall U.S. motor vehicle crash picture:

- Signalized Intersection/Perpendicular Crossing Path (SI/PCP): 260,000 crashes (4.2 percent of all crashes)
- Unsignalized Intersection/Perpendicular Crossing Path (UI/PCP): 621,000 crashes (10.2 percent of all crashes)
- Left Turn Across Path/Initial Opposite Direction (LTAP) including both signalized and unsignalized intersections: 413,000 crashes (6.8 percent of all crashes).
- Other miscellaneous ICP crashes (e.g., Turn Across path, Initial Same Direction) accounted for 509,000 crashes.

Figure 2-11 Various ICP Crash Subtypes as a Portion of All Crashes



3. DESCRIPTIVE STATISTICS

This chapter presents descriptive statistics for

- Intersection Crossing Path (ICP) crashes
- Signalized Intersection/Perpendicular Crossing Path (SI/PCP)
- Unsignalized Intersection/Perpendicular Crossing Path (UI/PCP)
- Left Turn Across Path (LTAP) crashes.

The above crash types/subtypes were defined in Chapter 2.

Bivariate or univariate weighted percentage distributions were obtained from the 1991 GES to describe the target crashes. The problem size information presented in Chapter 2 indicated that 99 percent of ICP crashes involved at least one passenger vehicle; therefore, there is little value in disaggregating descriptive statistics by vehicle type. Thus, all descriptive statistics presented here are for all vehicles combined. In addition, certain vehicle/driver statistics provided for specific vehicle maneuvers. Imputed and Hotdeck imputed GES variables (i.e., variables where unknown values were distributed statistically across known values) were used if available. Statistics relating to the following variables were obtained:

Imputed Time Blocks (i.e., 24:00-06:30; 06:31-09:30; 09:31-15:30; 15:31-18:30; 18:31-23:59)
Imputed Day of Week (AlCI, WKDY-I)
Imputed Manner of Collision (A7I, MANCOL-I)
Trafficway plow (Al1, TRAP-WAY)
Number of Travel Lanes (A12, NUM-LAN)
Imputed Roadway' Alignment (Al31, ALIGN-I.)
Imputed Roadway Profile (A141, PROP&-I)
Imputed Surface Condition (A151, SURCON-I)
Imputed Traffic Control Device (A161, TRFCON-I)
Hotdeck Imputed Speed limit (Al8H; SPDLIM-H)
Imputed Light Condition (A191, LGTCONJ)
Imputed Atmosphere Condition (A201, WEATHR_I)
Imputed Maximum Injury Severity in Crash (A901, MAXSEV-I)
Imputed Alcohol Involvement (A92-I, ALCHL-I)
Imputed Violations Charged (D21, VLTN-I)
Driver's Vision Obscured by . . . (DO4, VIS-OBSC)
Emergency Use (V9, BMCY-USE)
Imputed Vehicle Maneuver (V211, MANEW-I)
Hotdeck Imputed Initial Point of Impact (V24H, IMPACT-H)
Hotdeck Imputed Driver's Age (P7H, AGE-H)
Hotdeck Imputed Driver's Sex (P8H, SEx_H).

Several figures in the chapter display target crash involvement rates by various age and sex groups based on vehicle miles traveled (VMT) and licensed drivers. Due to unavailability of 1991 VMT data by driver age and sex, crash involvement rates were estimated using 1990 data, including VMT data from the Nationwide Personal Transportation Study (Pisarsk, 1992). Driver information for calculating target crash involvement likelihood also was retrieved from the 1990 GES. Note also that all crash involvement rates and likelihoods were calculated based on all involvements, regardless of role (e.g., striking vs. struck).

In addition, this chapter presents statistics to describe the pre-crash characteristics of the target crashes. A new set of pre-crash variables in the 1992 GES make these analyses possible. The new elements reported here include Critical Event (V26, P-CRASH2), Corrective Action Attempt (V27, P_CRASH3), and Vehicle Control After Corrective Action (V29, P-CRASH4) These new elements also allow the differentiation of the subject vehicle (SV), from the principal other vehicle (POV) for SI/PCP and UI/PCP crashes. Findings regarding driver/vehicle characteristics are presented separately for SVs and POVs at the end of sections that describe SYPCP and UI/PCP crashes.

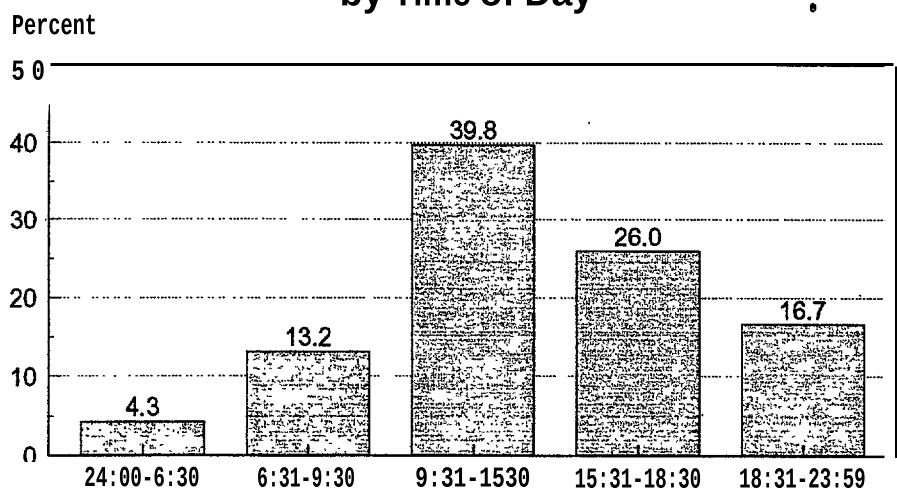
3.1 INTERSECTION CROSSING PATH (ICP) CRASHES

This section presents statistics about ICP crashes. The following major findings, listed by the order of corresponding variables in the GES SAS data files, are noted.

- **Time of Day**

  Overall, about 26.0 percent of ICP crashes occurred during afternoon traffic hours (15:31 -18:30) This percentage is about twice as high as the 13.2 percent occurring during morning traffic hours (6:3 1 - 9:30) See Figure 3-l.

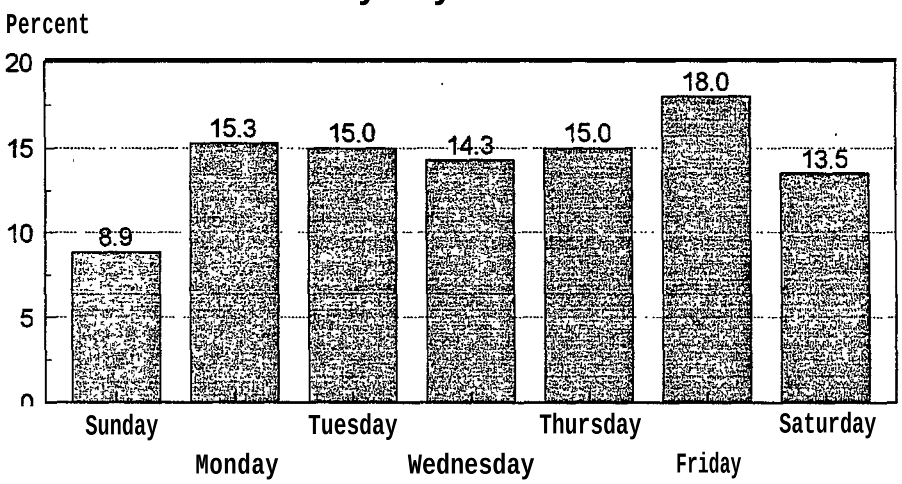
Figure 3-1. ICP Crashes by Time of Day



- **Day of Week**

ICP crashes occurred most frequently on Friday and least frequently on Sunday. About 40 percent more crashes occurred on an average weekday than on an average weekend day. See Figure 3-2.

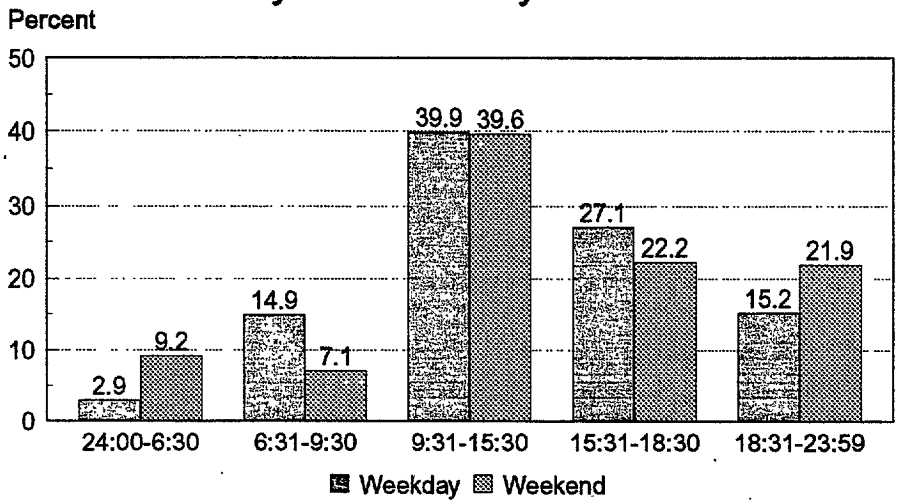
Figure 3-2. ICP Crashes by Day of Week



- **Time/Day**

Figure 3-3 compares weekdays and weekend days by crash time distribution. It indicates that, during weekends, relatively more ICP crashes occurred during nighttime hours (18:0l pm-06:30 am). During weekdays, relatively more crashes occurred during morning and evening rush hours.

Figure 3-3. ICP Crashes
by Time and Day of Week



- **Manner of Collision**

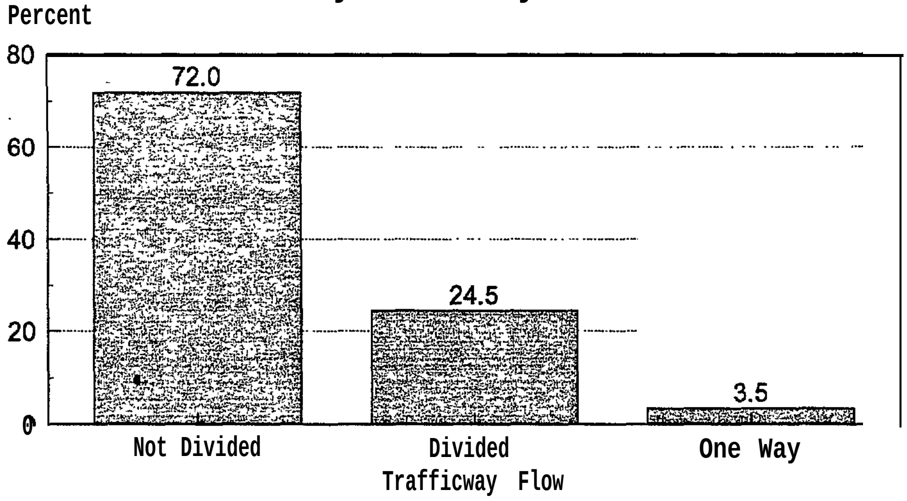
  Not surprisingly, the majority of ICP crash collision orientations were "angle".

The following seven roadway-specific GES *accident* variables describe the principal roadway where the crash occurred. By convention, the roadway coded is that with the higher roadway function classification. When a crash occurs at an intersection of two roadways with the same classification, the roadway with the higher number of lanes is coded.

- **Trafficway Flow**

  The unknown rate for trafficway flow was 29.1 percent. For all known values, about 72.0 percent of ICP crashes occurred on non-divided highways, 24.5 percent on divided highways, and 3.5 percent on one-way trafficways. See **Figure 3-4.**

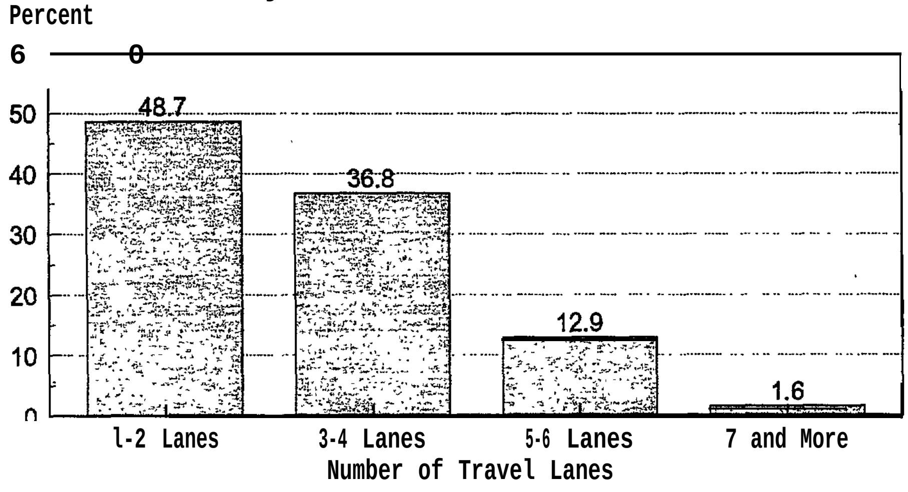
Figure 3-4. ICP Crashes by Trafficway Flow



- **Number of Travel Lanes**

The unknown rate for this variable was 25.9 percent. **Figure 3-5** presents percentages for known values. It shows that 48.7 percent of ICP crashes occurred on l- or 2-lane roadways, 36.8 percent on 3-4 lane roadways, and 14.5 percent on roadways with 5 or more lanes. As noted above, the roadway coded is that with the higher number of travel lanes.

Figure 3-5. ICP Crashes by Number of Travel Lanes



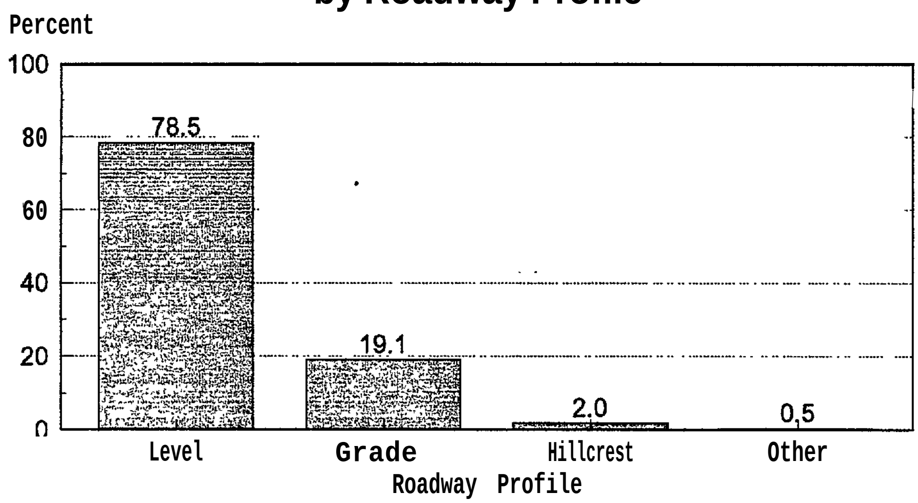
- **Roadway Alignment**

  Most ICP crashes (96.8 percent) occurred on straight roadways.

- **Roadway Profile**

  More than three-fourths of ICP crashes occurred on level roadways; see **Figure 3-6.**

Figure 3-6. ICP Crashes by Roadway Profile



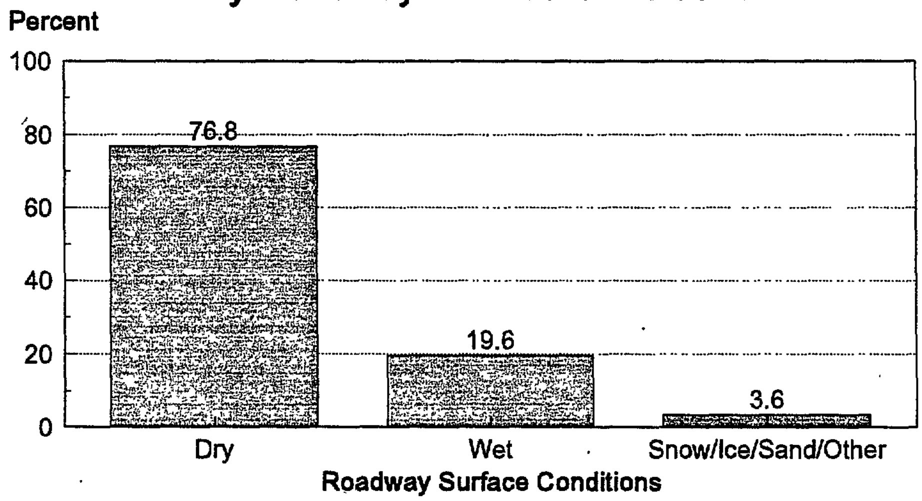
- **Roadway Alignment/Profile**

  Seventy-six percent of ICP crashes occurred on roadways which were ***both*** straight and level.

- **Roadway Surface Condition**

Overall, 76.8 percent of ICP crashes occurred on dry roadways, and 19.6 percent occurred on wet roadways. Only 3.6 percent occurred on extreme surface conditions such as snow, ice, or sand. See **Figure 3-7**.

Figure 3-7. ICP Crashes by Roadway Surface Conditions



- **Traffic Control Device**

Of all ICP crashes, 36.5 percent occurred at intersections with no traffic control devices, 32.6 percent at intersections controlled by a traffic control signal (including on colors, flashing, and other), and 29.2 percent at intersections with traffic signs. Overall, 63.5 percent of ICP crashes occurred at intersections with some type of control devices. Below is the list of the percentage contribution by various control devices:

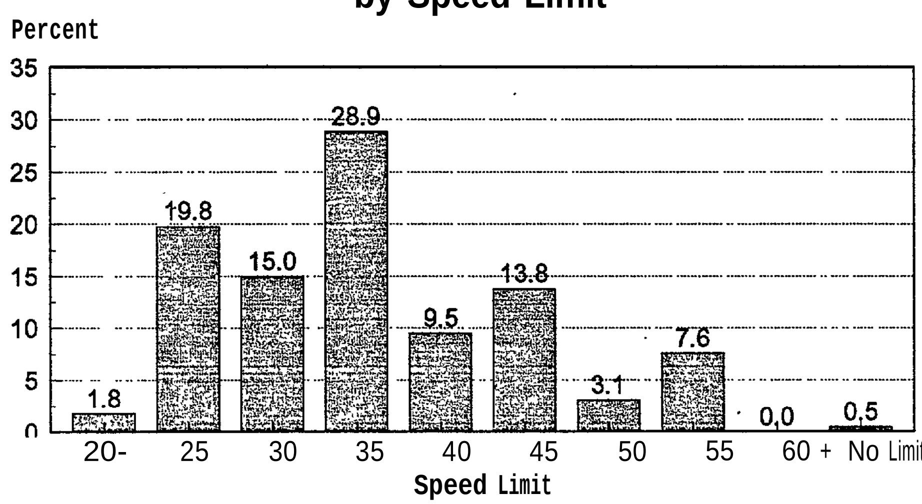
- No Controls	36.5 %
- Traffic Control Signal (on Colors)	30.2 %
- Flashing Traffic Control Signal or Flashing Beacon	1.2 %
- Other Traffic Signals	1.3 %
- Stop Sign	27.6 %
- Yield Sign	1.0 %
- Warning/Advisory/Other Sign	0.6 %
- Other Control Devices	1.6 %

The large percentage of ICP crashes occurring at intersections with no controls is due, in part, to the inclusion of crashes occurring at intersections of driveways and alleys with larger roadways. Such intersections rarely have-traffic control devices. More than half of the "No Controls" target crashes were of this driveway/alley crash type. Also note that if the vehicles involved were not subject to any control (e.g. two vehicles both traveling on the roadway with the right-of-way at an intersection with stop signs controlling the non-right-of-tiay roadway), the crash was coded "no controls".

- **Speed Limit**

Figure 3-8 shows the distribution of roadway speed limits for ICP crashes. It shows that 28.9 percent of ICP crashes occurred on roadways with a posted speed limit of 35 mph. Overall, 63.7 percent of ICP crashes occurred on roadways with speed limits of 35 mph or under.

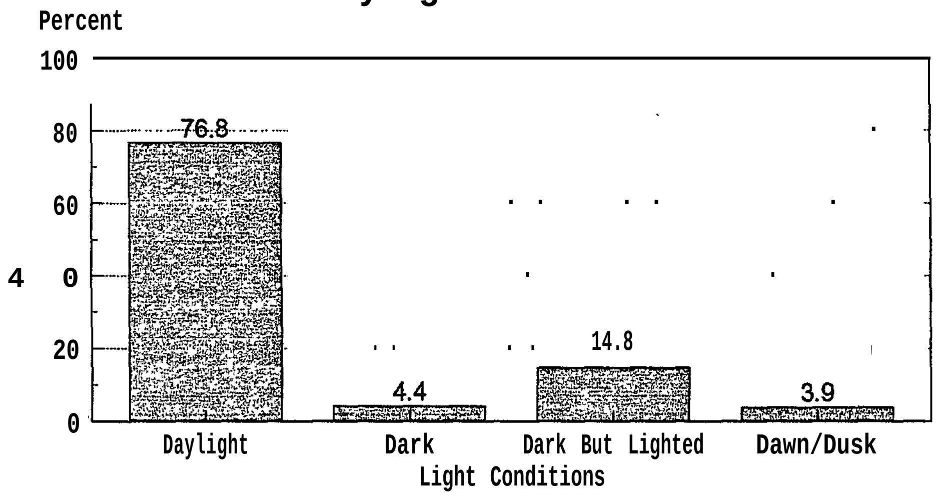
Figure 3-8. ICP Crashes by Speed Limit



- **Light Condition**

Figure 3-9 indicates that 76.8 percent of ICP crashes occurred in daylight, and 14.8 occurred under the condition "dark but lighted."

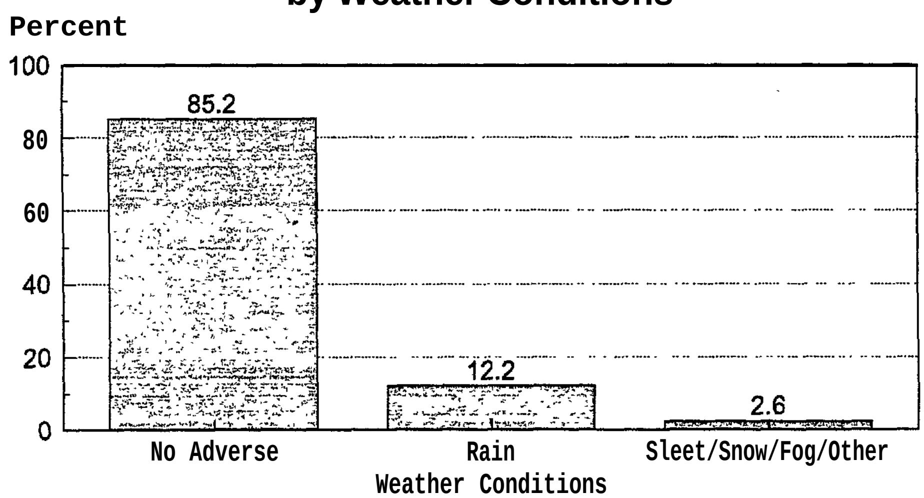
Figure 3-9. ICP Crashes by Light Conditions



- **Weather Condition**

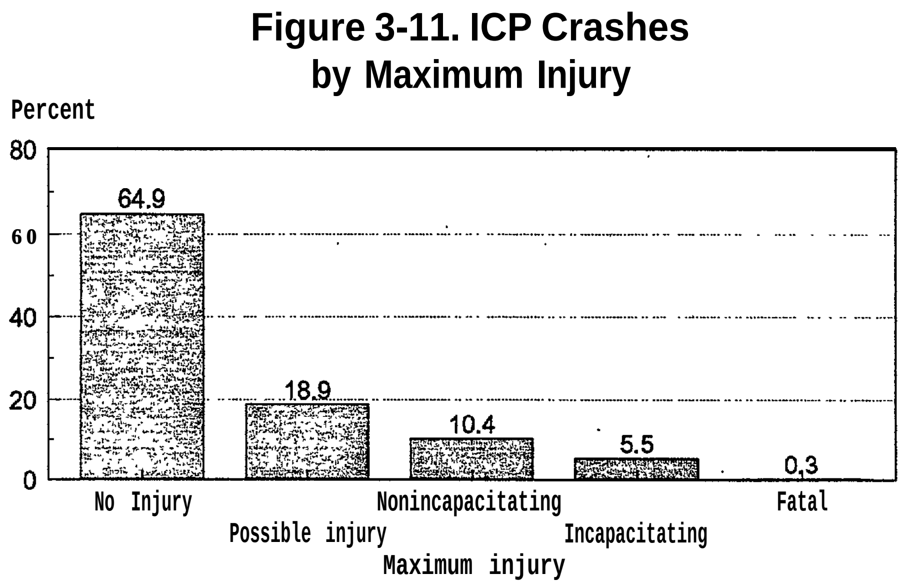
Overall, 12.2 percent of ICP crashes occurred in rainy weather conditions and 2.6 percent occurred during sleet/snow/fog/other. About 85 percent occurred during clear weather. **See Figure 3-10.**

Figure 3-10. ICP Crashes by Weather Conditions



- **Maximum Injury**

Figure 3-11 shows that 0.3 percent of ICP crashes caused fatal injuries and 5.5 percent caused incapacitating injuries. Approximately 65 percent produced no injury.



- **Alcohol Involvement**

Only 4.4 percent of ICP crashes involved alcohol.

- **Emergency Use**

There were an estimated 5,000 ICP crashes involving emergency vehicles. This represented 0.3 percent of all ICP crashes.

- **Vehicle Body Type**

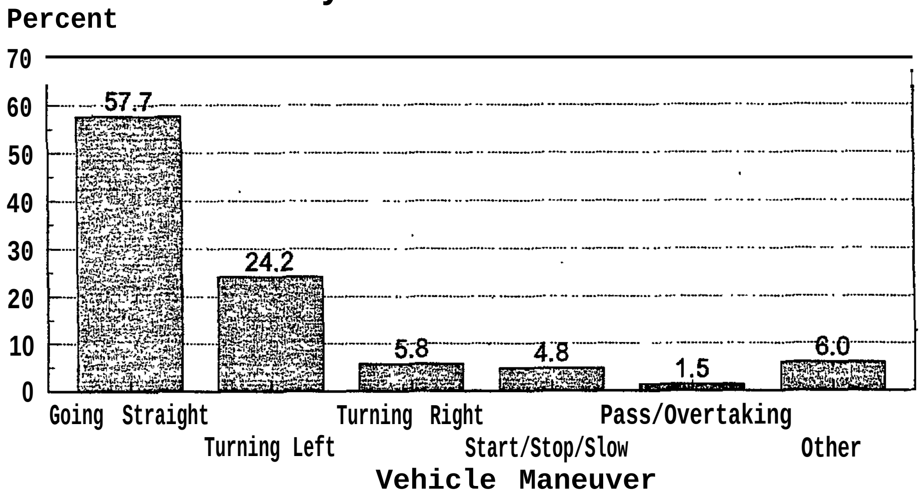
The vast majority of ICP crash-involved vehicles were passenger vehicles (96.7 percent). Medium/heavy trucks comprised 1.8 percent of ICP crash-involved vehicles, and motorcycles comprised 0.9 percent.

As noted earlier, more than 99 percent of ICP crashes involved at least one passenger vehicle.

- **Precrash Maneuver**

The most common vehicle precrash maneuver, representing 57.7 percent of vehicles, was "going straight". Approximately 24.2 percent of vehicles were making a left turn, and 5.8 percent were making a right turn. Finally, 4.8 percent were starting, stopping or slowing. Figure 3-l2 depicts the distribution.

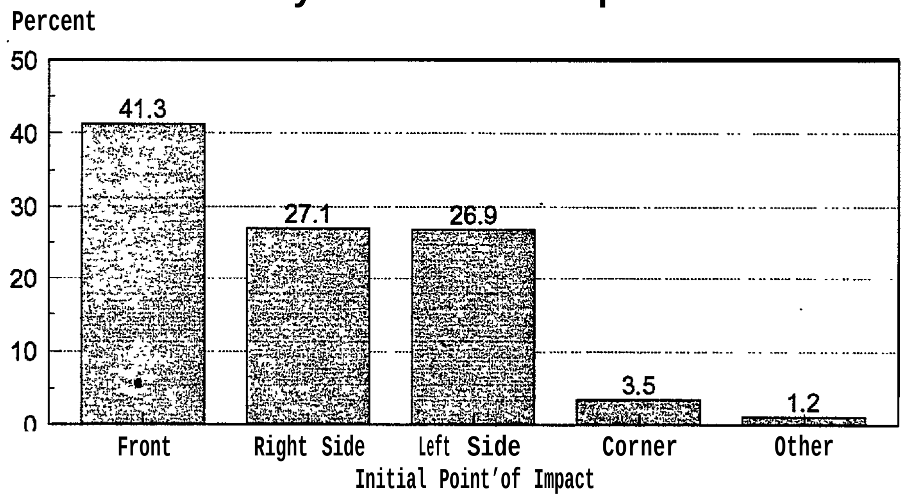
Figure 3-12. ICP Crash Involved Vehicles by Vehicle Maneuver



- **Initial Point of Impact**

The most frequent points of impact for ICP crash-involved vehicles were the front (41.3 percent), right side (27.1 percent), left side (26.9 percent), and corners (3.5 percent). See Figure 3-13.

Figure 3-13. ICP Crash Involved Vehicles by Initial Point of Impact



- **Violations Charged**

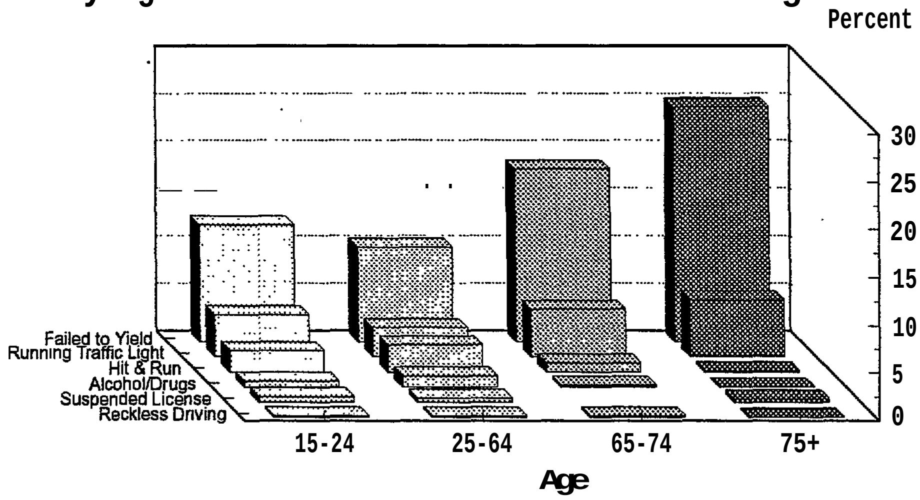
About 70.0 percent of drivers were not charged with a traffic violation. Below are the percentages for the most common violations charged:

- Failure to Yield	11.7 %
- Running Traffic Signal	3.8 %
- Hit & Run	2.6 %
- Alcohol/Drugs	1.0 %
- Suspended License	0.5 %
- speeding	0.4 %
- Reckless Driving	0.2 %
- Other Violations	9.8 %

- **Most Common Violations Charged by Age**

Figure 3-14 shows that older drivers (65 and older) were charged with "failure to yield" twice as frequently, relative to their involvement, as were drivers aged 25-64. Other violations charged are also shown in Figure 3-14, although the reader is cautioned that many of the cells in the figure may represent small sample sizes. Thus, specific comparisons across age groups may be spurious.

Figure 3-14. ICP Crashes by Age and Most Common Violations Charged

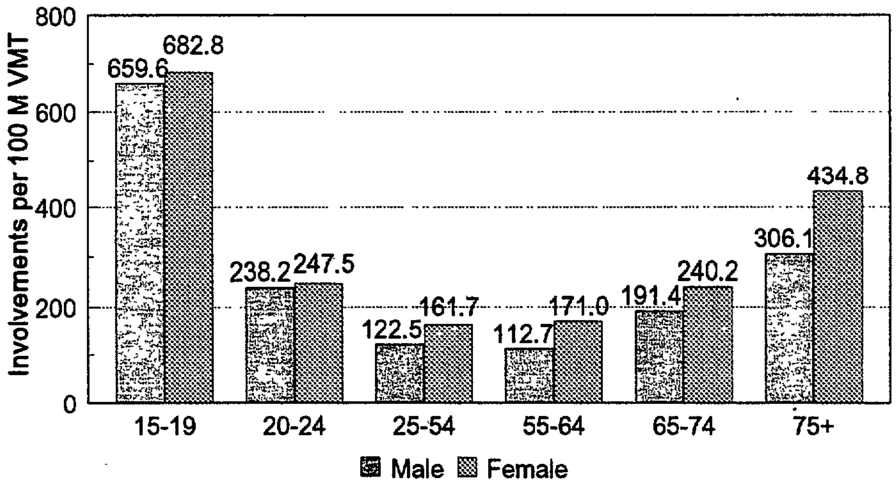


- **Crash Involvement Rate Based on VMT by Driver Age and Sex**

/Due to the unavailability of 1991 VMT data by driver age and sex, crash involvement rates were calculated using 1990 data. Driver information also was retrieved from the 1990 GES. As mentioned at the beginning of the chapter, crash involvement rates were calculated based on all involvements, regardless of vehicle role.

The distribution of crash involvement rate by age shows the familiar "U" shape for both males and females. **Figure 3-15** shows that teenaged drivers had the highest rate of ICP crash involvement. For males, the 55-64 age group had the lowest rate whereas for females the 25-54 age group had the lowest rate. Female crash involvement rates were higher-than males across all age groups, and overall, females had a higher involvement rate (203.1 per 100 million vehicle miles traveled) than did males (158.9 per 100 million VMT).

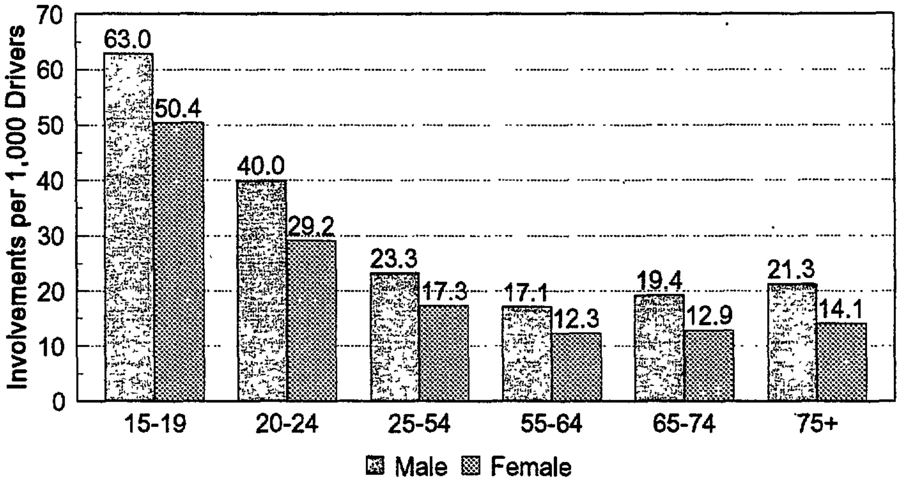
Figure 3-15. ICP Crash Involvement Rate by Driver Age and Sex (1990 Data)



- **Crash Involvement Likelihood Based on Licensed Drivers by Driver Age and Sex**

The involvement pattern based on number of licensed drivers is different than that based on VMT. **Figure 3-16** shows that the risk of involvement for teenagers was the highest among all age groups. Involvement likelihood decreased with advancing age though the 55-64 age group, and then increased somewhat for drivers older than 64. There were 57 ICP crash involvements per 1,000 teenaged drivers, compared to 16 ICP crash involvements per 1,000 licensed drivers aged 55 and older. Overall, in contrast to the involvement rate based on VMT, the likelihood of involvement for male drivers (26.2 per 1,000 licensed drivers) was slightly higher than that for females (19.2) across all age groups.

Figure 3-16. ICP Crash Involvement Likelihood by Driver Age and Sex (1990 Data)



- **Critical Event**

Critical Event (V26, P_CRASH2) is a new GES variable in the 1992 file. It is defined as follows:

> The event which made the crash imminent (i.e. something occurred which made the collision possible). A critical event is coded for each vehicle and identifies the circumstances leading to this vehicle's first impact in the crash.

In cases where more than one critical event is applicable (e.g., excessive speed *and* poor road conditions), the most significant critical event is coded.

The following ICP critical events were notable based on 1992 GES data. All percentages are for all vehicle types combined:

Vehicle encroaching into another vehicle's lane at junction	44.2 %	
- Entering intersection, straight across path		23.0 %
- Entering intersection, turning into opposite direction		8.0 %
- Entering intersection, turning into same direction		4.2 %
- Entering driveway, alley access, etc.		2.7 %
- From driveway, alley access, etc., turning into opposite direction		2.5 %
- From driveway, alley access, etc., turning into same direction		1.4 %
- Other		2.4 %

Another vehicle encroaching into this vehicle's lane at junction	42.5 %
- Entering intersection, straight across path	23.0 %
- Entering intersection, turning into opposite direction	6.7 %
- Entering intersection, turning into same direction	4.1 %
- Entering driveway, alley access, etc.	2.6 %
- From driveway, alley access, etc., turning into opposite direction	2.5 %
- From driveway, alley access, etc., turning into same direction	1.3 %
- Other	2.3 %
Vehicle encroaching into anothir vehicle's lane at non-junction	2.4 %
Another vehicle encroaching into this vehicle's lane at non-junction	2.4 %
Loss of Control	1.0 %.
Other/Miscellaneous (several subcategories)	7.5 %

- **Corrective Action Attempted**

Corrective Action Attempted (V27, P-CRASH3) is another new GES variable in the 1992 file. It is defined as the "actions taken by the driver of this vehicle in response to the impending danger. "

The following ICP corrective actions attempted are based on 1992 GES data. All percentages are for all vehicle types combined:

- No corrective action attempted	87.6 %
- Braked/slowed	4.6 %
- Steered to left	0.6 %
- Steered to right	0.4 %
- Braked and steered	0.5 %
- Other	3.7 %
- Unknown	2.6 %

Note that only 9.8 percent of the drivers of vehicles involved in ICP crashes were known to have attempted a corrective action prior their crashes.

- **Vehicle Control After Corrective Action**

Vehicle Control After Corrective Action (V29, P-CRASH4) is another new GES variable in the '1992 file. It is defined as follows:

> The stability of the vehicle during the period immediately after the attempted corrective action, up to the initial impact in the crash sequence. The stability of the vehicle prior to corrective action is not considered.

The following vehicle control states after corrective actions were notable based on 1992 GES data. All percentages are for all vehicle types combined:

- No corrective action	87.6 %
- Vehicle slid/skid longitudinally	2.8 %
- Vehicle control maintained	2.8 %
- Other	3.9 %
- Unknown	2.9 %

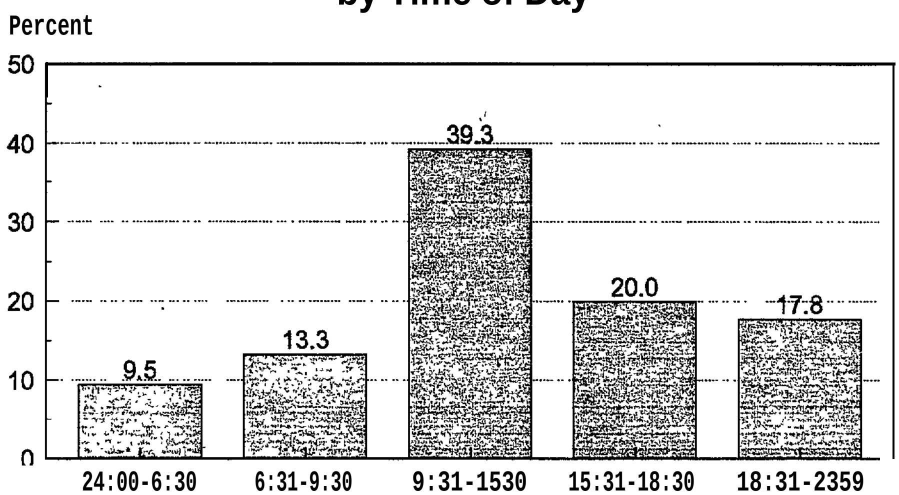
3.2 SIGNALIZED INTERSECTION PERPENDICULAR CROSSING PATH (SI/PCP) CRASHES

This section presents statistics about SI/PCP crashes. The following major findings, listed by the order of corresponding variables in the GES SAS data fites, are noted.

- **Time of Day**

  Overall, 27.3 percent of SI/PCP crashes occurred during night time hours (18:31 - 6:30) and 33.3 percent occurred during traffic hours (6:31 - 9:30 and 15:31 - l8:30). **See Figure 3-17.**

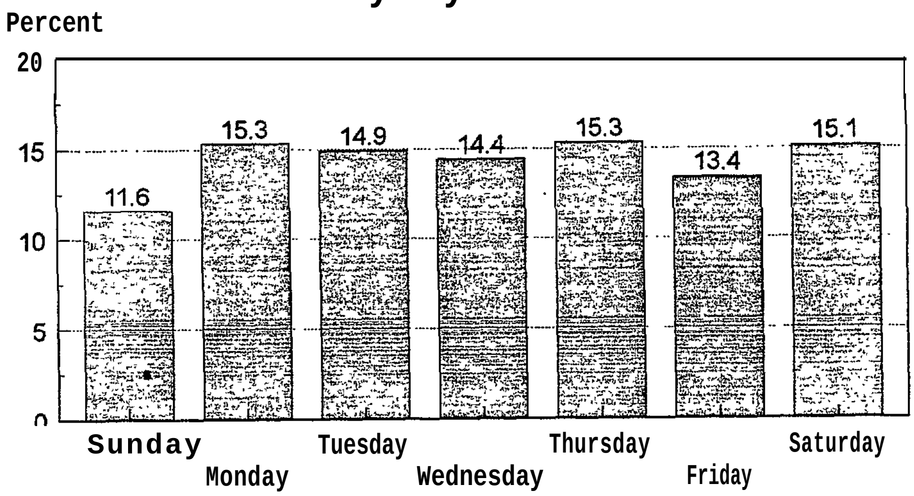
Figure 3-17. SI/PCP Crashes by Time of Day



- **Day of Week**

  SI/PCP crashes occurred least frequently on Sunday. About 14.6 percent of the crashes occurred on an average weekday and 13.4 percent on an average weekend day. **See Figure 3-18.**

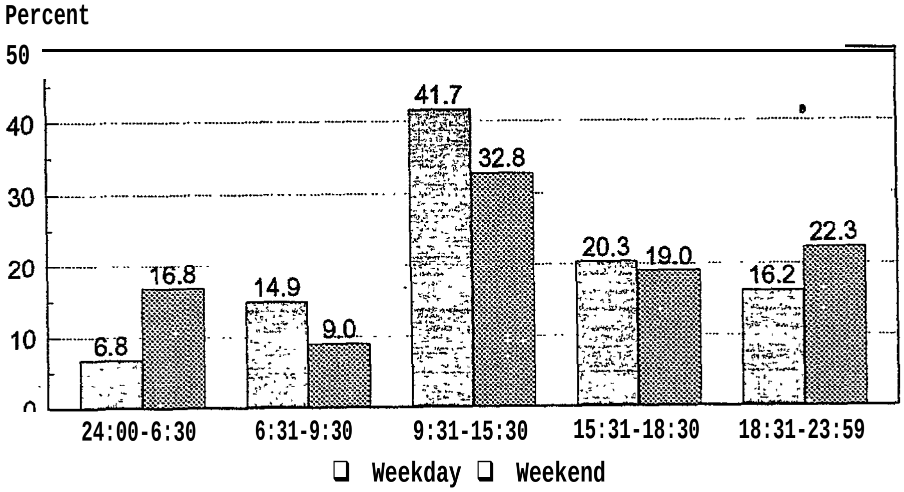
Figure 3-18. SI/PCP Crashes by Day of Week



- **Time/Day**

Figure 3-19 compares weekdays and weekend days by crash time distribution. It indicates that, during weekends, relatively more SYPCP crashes occurred during nighttime hours (18:Ol - 06:30), especially during hours 24:00-6:30. During weekdays, relatively more crashes occurred during morning and evening rush hours.

Figure 3-19. SI/PCP Crashes by Time and Day of Week

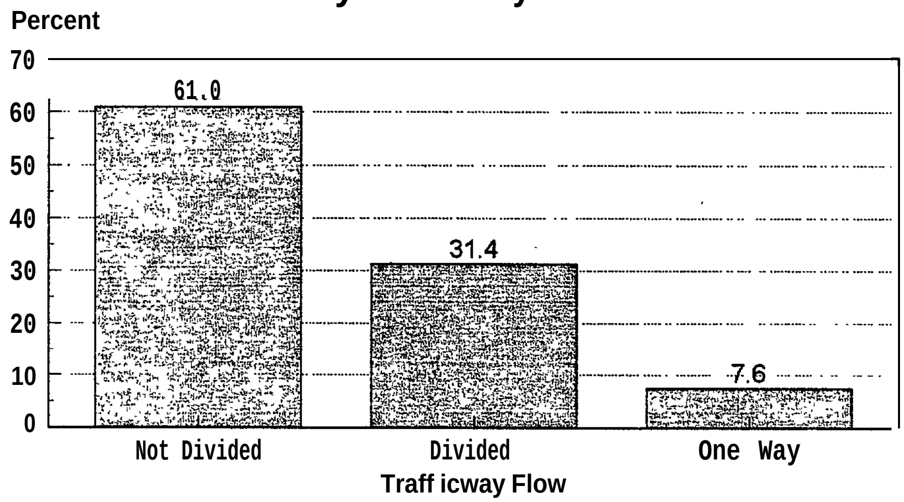


The following seven roadway-specific GES ***accident*** variables describe the principal roadway where the crash occurred. By convention, the roadway coded is that with the higher roadway function classification. When a crash occurs at an intersection of two roadways with the same classification, the roadway with the higher number of lanes is coded.

- **Trafficway Flow**

The unknown rate for trafficway flow was 27.0 percent. For all known values, about 61.1 percent of SI/PCP crashes occurred on non-divided highways, 31.4 percent on divided highways, and 7.5 percent on one-way trafficway. **See Figure 3-20.**

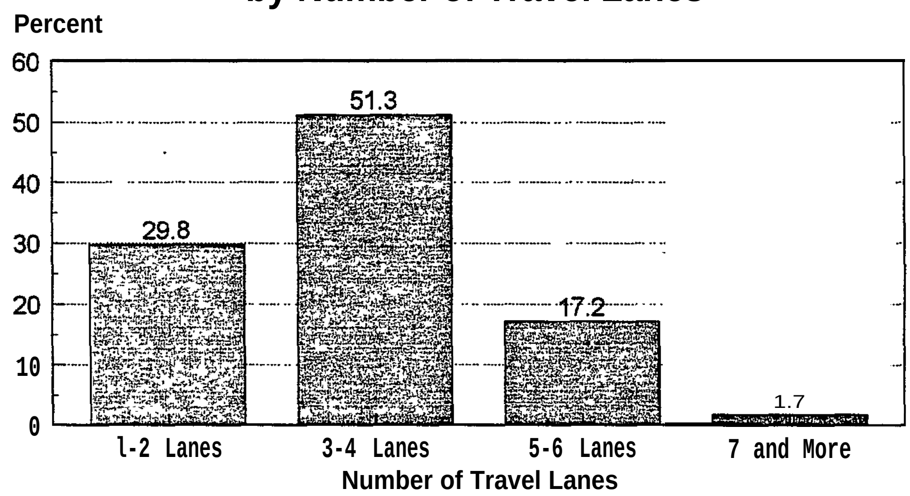
Figure 3-20. SI/PCP Crashes by Trafficway Flow



- **Number of Travel Lanes**

The unknown rate for this variable was 22.0 percent. **Figure 3-21** presents percentages for known values. It shows that 29.9 percent of SI/PCP crashes occurred on l- or 2-lane roadways, 51.3 percent on 3-4 lane roadways, and 18.9 percent on roadways with 5 or more lanes. As noted above, the roadway coded is that with the higher number of travel lanes.

Figure 3-21. SI/PCP Crashes by Number of Travel Lanes



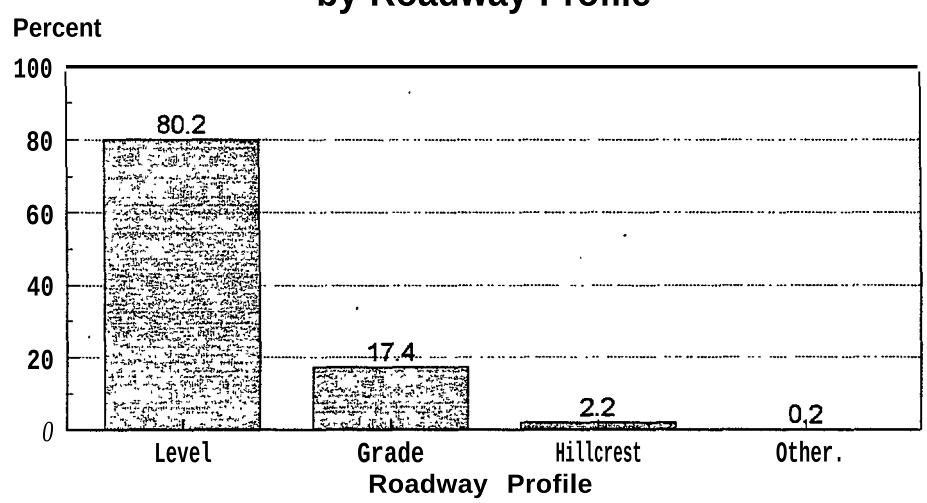
- **Roadway Alignment**

  Most SI/PCP crashes (98.6 percent) occurred on straight roadways.

- **Roadway Profile**

  About 80 percent of SYPCP crashes occurred on level roadways; see Figure 3-22.

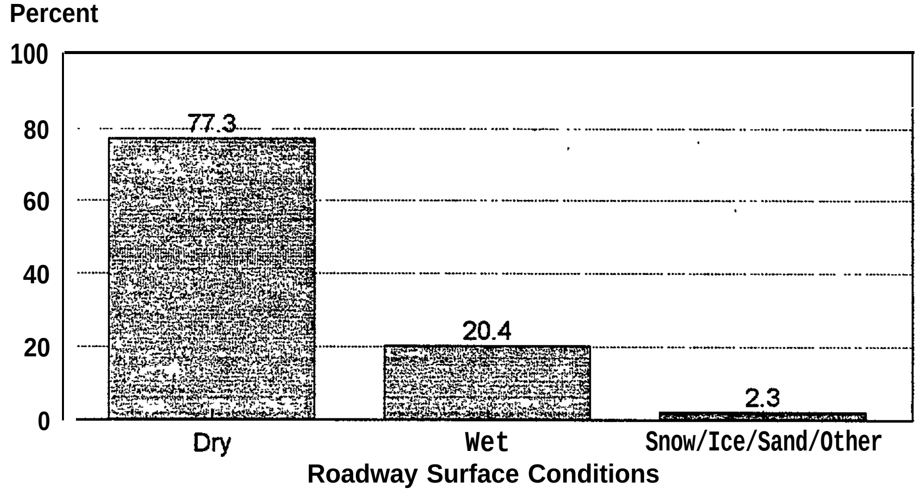
Figure 3-22. SI/PCP Crashes by Roadway Profile



- **Roadway Surface Condition**

Overall, 77.3 percent of SI/PCP crashes occurred on dry roadways, and 20.4 percent on wet roadways. Only 2.3 percent occurred on extreme surface conditions such as snow, ice, or sand. **See Figure 3-23.**

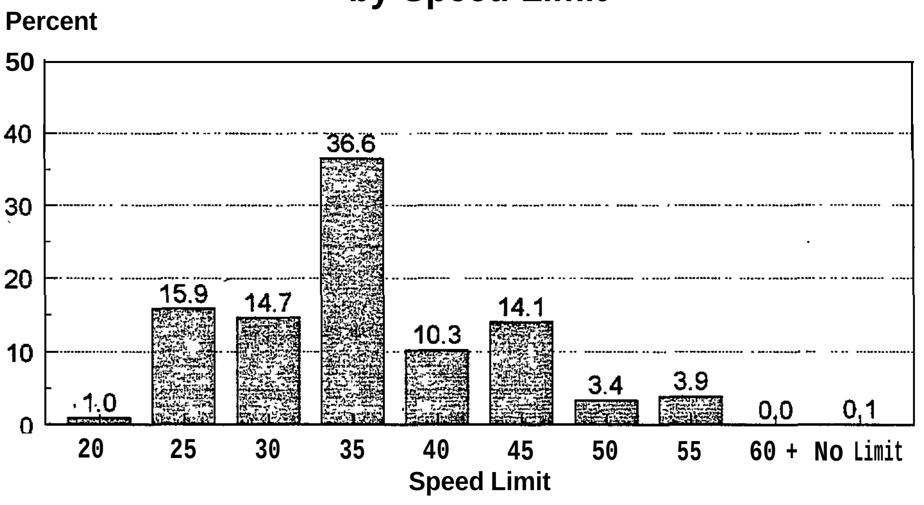
Figure 3-23. SI/PCP Crashes by Roadway Surface Conditions



- **Speed Limit**

Figure 3-24 shows the distribution of roadway speed limits for SI/PCP crashes. It shows that 36.6 percent of SI/PCP crashes occurred on roadways with a posted speed limit of 35 mph. Overall, over two-thirds of SI/PCP crashes occurred on roadway with speed limits of 35 mph and under.

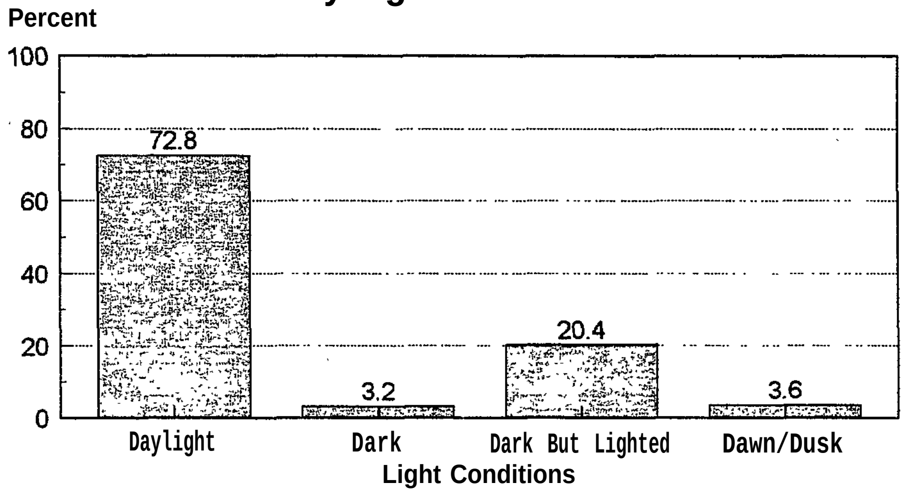
Figure 3-24. SI/PCP Crashes by Speed Limit



- Light Condition

Figure 3-25 indicates that 72.8 percent of SI/PCP crashes occurred in daylight, and 24.4 occurred under the condition "dark but lighted."

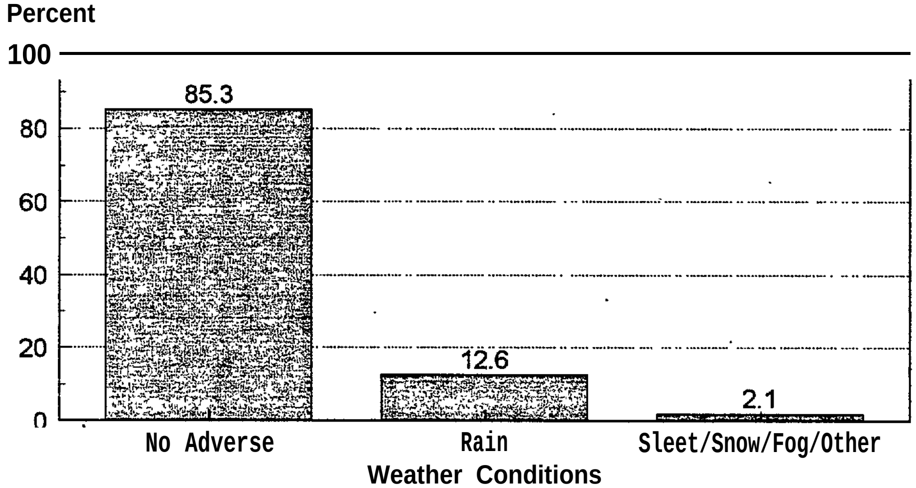
Figure 3-25. SI/PCP Crashes by Light Conditions



- **Weather Condition**

Overall, 12.6 percent of SI/PCP crashes occurred in rainy weather conditions and 2.1 percent occurred during sleet/snow/fog/other. About 85 percent occurred during clear weather. See **Figure 3-26.**

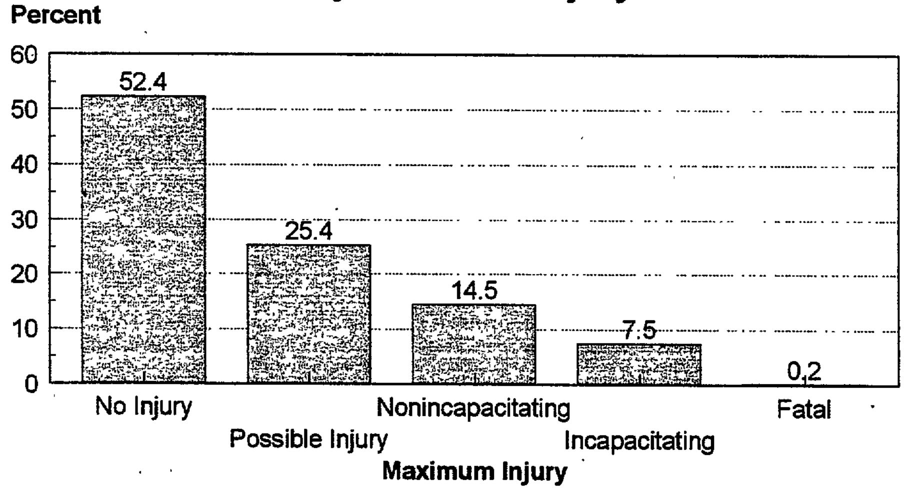
Figure 3.26. SI/PCPP Crashes by Weather Conditions



- **Maxhnum Injury**

Figure 3-27 shows that 0.2 percent of SI/PCP crashes caused fatal injuries and 7.5 percent caused incapacitating injuries. Approximately 52.4 percent produced no injury.

Figure 3-27. ICP Crashes by Maximum Injury



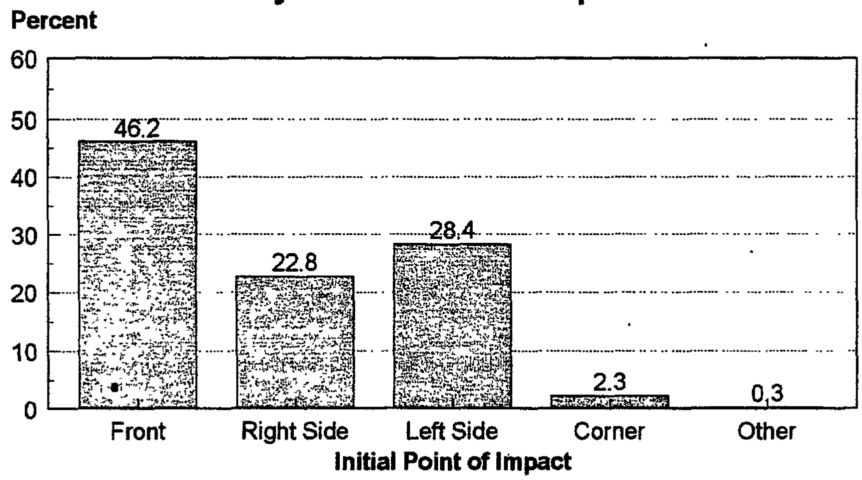
- **Vehicle Body Type**

The vast majority of SI/PCP crash-involved vehicles were passenger vehicles (97.4 percent). Medium/heavy trucks comprised 1.7 percent of SI/PCP crash-involved vehicles, and motorcycles comprised 0.4 percent.

- **Initial Point of Impact**

The most frequent points of impact for SI/PCP crash involved vehicles were the front (46.2 percent), left side (28.4 percent), right side (22.8 percent), and corners (2.3 percent). See **Figure 3-28.**

Figure 3-28. SI/PCP Crash Involved Vehicles by Initial Point of Impact



- **Violations Charged**

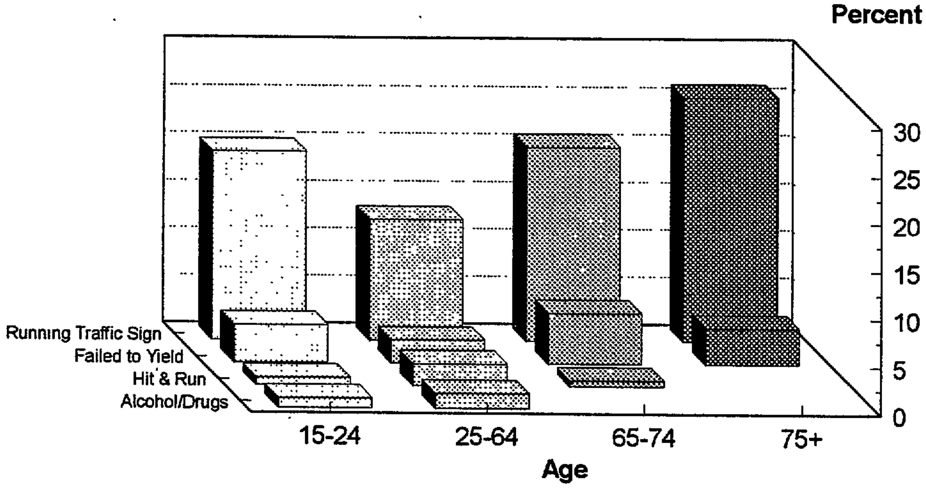
About 70.0 percent of drivers were not charged with a traffic violation. Below are the percentages for the most common violations charged:

- Running Traffic Signal	15.4 %
- Failure to Yield	3.1 %
- Hit & Run	1.8 %
- Alcohol/Drugs	1.3 %
- Suspended License/Speeding/Reckless Driving	0.4 %
- Other Violations	8.3 %

- **Most Common Violations Charged by Age**

Figure 3-29 compares various age groups. It shows that drivers aged 75 and older were charged with "running traffic signal" relatively more frequently than other age groups. Relatively more drivers aged 65-74 were charged with "failure to yield". Teenager drivers were next most frequently charged with these violations. The reader is cautioned that many of the cells in the figure may represent small sample sizes. Thus, specific comparisons across age groups may be spurious.

Figure 3-29. SI/PCP Crashes by Age and Most Common Violations Charged

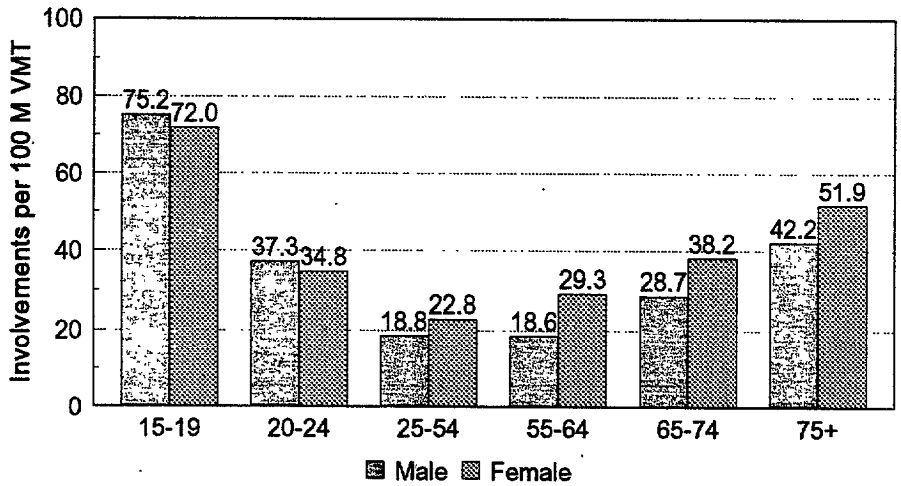


- **Crash Involvement Rate Based on VMT by Driver Age and Sex**

As mentioned before, 1990 data were used to estimate crash involvement rates. Involvement rates were calculated based on all involvements, regardless of vehicle role.

Figure 3-30 shows that teenaged drivers had the highest rate of SI/PCP crash involvement. Drivers aged 75 and older had the next highest involvement rate. For males, the 55-64 age group had the lowest rate whereas for females the 25-54 age group had the lowest rate. Compared to female drivers within the same age groups, younger male drivers had slightly higher involvement rates. Overall, females had a higher involvement rate (28.6 per 100 million vehicle miles traveled) than did males (23.5 per 100 million VMT).

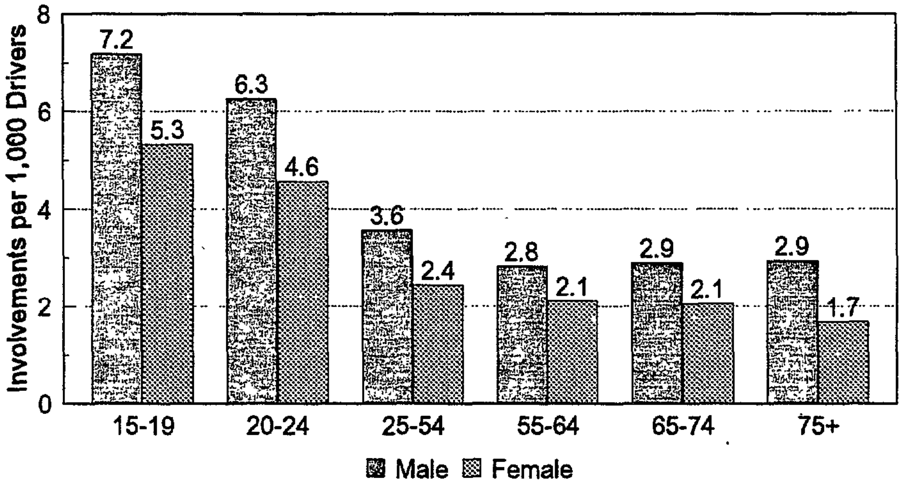
Figure 3-30. SI/PCP Crash Involvement Rate by Driver Age and Sex (1990 Data)



- **Crash Involvement Likelihood Based on Licensed Drivers by Driver Age and Sex**

Figure 3-31 shows that the risk of involvement for teenagers was the highest among all age groups. For both male and female drivers aged 65 and younger, the risk of involvement decreased as age advanced. However, the patterns between males and females were slightly different for drivers 65 and older: female involvements kept decreasing while male involvements somewhat increased. There were about six SI/PCP crash involvements per 1,000 teenaged drivers, compared to about two SI/PCP crash involvements per 1,000 licensed drivers aged 55 and older. Overall, the likelihood of involvement for male drivers (3.9 per 1,000 licensed drivers) was slightly higher than that of females (2.7) across all age groups.

Figure 3-31. SI/PCP Crash Involvement Likelihood by Driver Age and Sex (1990 Data)



- **Critical Event**

Critical Event (V26, P_CRASH2) is a new GES variable in the 1992 file. It is defined as follows:

> The event which made the crash imminent (i.e. something occurred which made the collision possible). A critical event is coded for each vehicle and identifies the circumstances leading to this vehicle's first impact in the crash.

In cases where more than one critical event is applicable (e.g., excessive speed *and* poor road conditions), the most significant critical event is coded.

The following SI/PCP critical events were notable based on 1992 GES data. All percentages are for all vehicle types combined:

Vehicle encroaching into another vehicle's lane at junction	44.4 %	
- Entering intersection, straight across path		37.8 %
- Entering intersection, turning into opposite direction		4.6 %
- Other		2.0 %
Another vehicle encroaching into this vehicle's lane at junction	42.3 %	
- Entering intersection, straight across path		36.6 %
- Entering intersection, turning into opposite direction		4.1 %
- Other		1.6 %

Lost of Control	1.2 %
Other/Miscellaneous (several subcategories)	12.1 %

- **Corrective Action Attempted**

Corrective Action Attempted (V27, P-CRASH3) is another new GES variable in the 1992 file. It is defmed as the "actions taken by the driver of this vehicle in response to the impending danger. "

The following SI/PCP corrective actions attempted were notable based on 1992 GES data. All percentages are for all vehicle types combined:

- No corrective action attempted	85.9 %
- Braked/slowed	4.4 %
- Steered to left/right	0.7 %
- Other	7.3 %
- Unknown	1.7 %

Note that only 12.3 percent of the drivers of vehicles involved in SI/PCP crashes were known to have attempted a corrective action prior to their crashes.

- **Vehicle Control After Corrective Action**

Vehicle Control After Corrective Action (V29, P-CRASH4) is another new GES variable in the 1992 file. It is defined as follows:

> The stability of the vehicle during the period immediately after the attempted corrective action, up to the initial impact in the crash sequence. The stability of the vehicle prior to corrective action is not considered.

The following vehicle control states after corrective actions were notable based on 1992 GES data. All percentages are for all vehicle types combined:

- No corrective action	85.9 %
- Vehicle slid/skid longitudinally	2.4 %
- Vehicle control maintained	2.4 %
- Other	7.3 %
- Unknown	2.0 %

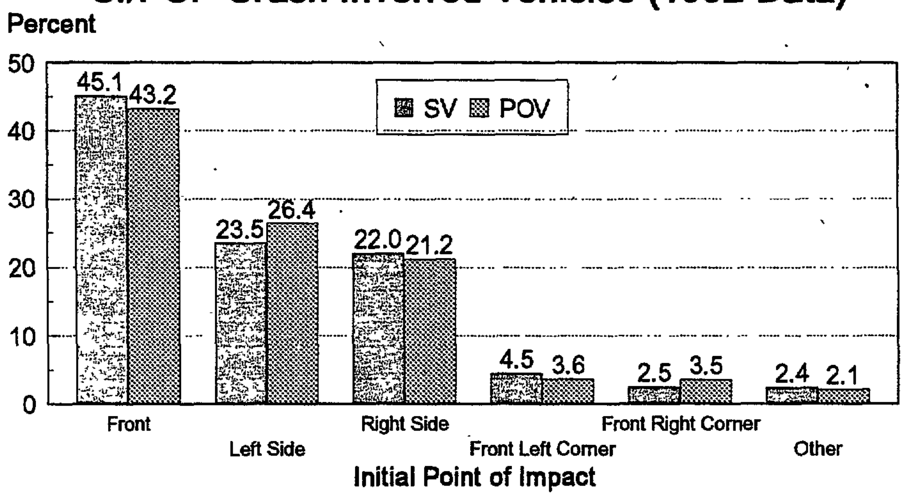
Subject Vehicle and Principal Other Vehicle Differences Based on 1992 GES Data

Prior to 1992, GES data elements did not generally permit the differentiation of the two involved vehicles in an SI/PCP crash. That is, one could not differentiate the **subject vehicle** (SV), defined as the vehicle encroaching into the other vehicle's lane or travel path, from the **principal other vehicle** (POV), the "encroached upon" vehicle. However, a set of pre-crash data variables added to the GES in 1992 now permit, in most cases, the differentiation of the two involved vehicles (i.e., SV versus POV). About 92 percent of 1992 SI/PCP crashes involved one vehicle encroaching into the lane/travel path of another vehicle and, further, identified these critical vehicle roles. Below are findings regarding vehicle/driver characteristics for those 1992 GES SI/PCP crashes where this differentiation can be made.

- **Initial Point of Impact by Vehicle Role**

  Figure 3-32 shows that, SVs and POVs had similar distributions for initial point of impact. Front impacts were most common. For both SVs and POVs, left-side impacts were somewhat more frequent than were right-side impacts.

Figure 3-32. Initial Points of Impact by Vehicle Role SI/PCP Crash Involved Vehicles (1992 Data)



The data in Figure 3-32 indicates that slightly fewer SYPCP crashes occur in the first half of the intersection crossing by the SV than in the second half. Collisions occurring in the first half of the intersection crossing would generally result in one of the following point-of-impact combinations (with 1992 GES percentages):

SV left side -- POV front	19.7 %
SV front -- POV right side	17.5 %
SV left front comer -- POV right front comer	1.2 %

Collisions occurring in the second half of the intersection crossing would generally result in one of the following point-of-impact combinations:

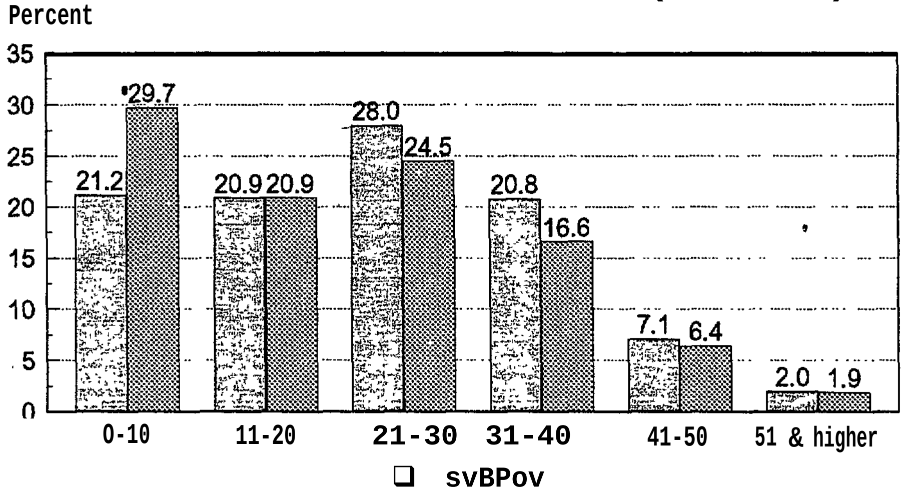
SV right side -- POV front	19.0 %
SV front -- POV left side	22.8 %
SV right front comer -- POV left front comer	0.8 %

Analysis of the combinations of point-of-impact for 1992 SI/PCP crashes indicates that, of those crashes with one of the above six combinations, 47.4 percent fall into the “probably first half” category, while 52.6 percent fall in the “probably second half" category.

- **Travel Speeds by Vehicle Role**

Overall, the percentage of unknown travel speed was high (61.2 percent). For all known speeds, Figure 3-33 presents the percentage distribution of vehicle travel speeds for SVs and POVs. Compared to SVs, a relatively higher percentage of POVs were either stopped or traveled at speeds under 5 mph.

Figure 3-33. Travel Speed by Vehicle Role
SI/PCP Crash Involved Vehicles (1992 data)



- **Violations Charged by Vehicle Role**

About 53 percent of SI/PCP crash violations charged were to drivers of the SV. **Table 3-l** shows the percentages for the most common violations charged for SVs and POVs. Running traffic signal, failure to yield, hit & run and alcohol/drug were the most common violations charged for SVs.

Table 3-l. Percent of Violations Charged by Vehicle Role SI/PCP Crashes (1992 Data)

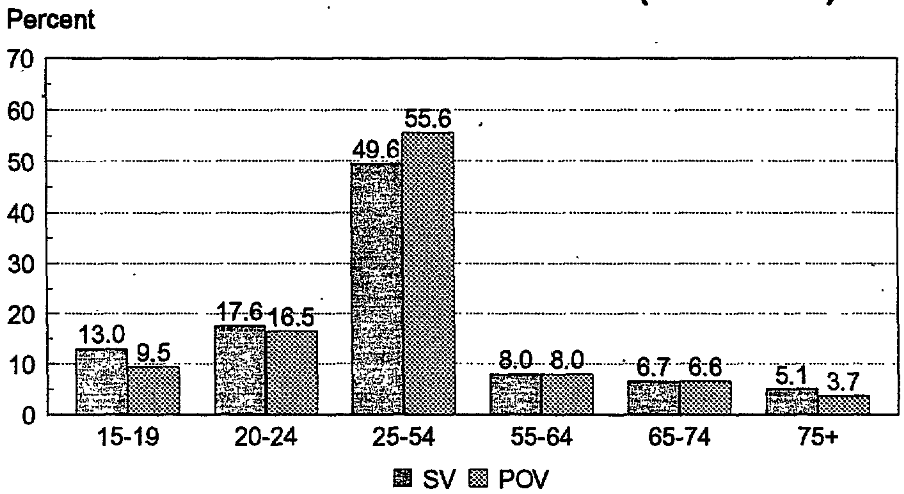
Common Violations Charged	SV	POV
None .	47.1 %	87.6 %
Running Traffic Signal'	25.6 %	5.1 %
Failure to Yield	6.0 %	0.7 %
Hit & Run	4.5 %	0.2 %
Alcohol/Drugs	2.2 %	0.4 %
Other Violations	14.6 %	6.0 %
Total .	100.0 %	100.0 %

More than 85 percent of POV drivers were not charged with a traffic violation. The most common violations charged for POVs were running a traffic signal (5.1 percent), and failure to yield (0.7 percent).

- **Drivers' Age by Vehicle Role**

Figure 3-34 compares drivers of SVs and POVs. It indicates that relatively more drivers of the SVs were in the age groups 15-24 and 75+.

Figure 3-34. Drivers Age by Vehicle Role SI/PCP Crash Involved Drivers (1992 Data)



- **Corrective Action Attempted by Vehicle Role**

There was little observed difference between SVs and POVs. Only about 5 percent of drivers of SVs and POVs made corrective actions prior to SI/PCP crashes. Also, for both SVs and POVs, "braked/slowed" was the most common action attempted. The percentages in **Table 3-2** are for all vehicle types combined.

Table 3-2. Percent of Corrective Action Attempted by Vehicle Role SI/PCP Crashes (1992 Data)

Corrective Action Attempted	SV	POV
No corrective action attempted	92.1 %	92.1 %
Braked/slowed	4.3 %	5.0 %
Other	1.1 %	1.7 %
Unknown	2.5 %	1.2 %
Total	100.0 %	100.0 %

- **Vehicle Control After Corrective Action by Vehicle Role**

The following table shows the percent distribution of vehicle control states after corrective actions. All percentages in **Table** 3-3 are for all vehicle types combined.

Table 3-3. Percent of Vehicle Control After Corrective Action by Vehicle Role SI/PCP Crashes (1992 Data)

Vehicle Control	SV	POV
No corrective action	92.1 %	92.1 %
Vehicle slid/skid longitudinally	2.6 %	2.6 %
Vehicle control maintained	1.8 %	3.5 %
Other	0.8 %	0.3 %
Unknown	2.7 %	1.5 %
Total	100.0 %	100.0 %

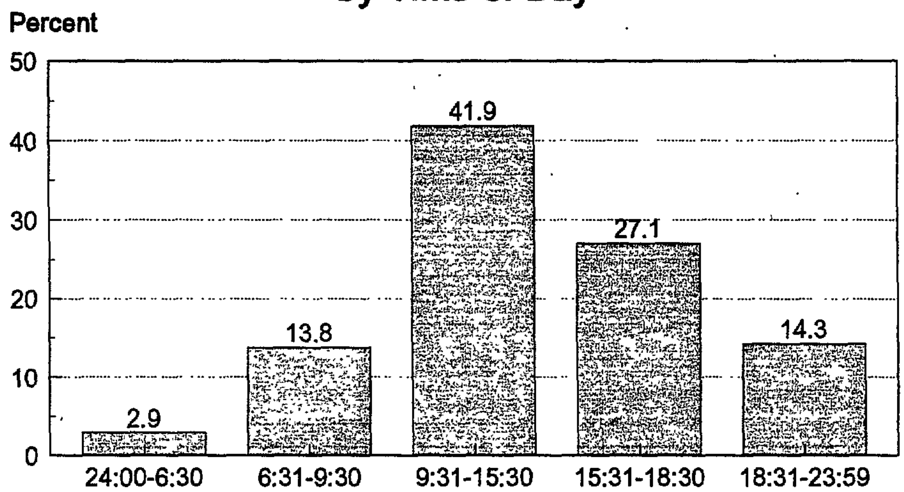
3.3 UNSIGNALIZED INTERSECTION PERPENDICULAR CROSSING PATH (UI/PCP) CRASHES

This section presents statistics about UI/PCP crashes. Statistics are for all vehicle types combined. The following major findings are noted.

- **Time of Day**

About 27 percent of UI/PCP crashes occurred during afternoon traffic hours (15:31 - 18:30). This percentage is twice as high as the 13.8 percent occurring during morning traffic hours (6:31 - 9:30). See **Figure 3-35**.

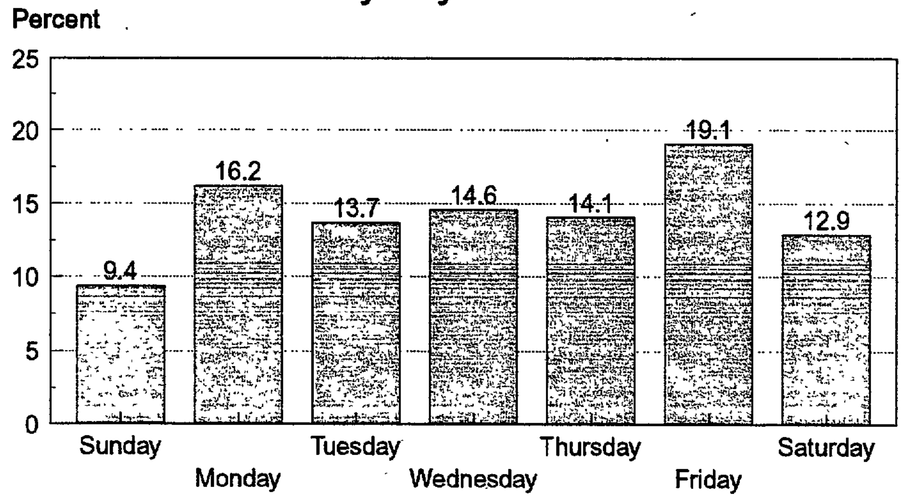
Figure 3-35. UI/PCP Crashes by Time of Day



- **Day of Week**

UI/PCP crashes occurred most frequently on Friday and least frequently on Sunday. About 40 percent more crashes occurred on an average weekday than on an average weekend day. See **Figure 3-36**.

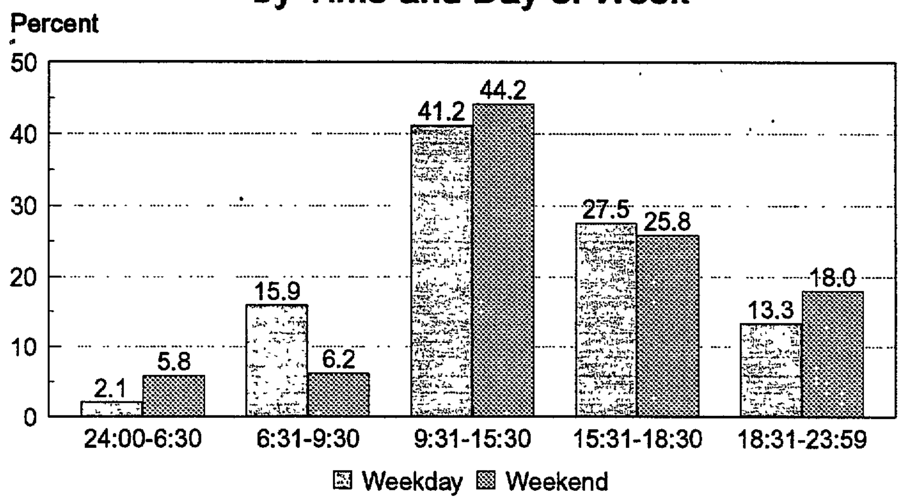
Figure 3-36. UI/PCP Crashes by Day of Week



- **Time/Day**

Figure 3-37 compares weekdays and weekend days by crash time distribution. It indicates that, during weekends, relatively more UI/PCP crashes occurred during nighttime hours (18:01 - 06:30). During weekdays, relatively more crashes occurred during morning and evening rush hours.

Figure 3-37. UI/PCP Crashes by Time and Day of Week

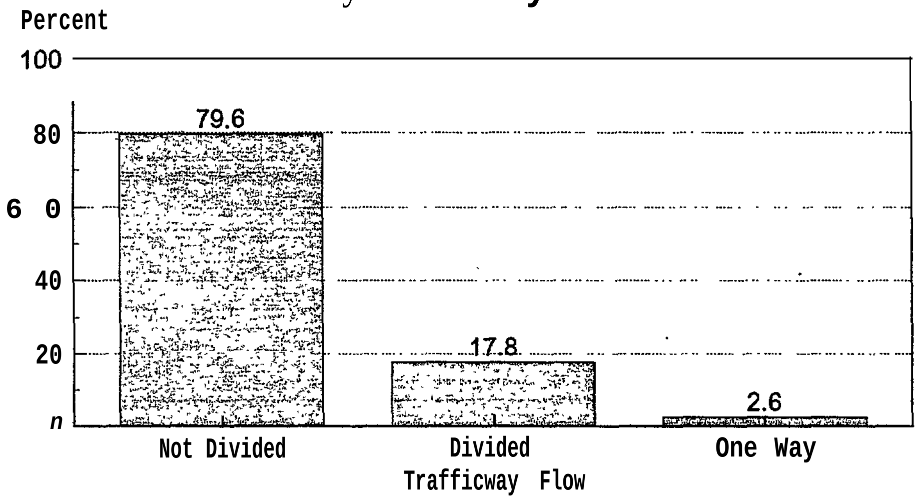


The following roadway-specific GES ***accident*** variables describe the principal roadway where the crash occurred. By convention, the roadway coded is that with the higher roadway function classification. When a crash occurs at an intersection of two roadways with the same classification, the roadway with the higher number of lanes is coded.

- **Trafficway Flow**

  The unknown rate for trafficway flow was 3 1.7 percent. For all known values, about 79.6 percent of UI/PCP crashes occurred on non-divided highways, 17.8 percent on divided highways, and 2.6 percent on one-way trafficways **See Figure 3-38.**

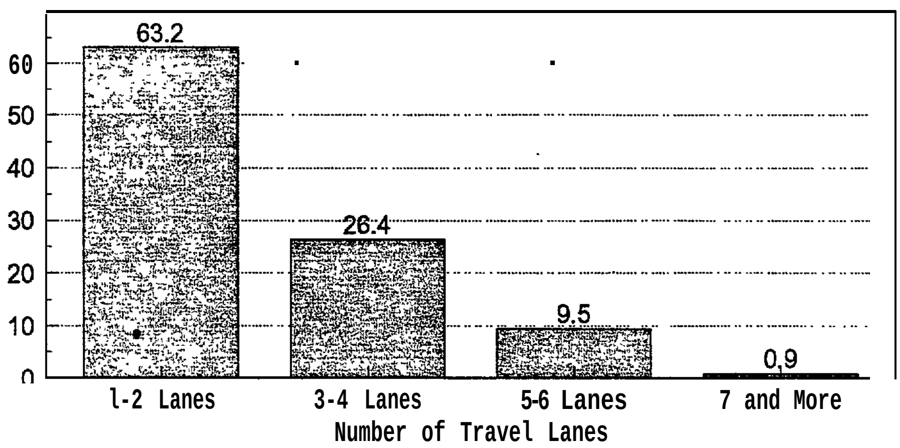
Figure 3-38. UI/PCP Crashes
by **Trafficway Flow**



- **Number of Travel Lanes**

  The unknown rate for this variable was 27.7 percent. **Figure** 3-39 presents percentages for known values. It shows that 63.2 percent of UI/PCP crashes occurred on l- or 2-lane roadways, 26.4 percent on 3-4 lane roadways, and 9.5 percent on roadways with 5 or more lanes. As noted above, the roadway coded is that with the higher number of travel lanes.

Figure 3-39. UI/PCP Crashes by Number of Travel Lanes



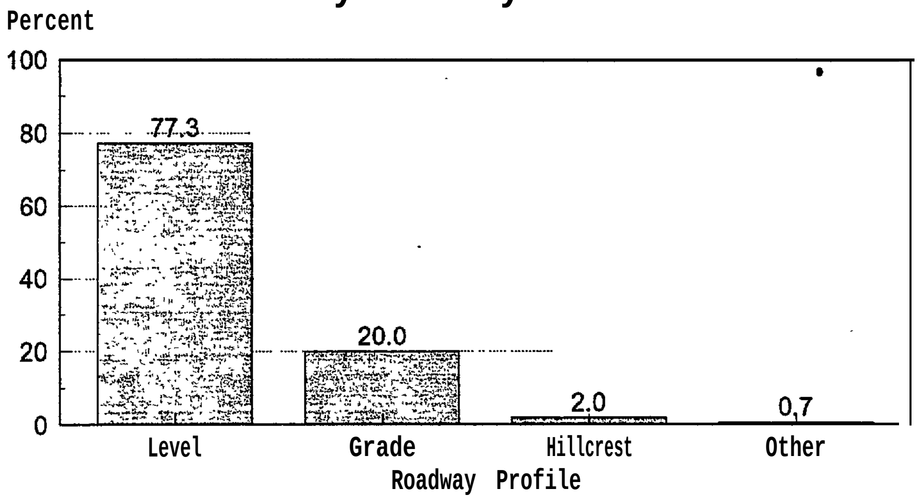
- **Roadway Alignment**

Most UI/PCP crashes (96.4 percent) occurred on straight roadways.

- **Roadway Profile**

About 77 percent of UI/PCP crashes occurred on level roadways; see **Figure 3-40.**

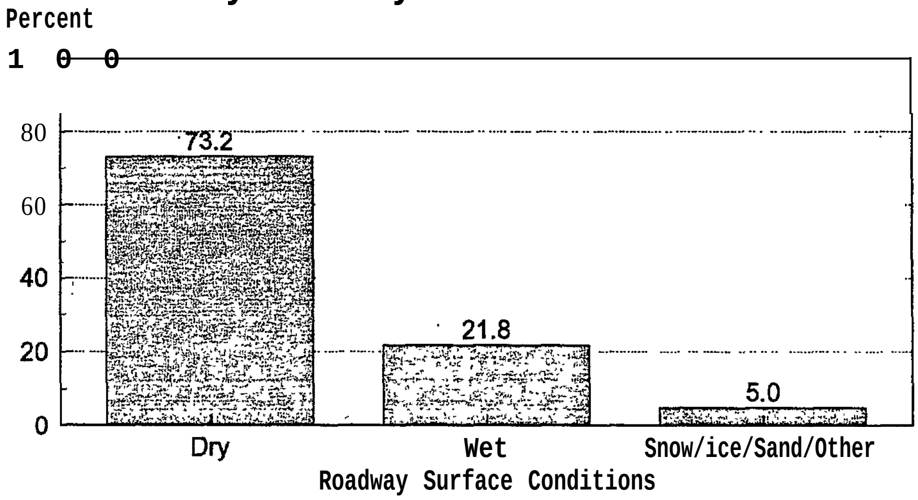
Figure 3-40. UI/PCP Crashes by Roadway Profile



- **Roadway Surface Condition**

Overall, 73.2 percent of UI/PCP crashes occurred on dry roadways, and 21.8 percent on wet roadways. Only 5.0 percent occurred on extreme surface conditions such as snow, ice, or sand. **See Figure 3-41.**

Figure 3-41. UI/PCP Crashes by Roadway Surface Conditions

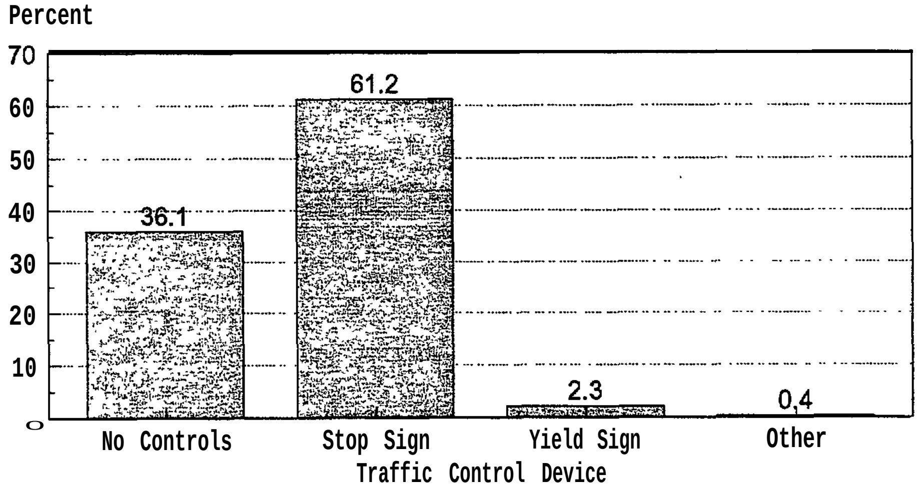


- **Traffic Control Device**

Of all UI/PCP crashes, 36.1 percent occurred at intersections with no traffic control devices, 61.2 percent at intersections controlled by stop signs, and 2.3 percent at intersections with yield signs. **See Figure 3-42.**

The large percentage of UI/PCP crashes occurring at intersections with no controls is due, to the inclusion of crashes occurring at intersections of driveways and alleys with larger roadways. Such intersections rarely have traffic control devices.

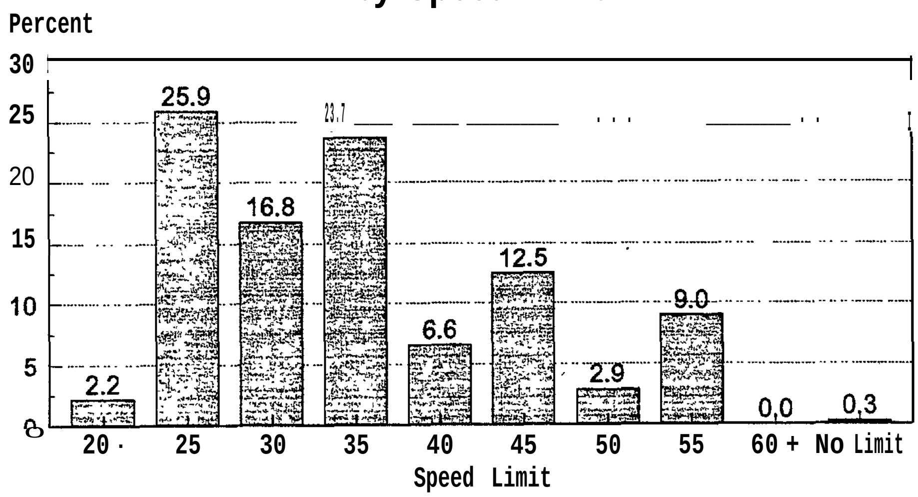
Figure 3-42. UI/PCP Crashes by Traffic Control Device



Speed Limit

Figure 3-43 shows the distribution of roadway speed limits for UI/PCP crashes. It shows that 25.9 percent of WPCP crashes occurred on roadways with a posted speed limit of 25 mph, and 23.7 percent occurred on roadways with a posted speed limit of 35 mph. Overall, 68.6 percent of UI/PCP crashes occurred on roadways with speed limits of 35 mph and under.

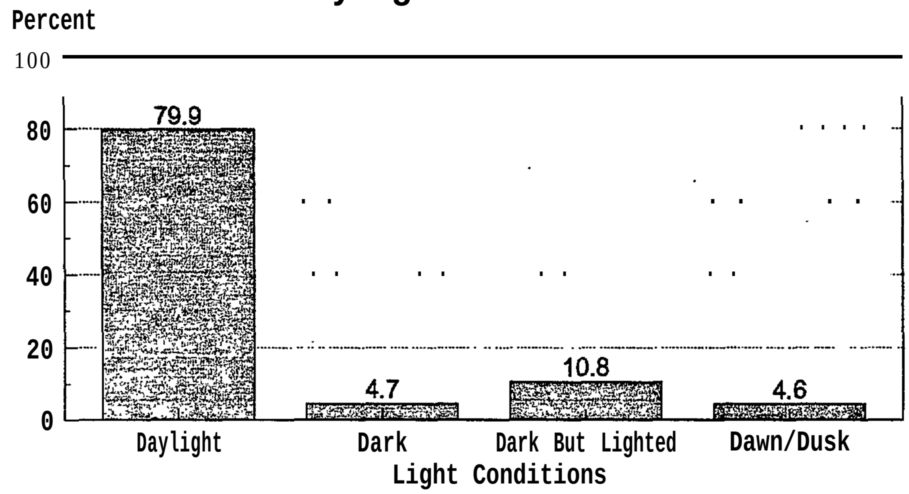
Figure 3-43. UI/PCP Crashes by Speed Limit



- **Light Condition**

Figure 3-44 indicates that 79.9 percent of UI/PCP crashes occurred in daylight, and 10.8 occurred under the condition “dark but lighted."

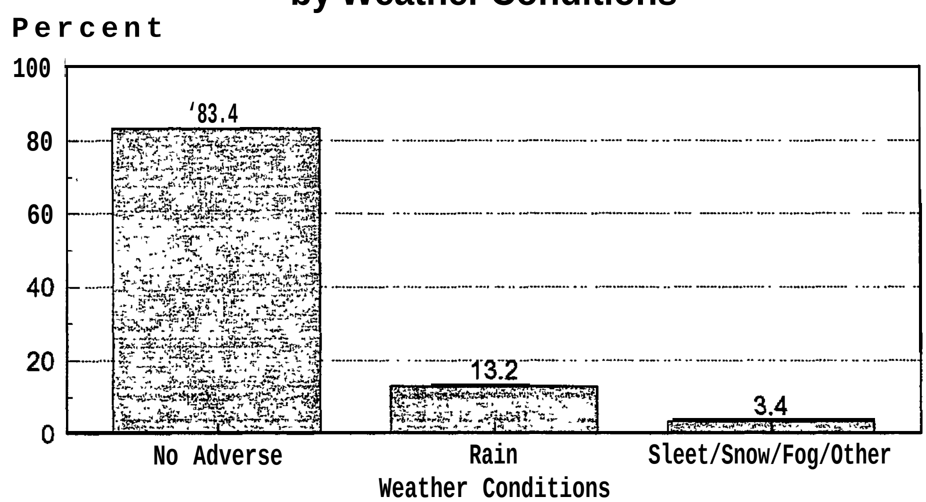
Figure 3-44. UI/PCP Crashes by Light Conditions



- **Weather Condition**

Overall, 13.2 percent of UI/PCP crashes occurred in rainy weather conditions and 3.4 percent occurred during sleet/snow/fog/other. About 83 percent occurred during clear weather. See **Figure 3-45.**

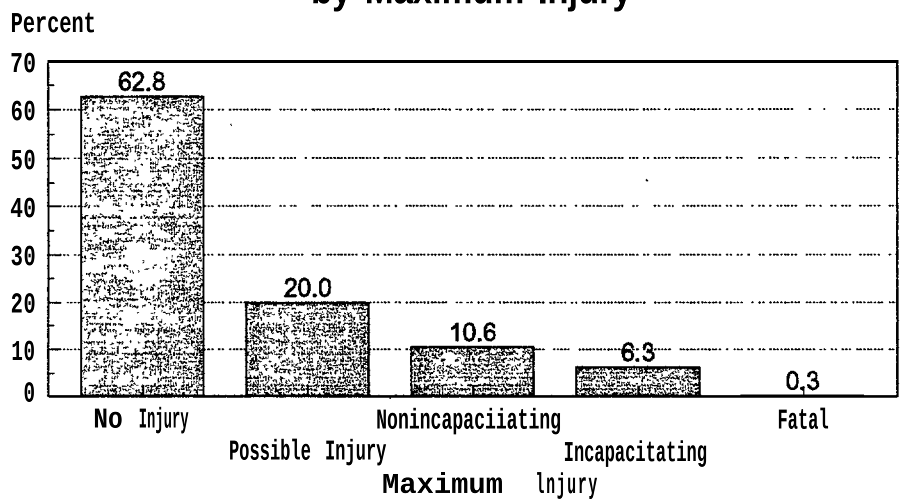
Figure 3-45. UI/PCP Crashes by Weather Conditions



- **Maximum Injury**

Figure 3-46 shows that 0.3 percent of UI/PCP crashes caused fatal injuries and 6.3 percent caused incapacitating injuries. Approximately 63 percent produced no injury.

Figure 3-46. UI/PCP Crashes by Maximum Injury



- **Alcohol Involvement**

Only 3.7 percent of UI/PCP crashes involved alcohol.

- **Vehicle Body Type**

The vast majority of UI/PCP crash-involved vehicles were passenger vehicles (97.5 percent). Medium/heavy trucks comprised 1.1 percent of UI/PCP crash-involved vehicles, and motorcycles comprised 1.0 percent.

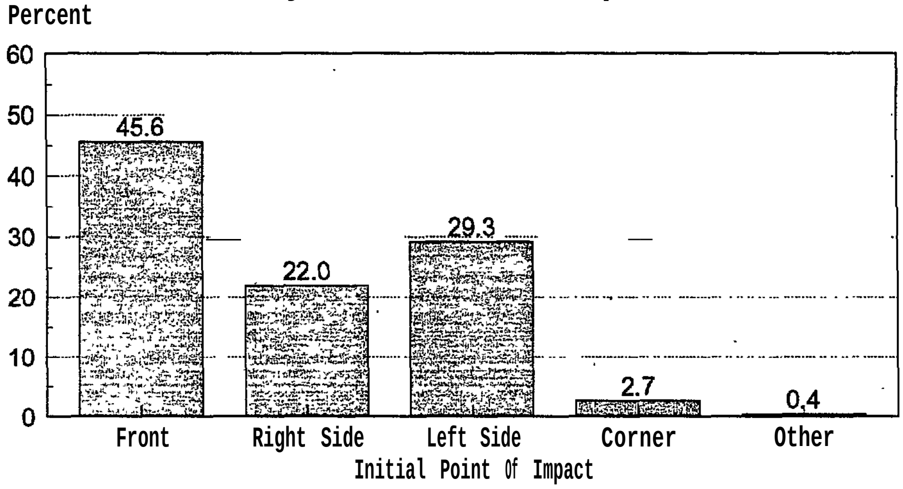
- **Prewash Maneuver**

The most common vehicle precrash maneuver, representing 70.4 percent of vehicles, was "going straight". Approximately 13.1 percent of vehicles were making a left turn, and 7.8 percent were starting, stopping or slowing.

- Initial Point of Impact

The most frequent points of impact for UI/PCP crash involved vehicles were the front (45.6 percent),' left side (29.3 percent), right side (22.0 percent), and comers (2.7 percent). See Figure 3-47.

Figure 3-47. UI/PCP Crash Involved Vehicles by Initial Point of Impact



- **Violations Charged**

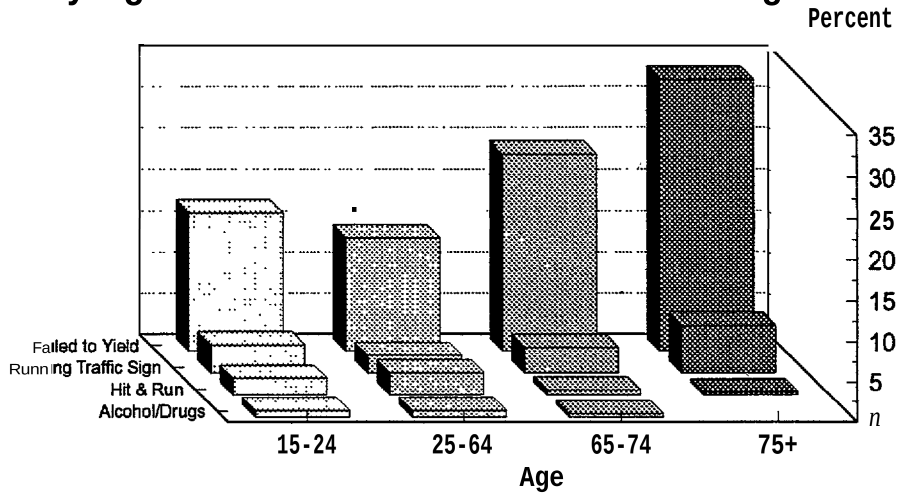
About 70.0 percent of drivers were not charged with a traffic violation. Below are the percentages for the most common violations charged:

- Failure to Yield	16.2 %
- Running Traffic Sign	2.9 %
- Hit&Run	2.5 %
- Alcohol/Drugs	0.8 %
- Other Violations	8.9 %

- Most **Common Violations Charged by Age**

Figure 3-48 shows that older drivers (65 and older) were charged with "failure to yield" more than twice as frequently, relative to their involvements, as were drivers aged 25-64.

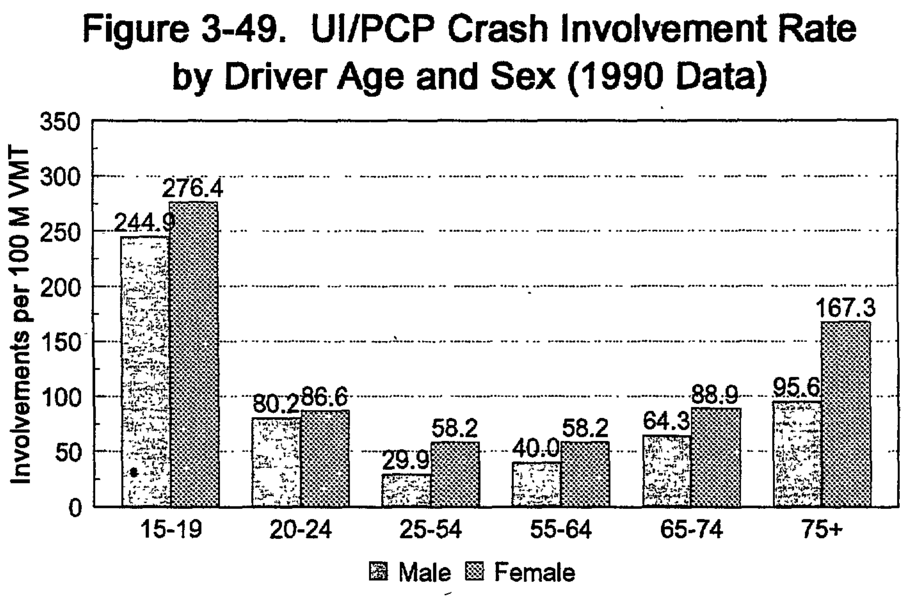
Figure 3-48. UI/PCP Crashes by Age and Most Common Violations Charged



Crash Involvement Rate Based on VMT by Driver Age and Sex

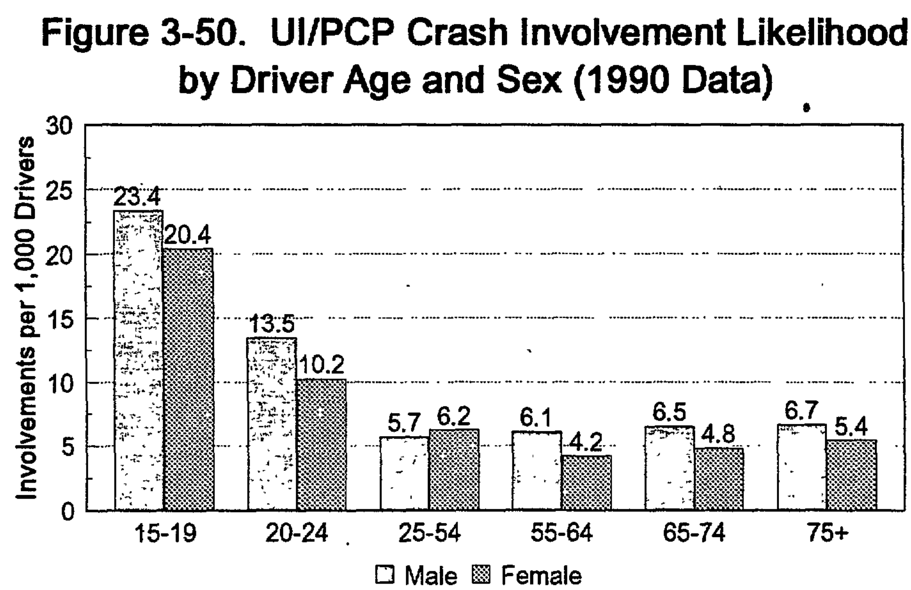
Due to unavailability of 1991 VMT data by driver age and sex, crash involvement rates were calculated using 1990 data. Driver information also was retrieved from 1990 GES As mentioned at the beginning of the chapter, crash involvement rates were calculated based on all involvements, regardless of vehicle role.

Figure 3-49 shows that teenaged drivers had the highest rate of UI/PCP crash involvement. Female crash involvement rates were higher than those for males across all age groups; the difference was relatively greatest for the 25-54 and 75+ age groups. Overall, females had a higher involvement rate (74.1 per 100 million vehicle miles traveled) than did males (46.4 per 100 million VMT).



- **Crash Involvement Likelihood Based on Licensed Drivers by Driver Age and Sex**

Figure 3-50 shows that the risk of involvement for teenagers was the highest among all age groups. Involvement likelihood decreased with advancing age through the 55-64 age group, and then increased somewhat for drivers older than 64. There were 22 UI/PCP crash involvements per 1,000 teenaged drivers, compared to 6 UI/PCP crash involvements per 1,000 licensed drivers aged 55 and older. Overall, in contrast to the involvement rate based on VMT, the likelihood of involvement for male drivers (7.7 per 1,000 licensed drivers) was slightly higher than that for female drivers (7.0).



- **Critical Event**

Critical Event (V26, P-CRASH2) is a new GES variable in the 1992 file. It is defined as follows:

> The event which made the crash imminent (i.e. something occurred which made the collision possible). A critical event is coded for each vehicle and identifies the circumstances leading to this vehicle's first impact in the crash.

In cases where more than one critical event is applicable (e.g., excessive speed ***and*** poor road conditions), the most significant critical event is coded.

The following UI/PCP critical events were notable based on 1992 GES data. All percentages are for all vehicle types combined:

Vehicle encroaching into another vehicle's lane at junction	47.6 %
- Entering intersection, straight across path	27.1 %
- Entering intersection, turning into opposite direction	9.8 %
- From driveway, alley access, etc., straight across path	1.4%
- From driveway, alley access, etc., turning into opposite direction	6.0 %
- Other	3.3 %
Another vehicle encroaching into this vehicle's lane at junction	46.0 %
- Entering intersection, straight-across path	26.7 %
- Entering intersection, turning into opposite direction	9.2 %
- From driveway, alley, access, etc., straight across path	1.5 %-
- From driveway, alley access, etc., turning into opposite direction	5.9 %
- Other	2.7 %
Other/Miscellaneous (several subcategories)	6.4 %

- **Corrective Action Attempted**

Corrective Action Attempted (V27, P-CRASH3) is another new GES variable in the 1992 file. It is defined as the "actions taken by the driver of this vehicle in response to the impending danger."

The following UI/PCP corrective actions attempted were notable based on 1992 GES data. All percentages are for all vehicle types combined:

- No corrective action attempted 87.3 %

- Braked/slowed 5.5%
- Steered to left/right 1.1 %
- Other 3.5 %
- Unknown 2.6 %

Note that only 10.1 percent of the drivers of vehicles involved in UI/PCP crashes were known to have attempted a corrective action prior their crashes.

Vehicle Control After Corrective Action

Vehicle Control After Corrective Action (V29, P-CRASH4) is another new GES variable in the 1992 file. It is defined as follows:

> The stability of the vehicle during the period immediately after the attempted corrective action, up to the initial impact in the crash sequence. The stability of the vehicle prior to corrective action is not considered.

The following vehicle control states after corrective actions were notable based on 1992 GES data. All percentages are for all vehicle types combined:

- No' corrective action 87.3 %
- Vehicle control maintained 3.5 %
- Vehicle slid/skid longitudinally 3.4 %
- Other 2.9 %
- Unknown 2.9 %

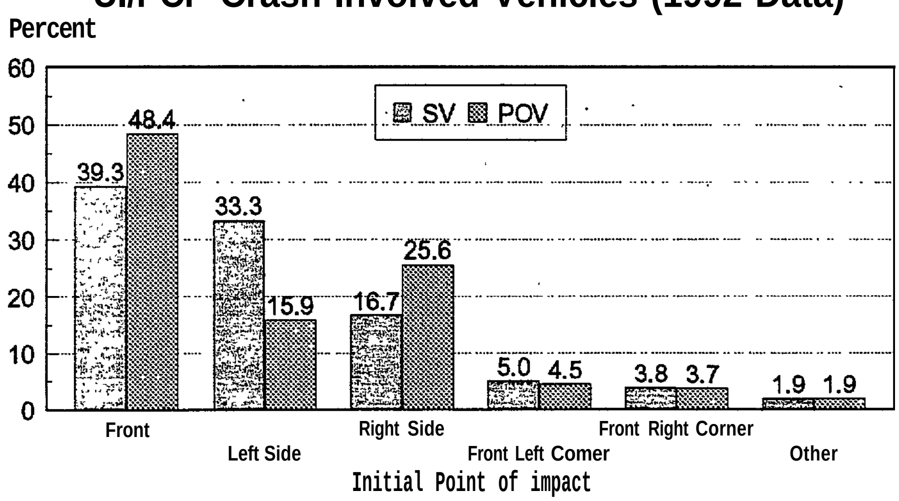
Subject Vehicle and Principal Other Vehicle Differences Based on 1992 GES Data

Prior to 1992, GES data elements did not generally permit the differentiation of the two involved vehicles in an UI/PCP crash. That is, one could not differentiate the **subject vehicle** (SV), defined as the vehicle encroaching into the other vehicle's lane or travel path, from the **principal other vehicle** (POV), the "encroached upon" vehicle. However, a set of pre-crash data variables added to the GES in 1992 now permit, in most cases, the differentiation of the two involved vehicles (i.e., SV versus POV). About 93 percent of 1992 UI/PCP crashes involved one vehicle encroaching into the lane/travel path of another vehicle and, further, identified these critical vehicle roles. Below are findings regarding vehicle/driver characteristics for those 1992 GES UI/PCP crashes where this differentiation can be made.

- **Initial Point of Impact by Vehicle Role**

  The most frequent points of impact for UI/PCP crash-involved SVs were the front (39.9 percent), left side (33.0 percent) and right side (16.6 percent). For POVs, the most frequent points of impact were the front (48.2 percent), right side (25.6 percent), and left side (16.2 percent). SVs were more likely to have the point of impact on the left side, whereas POVs were more likely to have the point of impact on right side. **See Figure 3-51.**

Figure 3-51. Initial Points of Impact by Vehicle Role UI/PCP Crash Involved Vehicles (1992 Data)



The data in Figure 3-51 are consistent with the idea that many more UI/PCP crashes occur in the first half of the intersection crossing by the SV than in the second half. Collisions occurring in the first half of the intersection crossing would generally result in one of the following point-of-impact combinations (with 1992 GES percentages):

SV left side -- POV front	26.8 %
SV front -- POV right side	20.3 %
SV left front corner -- POV right front comer	1.1 %

Collisions occurring in the second half of the intersection crossing would generally result in one of the following point-of-impact combinations:

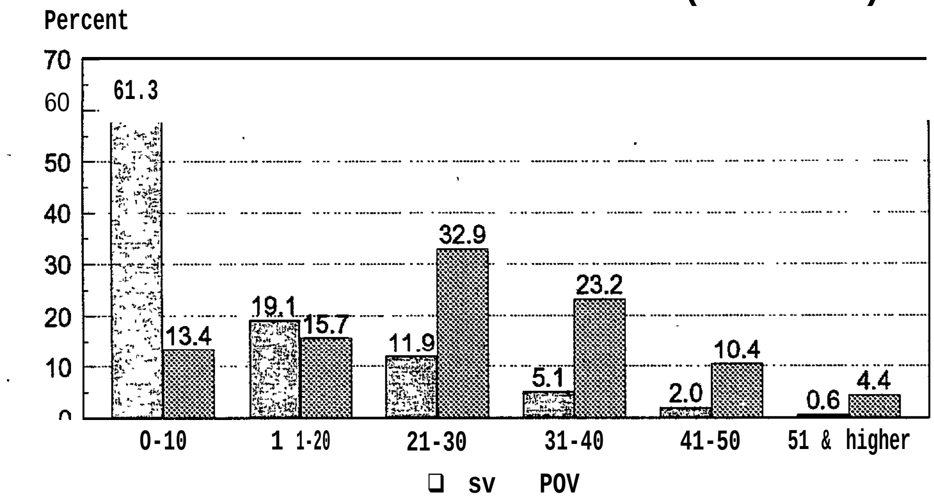
SV left side -- POV front	14.1 %
SV front -- POV left side	12.4 %
SV right front comer -- POV left front comer	0.9 %

Analysis of the combinations of point-of-impact for 1992 UI/PCP crashes indicates that, of those crashes with one of the above six combinations, 63.8 percent fall into the "probably first half" category, while 36.2 percent fall in the "probably second half" category. Note that the preponderance of "probably first half" crashes is unique to UI/PCP crashes; for SI/PCP crashes, slightly more than half of the crashes were "probably second half".

Travel Speed by Vehicle Role

The percentage of vehicles traveling at an unknown (?) travel speed was over 60 percent. For all known speeds, **Figure 3-52** presents the percentage distribution of vehicle travel speed for SVs and POVs. Compared to POVs, a relatively higher percentage of SVs were traveling at a speed of 10 mph or lower.

**Figure 3-52. Travel Speed by Vehicle Role
UI/PCP Crash Involved Vehicles (1992 Data)**



- **Violations Charged by Vehicle Role**

Table 3-4 shows the percentages for the most common violations charged for SVs and POVs For drivers of SVs, 28.1 percent were charged with "failure to yield", and 6.3 percent were charged with "running traffic signal".

**Table 3-4. Percent of Violations Charged by Vehicle Role
WPCP Crashes (1992 Data)**

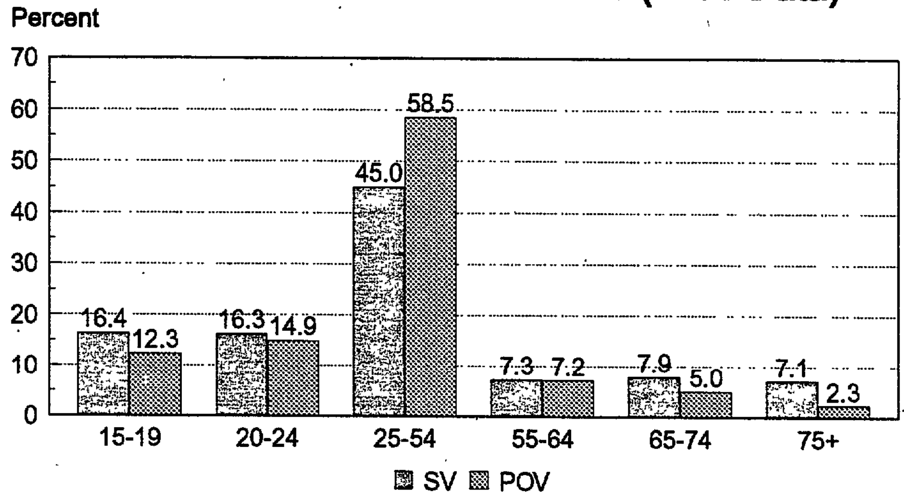
Common Violations Charged	**S V**	**POV**
None	47.4 %	89.1 %
Failure to Yield	28.1 %	2.5 %
Running Traffic Signal	6.3 %	0.7 %
Hit & Run	3.7 %	0.9 %
Alcohol/Drugs	1.2 %	0.3 %
Other Violations	13.3 %	6.5 %
Total	100.0 %	100.0 %

About 90 percent of POV drivers were not charged with a traffic violation. The most frequent violation charged for POVs was "failure to yield"(2.5 percent).

- **Drivers' Age by Vehicle Role**

Figure 3-53 indicates that drivers aged 65 and older comprised about 15.0 percent of SV drivers, compared to 7.3 percent of POV drivers.

Figure 3-53. Drivers Age by Vehicle Role UI/PCP Crash Involved Drivers (1992 Data)



- **Corrective Action Attempted by Vehicle Role**

There was little observed difference between SVs and POVs. Only about 5 percent of drivers of SVs and POVs made corrective actions prior to UI/PCP crashes. Also, for both SVs and POVs, "braked/slowed" was the most common action attempted. The percentages in **Table 3-5** are for all vehicle types combined:

Table 3-5. Percent of Corrective Action Attempted by Vehicle Role UI/PCP Crashes (1992 Data)

Corrective Action Attempted	SV	POV
No corrective action attempted	92.1 %	92.1 %
Braked/slowed	4.3 %	5.0 %
Other	1.1 %	2.7 %
Unknown	2.5 %	1.2 %
Total	100.0 %	100.0 %

- **Vehicle Control After Corrective Action by Vehicle Role**

The following table shows the percent distribution of vehicle control states after corrective actions. All percentages in **Table 3-6** are for all vehicle types combined.

Table 3-6. Percent of Vehicle Control by Vehicle Role UI/PCP Crashes (1992 Data)

Vehicle Control	SV	POV
No corrective action	92.1 %	92.1 %
Vehicle slid/skid longitudinally	2.6 %	2.6 %
Vehicle control maintained	1.8 %	3.5 %
Other	0.8 %	0.3 %
Unknown	2.7 %	1.5 %
Total	100.0 %	100.0 %

3.4 LEFT TURN ACROSS PATH (LTAP) CRASHES

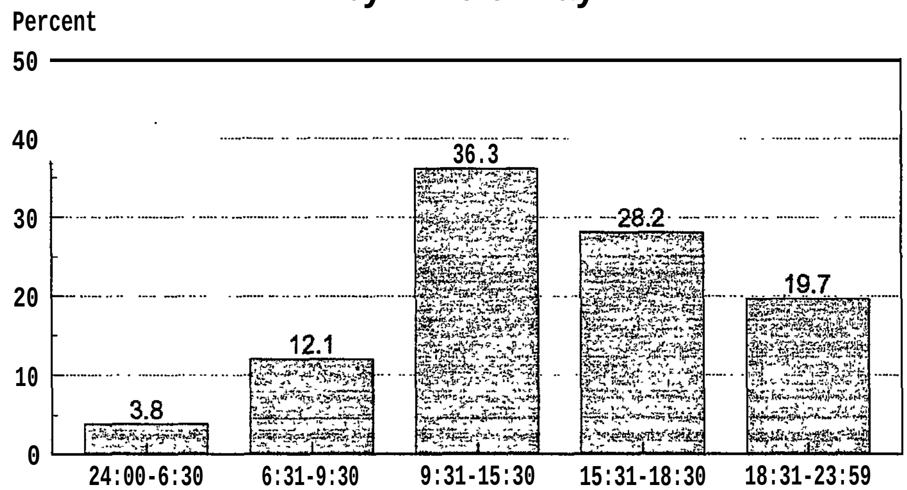
Unlike other ICP crash types, LTAP crashes involve vehicles with two distinctly different pre-crash maneuvers which can be distinguished from each other based on coded data elements in the 1991 GES file. That is, the left-turning vehicle (Accident Type 68) can be distinguished from the vehicle going straight (Accident Type 69). Therefore, vehicle and driver variables can be searched separately for the left-turning and going-straight vehicles in the crash. By definition, the **subject vehicle (Sv) in** LTAP crashes is the **left-turning vehicle,** whereas the **principal other vehicle (POV)** is the vehicle that is going straight.

Below are major findings regarding the characteristics of LTAP crashes. Accident variables apply to the entire crash, as always. Vehicle and-driver variables may refer to all vehicles/drivers involved in the crash or may refer specifically to SVs or POVs, as will be stated.

- **Time of Day**

  About 28 percent of LTAP crashes occurred during afternoon traffic hours (15:31 - 18:30) This percentage is more than twice as high as the 12.1 percent occurring during morning traffic hours **(6:3 1 - 9:30). See Figure 3-54.**

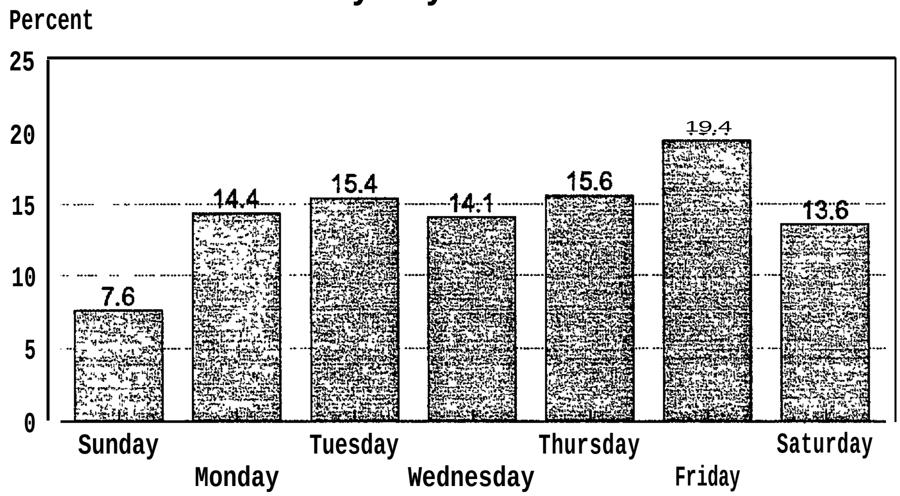
Figure 3-54. LTAP Crashes by Time of Day



- Day of Week

LTAP crashes occurred most frequently on Friday and least frequently on Sunday. About 50 percent more crashes occurred on an average weekday than on an average weekend day. See Figure 3-55.

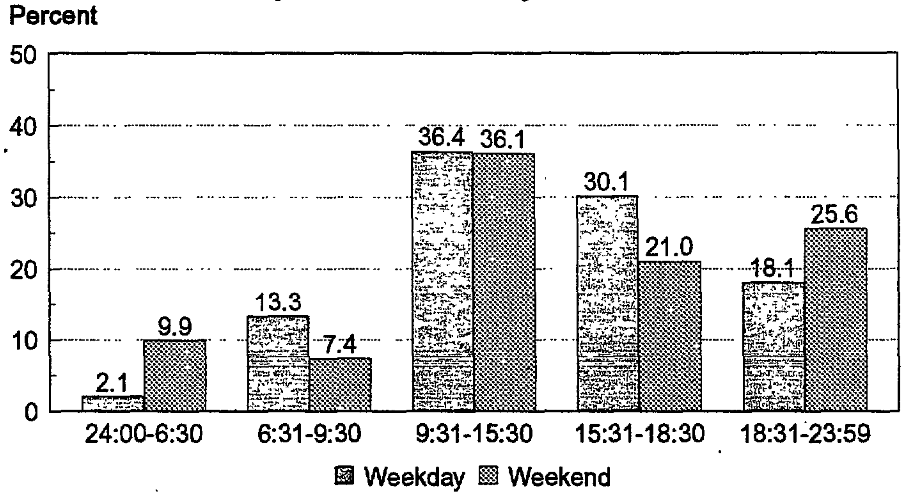
Figure 3-55. LTAP Crashes by Day of Week



- Time/Day

Figure 3-56 compares weekdays and weekend days by crash time distribution. It indicates that, during weekends, relatively more LTAP crashes occurred during nighttime hours (18:0l - 06:30). During weekdays, relatively more crashes occurred during morning and evening rush hours.

Figure 3-56 LTAP Crashes by Time and Day of Week



- **Manner of Collision**

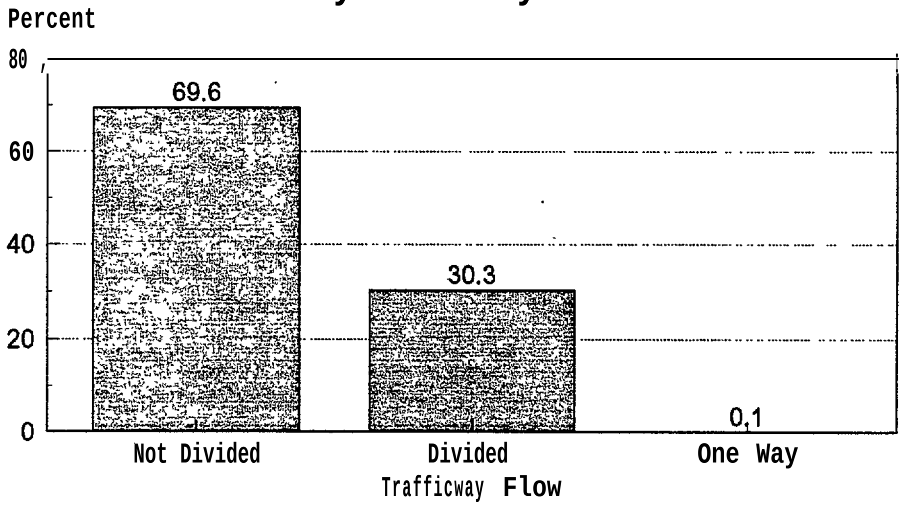
  Not surprising, 93.1 percent of LTAP crash collision orientations were "angle". The next frequent collision orientation was "head-on" (about 6 percent).

The following (up to speed limit) roadway-specific GES *accident* variables describe the principal roadway where the crash occurred. By convention, the roadway coded is that with the higher roadway function classification. When a crash occurs at an intersection of two roadways with the same classification, the roadway with the higher number of lanes is coded.

- **Trafficway Flow**

  The unknown rate for trafficway flow was 22.3 percent. For all known values, 69.6 percent of LTAP crashes occurred on non-divided highways, 30.3 percent on divided highways, and 0.1 percent on one-way trafficway. See **Figure 3-57**.

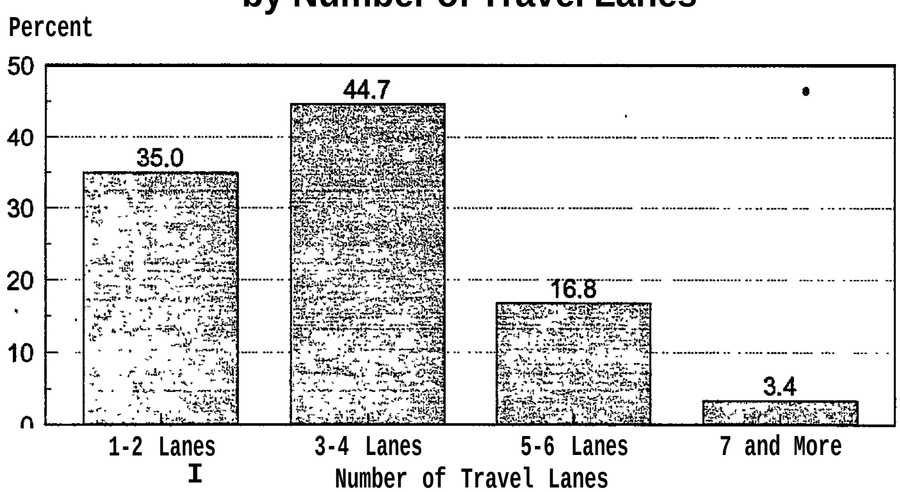
Figure 3-57. LTAP Crashes by Trafficway Flow



Number of Travel Lanes

The unknown rate for this variable was 23.3 percent. **Figure 3-58** presents percentages for known values. It shows that 35.0 percent of LTAP crashes occurred on l- or 2-lane roadways, 44.7 percent on 3-4 lane roadways, and 16.8 percent on roadways with 5 or more lanes. As noted above, the roadway coded is that with the' higher number of travel lanes.

Figure 3-58. LTAP Crashes by Number of Travel Lanes



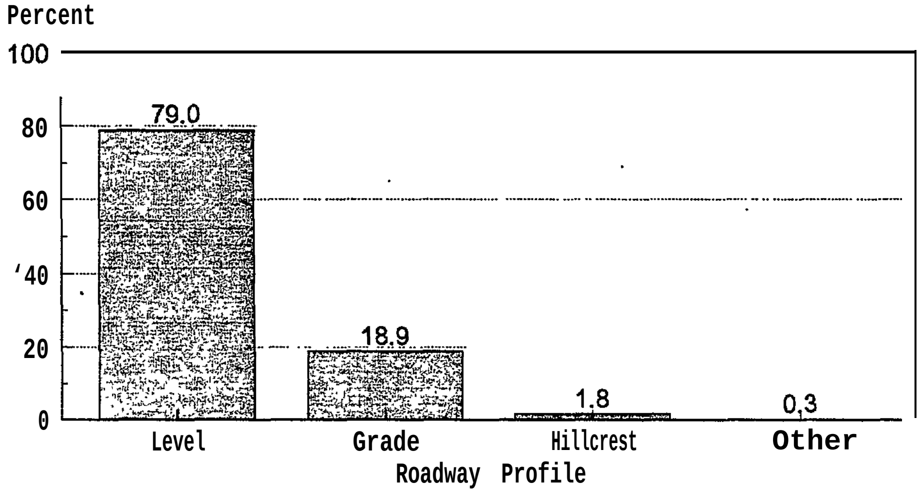
- **Roadway Alignment**

  Most LTAP crashes (97.2 percent) occurred on straight roadways.

- **Roadway Profile,**

  More than three-fourths of LTAP crashes occurred on level roadways; see **Figure 3-59.**

Figure 3-59. LTAP Crashes by Roadway Profile



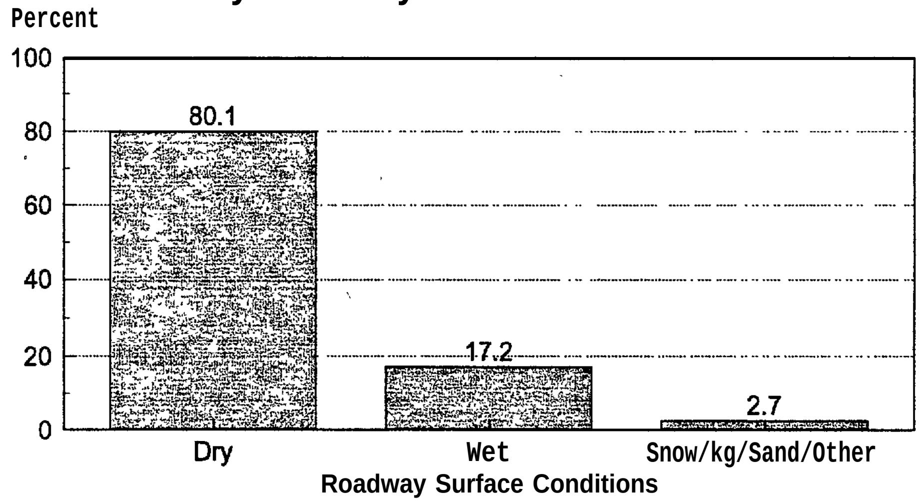
- **Roadway Alignment/Profile**

  About 80 percent of LTAP crashes occurred on roadways which were ***both*** straight and level.

- **Roadway Surface Condition**

  Overall, 80.1 percent of LTAP crashes occurred on dry roadways, and 17.2 percent on wet roadways. Only 2.7 percent occurred on extreme surface conditions such as snow, ice, or sand. See **Figure 3-60.**

Figure 3-60. LTAP Crashes by Roadway Surface Conditions



Traffic Control Device

Of all LTAP crashes, 42.6 percent occurred at intersections with no traffic control devices, 51.2 percent at intersections controlled by a traffic control signal (including on colors, flashing, and other), and 6.2 percent at intersections with traffic signs. Overall, 63.6 percent of LTAP crashes occurred at intersections with some type of control device. Below is the list of the percentage contribution by various control devices:

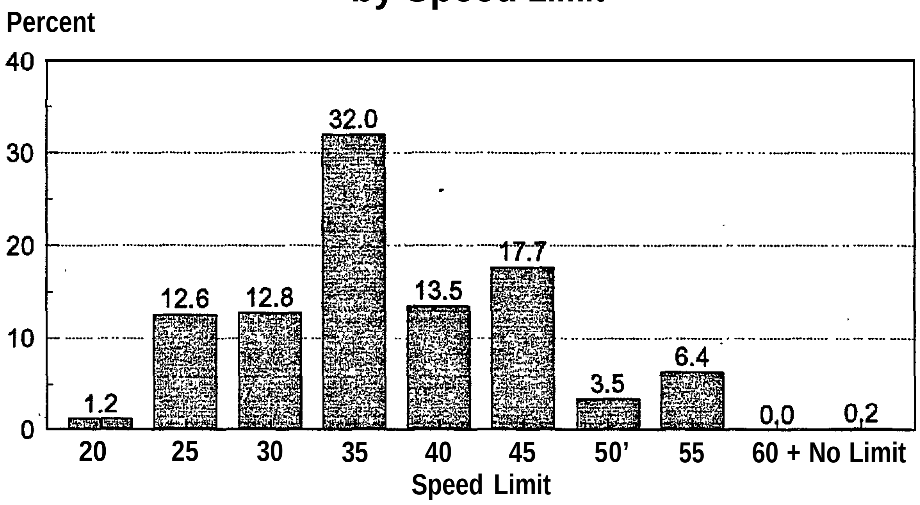
- No Controls	42.6 %
- Traffic Control Signal (on Colors)	48.9 %
- Flashing/Other/Unknown Traffic Control Signal	2.3 %
- Stop Sign	5.1 %
- Yield Sign/Warning/Advisory/Other	1.1 %

The large percentage of LTAP crashes occurring at intersections with no controls reflects partially the fact that if the involved vehicles were not subject to any control (e.g. two vehicles both traveling on the roadway with the right-of-way at an intersection with stop signs controlling the non-right-of-way roadway), the crash would be coded “no controls”. Also, the definition used in this report, LTAP crashes include applicable crashes occurring at intersections of driveways and alleys with larger roadways. Such intersections rarely have traffic control devices.

Speed Liiit

Fiire 3-61 shows the distribution of roadway speed limits for LTAP crashes. It shows that 32.0 percent of LTAP crashes occurred at rqadways with a posted speed limit of 35 mph. Overall, 58.6 percent of LTAP crashes occurred on roadways with speed limits of 35 mph and under, and 31.2 percent occurred on roadways with speed limits 40 or 45 mph.

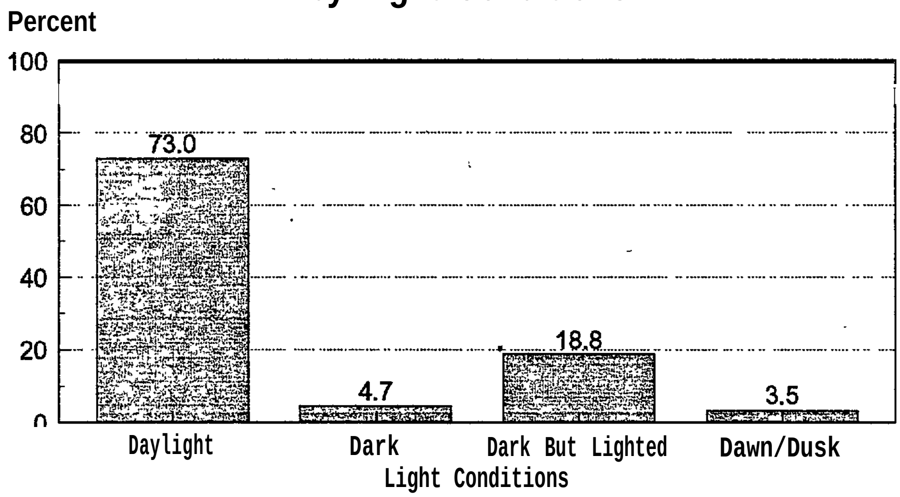
Figure 3-61. LTAP Crashes by Speed Limit



- **Light Condition**

Figure 3-62 indicates that 73.0 percent of LTAP crashes occurred in daylight, and 18.8 occurred under the condition "dark but lighted."

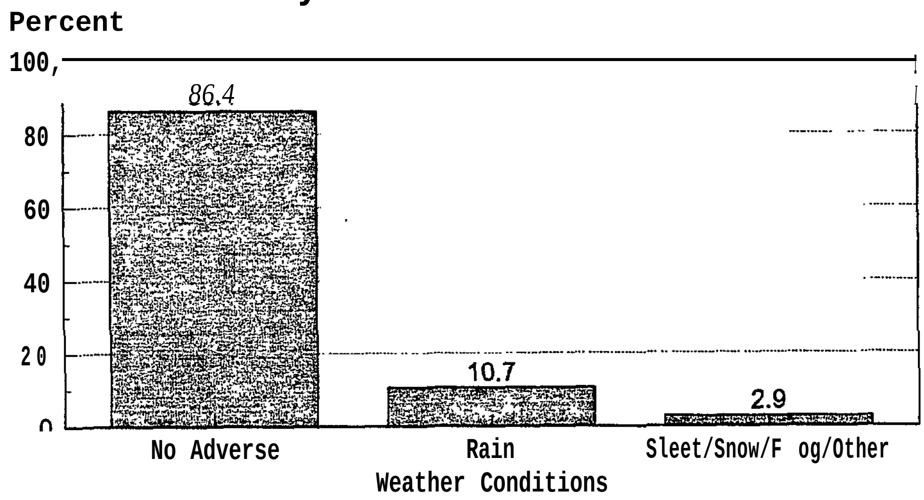
Figure 3-62. LTAP Crashes by Light Conditions



- **Weather Condition**

Overall, 10.7 percent of LTAP crashes' occurred in rainy weather conditions and 2.9 percent occurred during sleet/snow/fog/other. About 86 percent occurred during clear weather. **See Figure 3-63.**

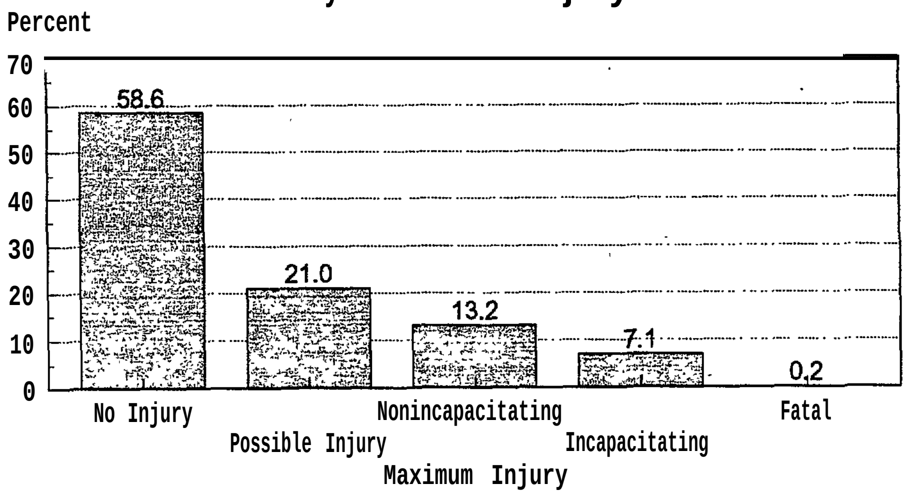
Figure 3-63. LTAP Crashes by Weather Conditions



- **Maximum Injury**

Figure 3-64 shows that 0.2 percent of LTAP crashes caused fatal injuries and 7.1 percent caused incapacitating injuries. Approximately 60 percent produced no injury.

Figure 3-64. LTAP Crashes by Maximum Injury



- **Alcohol Involvement**

  Only 4.9 percent of LTAP crashes involved alcohol.. Also, alcohol use was more apparent under dry roadway surface conditions; that is, under dry conditions, 5.4 percent of LTAP crash involved alcohol, whereas under wet/snow/ice/other conditions only 2.7 percent of LTAP crashes involved alcohol.

The following five statistics (up to drivers' age) describe the LTAP crash-involved vehicles and drivers. Statistics in the figures are presented separately for the SV (i.e., the left-turning vehicle) and POV (other maneuver-making vehicle).

- **Vehicle Body Type**

  As indicated **in Table** 3-7, the vast majority of LTAP crash-involved vehicles were passenger vehicles (97.7 percent). Medium/heavy trucks comprised 0.8 p&cent of LTAP crash-involved vehicles, and motorcycles comprised 1.2 percent. As comparing vehicles' roles, medium/heavy trucks were more likely to be involved as the SV. Motorcycles were more likely to be involved as the POV.

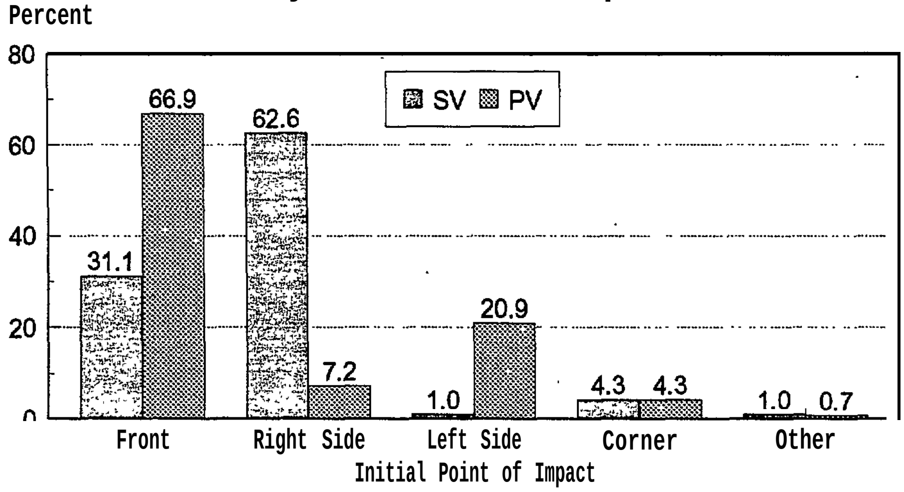
Table 3-7. Percent of Vehicle Body Types
LTAP Crashes

Vehicle Body Types	SV	POV
Passenger Vehicles	98.2 %	97.2 %
Combination-Unit Trucks	0.5 %	0.4 %
Single-Unit Trucks	0.5 %	0.2 %
Motorcycles	0.4 %	2.1 %
Others	0.3 %	0.2 %
Total	99.9 %	100.1 %

- **Initial Point of Impact**

The most frequent points of impact for LTAP crash-involved SVs were right side (62.6 percent), front (3 1.1 percent), and corners (4.3 percent). For POVs, the most frequent points of impact were front (66.9 percent), left side (20.9 percent), right side (7.2 percent) and comers (4.3 percent). **See Figure 3-65.**

Figure 3-65. LTAP Crash Involved Vehicles by Initial Point of Impact



- **Violations Charged**

More than half (52.4 percent) of the drivers of SVs were charged with traffic violations whereas only 13.2 percent of POV drivers were charged with a violation. **Table** 3-8 has the percentages for the most common violations charged for SVs and POVs.

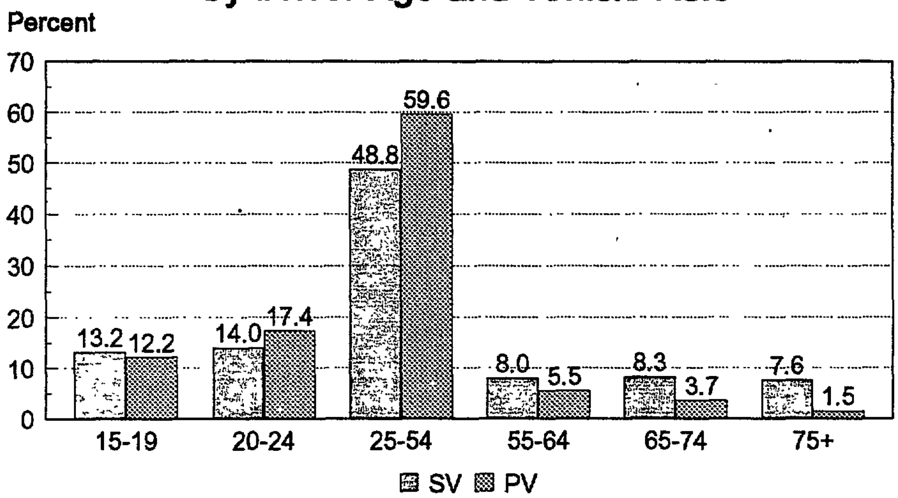
Table 3-8. Percent of Violations Charged
LTAP Crashes

Common Violations Charged	SV	POV
None	47.6 %	86.8 %
Failure to Yield	32.2 %	0.8 %
Hit & Run	3.0 %	1.2 %
Alcohol/Drugs	1.8 %	0.5 %
Running Traffic Signal	1.1 %	2.0 %
Suspended License	0.5 %	0.5 %
Speeding	0.2 %	0.6 %
Other Violations	13.6 %	7.6 %
Total	100.0 %	100.0 %

- **Drivers' Age**

Figure 3-66 compares drivers of SVs and POVs. Most notably, it indicates that relatively more drivers of the SVs were 55 and older. Indeed, 15.9 percent of SV drivers were aged 65+, versus only 5.2 percent of POV drivers.

Figure 3-66. LTAP Crash Involved Drivers by Driver Age and Vehicle Role

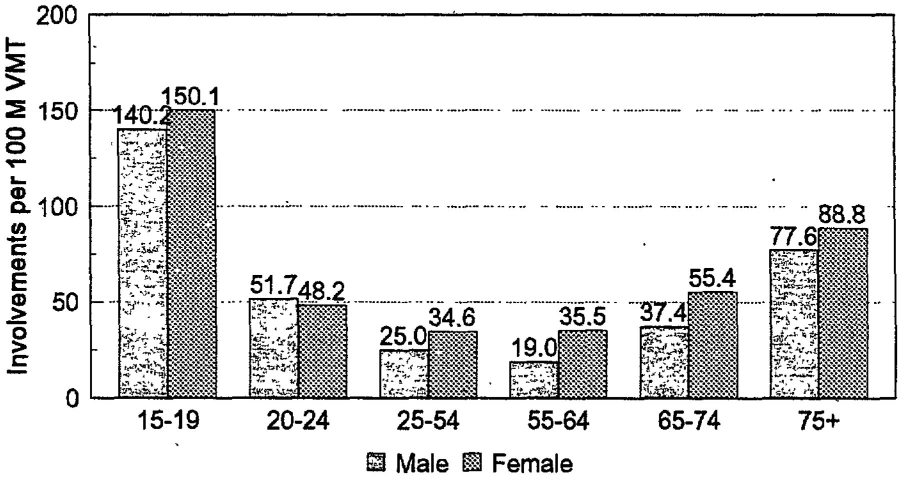


- **Crash Involvement Rate Based on VMT by Driver Age and Sex**

As mentioned at beginning of the chapter, 1990 data were used to estimate crash involvement rates. Involvement rates were calculated based on all involvements, regardless of vehicle role.

Figure 3-67 shows the distribution of crash involvement rate by age. It indicates that teenaged drivers had the highest rate of LTAP crash involvement. For males, the 55-64 age group had the lowest rate whereas for females the 25-54 age group had the lowest rate. Female crash involvement rates were higher than males for all age groups except for the 20-24 age group. Overall, females had a higher involvement rate (43.0 per 100 million vehicle miles traveled) than did males (32.7 per 100 million VMT).

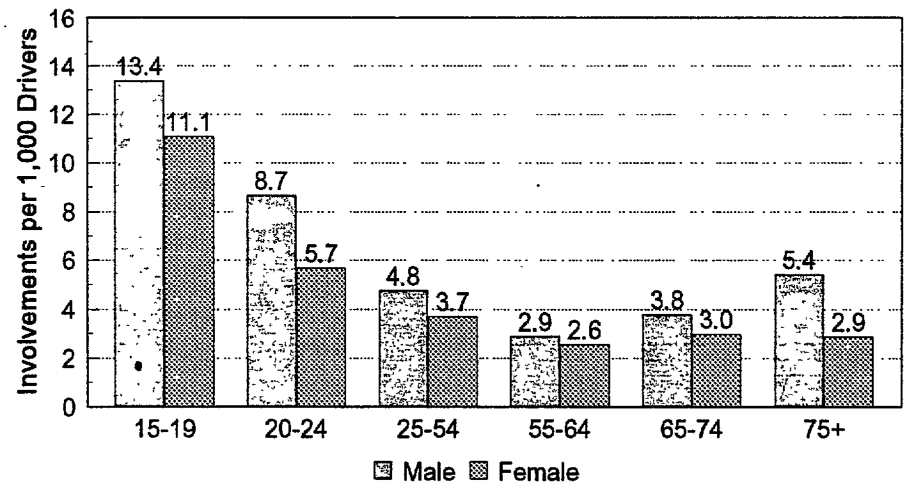
Figure 3-67. LTAP Crash Involvement Rate by Driver Age and Sex (1990 Data)



- **Crash Involvement Likelihood Based on Licensed Drivers by Driver Age and Sex**

The crash involvement based on number of licensed drivers shows a different pattern than that based on VMT. **Figure 3-68** shows that the risk of involvement for teenagers was the highest among all age groups. Involvement likelihood decreased with advancing age though the 55-64 age group, and then increased somewhat for drivers older than 64. Crash involvements per 1,000 teenaged drivers were four times higher than the value per 1,000 licensed drivers aged 55 and older. Overall, in contrast to the involvement rate based on VMT, the likelihood of involvement for male drivers (5.4 per 1,000 licensed drivers) was higher than that of females (4.1) across all age groups, especially for older drivers.

Figure 3-68. LTAP Crash Involvement Likelihood by Driver Age and Sex (1990 Data)



- **Critical Event**

Critical Event (V26, P_CRASH2) is a new GES variable in the 1992 file. It is defined as follows:

> The event which made the crash imminent (i.e. something occurred which made the collision possible). A critical event is coded for each vehicle and identifies the circumstances leading to this vehicle's first impact in the crash.

In cases where more than one critical event is applicable (e.g., excessive speed *and* poor road conditions), the most significant critical event is coded.

The 1992 coding scheme of this particular variable didn't address the situation for LTAP crashes, but has already been improved for the 1994 data collection. Therefore, LTAP critical events for the involved vehicles presented here are less detailed than those presented earlier. All percentages are for all vehicle types combined:

<u>Subject Vehicles</u>

Vehicle encroaching into another vehicle's lane at junction	81.4 %	
- Entering intersection		68.7 %
- Entering driveway, alley access, etc.		11.5 %
- Other		1.2 %
Vehicle encroaching into another vehicle's lane at non-junction	4.9 %	

Another vehicle encroaching into this vehicle's lane at junction	5.8 %
Other/Miscellaneous (several subcategories)	7.9 %

Principal Other Vehicles

The following LTAP critical events were for the involved non-subject vehicles. Percentages are for all vehicle types combined:

Vehicle encroaching- into another vehicle's lane at junction	7.8 %
Another vehicle encroaching into this vehicle's lane at junction	79.1 %
Entering intersection, straight across path	67.2 %
- Entering driveway, alley access, etc.	11.0 %
Other	0.9 %
Another vehicle encroaching into this vehicle's lane at non-junction	4.8 %
Other/Miscellaneous (several subcategories)	8.3 %

- **Corrective Action Attempted**

Corrective Action Attempted (V27, P-CRASH3) is another new GES variable in the 1992 file. It is defined as the "actions taken by the driver of this vehicle in response to the impending danger."

About 11 percent of POVs involved in LTAP crashes were known to have attempted a corrective action prior their crashes, whereas only 1.1 percent of drivers of SVs made a corrective action prior LTAP crashes. The percentages in **Table 3-9** are for all vehicle types combined:

Table 3-9. Percent of Corrective Action Attempted
LTAP Crashes

Corrective Action Attempted	S V	POV
No corrective action attempted	91.7 %	81.2 %
Braked/slowed	0.4 %	9.0 %
Accelerated	0.1 %	0.1 %
Steered to left or right	0.0 %	1.3 %
Braked & steered	0.0 %	0.8 %
O t h e r	5.1 %	5.3 %
Unknown	2.7 %	2.3 %
Total	100.0 %	100.0 %

- **Vehicle Control After Corrective Action**

Vehicle Control After Corrective Action (V29, P-CRASH4) is another new GES variable in the 1992 file. It is defined as follows:

> The stability of the vehicle during the period immediately after the attempted corrective action, up to the initial impact in the crash sequence. The stability of the vehicle prior to corrective action is not considered.

The following table shows the'percent distribution of vehicle control states after corrective actions. All percentages are for all vehicle types combined.

Table 3-10. Percent of Vehicle Control After Corrective Action
LTAP Crashes

Vehicle Control	S V	POV
No corrective action	91.7 %	87.6 %
Vehicle slid/skid longitudinally	0.3 %	2.8 %
Vehicle control maintained	0.2 %	2.8%
Other	5.0 %	4.1 %
Unknown	2.8 %	2.7 %
Total	100.0 %	100.0 %

4. TRI-LEVEL STATISTICS ON CRASH CAUSES

This chapter uses the Indiana Tri-Level Study (See Appendix A, Item A. 1.5) information to present possible causes for intersection crossing path (ICP) crashes (CARDfiie Accident Type 409-519). The Indiana Tri-Level Study (Treat et al, 1979a), was an in-depth study of crash causes conducted in the late 1970s by Indiana University. The term "Tri-Level" referred to the collection of three qualitatively-different types of data: mass data (e.g., driver license data including past violations), on-scene crash data (e.g., driver interviews, photography of skidmarks and vehicle final rest positions), and follow-up reconstructions, which included ,a consideration of human, vehicle, and environmental factors contributing to the crash. The recent addition of CARDfile accident type codes to the Indiana sample by NHTSA has made it possible to use the Tri-Level findings on causal factors in conjunction with CARDfile and other databases.

The T&Level study did not employ a large nationally-representive sample like the GES, but it does provide more m-depth information on crash causes than does GES or other similar national crash dam files. The study presented findings on the causal factors associated with 122 identified ICP crashes. 98 of the 122 cases were "perpendicular crossing path" (PCP, CARDfrle 511 and 515) crashes , and 8 of those are "left turn across path" (LTAP, CARDfile 411) crashes. 'In the study, crash causes were indicated in three major categories: vehicular factors, human causes, and environment causes. Typically, multiple crash causes were cited; thus the percentage of various causal categories add to more than 100 percent. Causal factors cited as "certain", "probable" or "possible" for a total of 10 percent or more of the target crash cases are listed below. Statistics are presented first for all ICP crashes, and then separately for PCP and LTAP crashes. Due to unavailability of the information on traffic control devices, causal findings for PCP crashes can not be categorized further as shown in the previous chapters.

Intersection Crossing Path Crashes (122 cases)

The crash causes at more detailed levels for the ICP crashes are provided below. At the broadest level of classification, one finds that human factors were cited as certain, or probable causes in 120 of the 122 cases. Recognition errors are most frequently cited (98 cases; 80 percent). No vehicular factors are indicated for ICP crashes.

Causal Factors	**Certain**		**Probable**		**Possible**	
	Cases	%	Cases	%	Cases	%
Human causes	103	84%	17	14%	2	2%
Direct human causes	102	14%	17	14%	2	2%
Recognition errors	82	67%	16	13%	6	5%
Driver fail observe, stop sign	24	20%	0	0%	1	1%

Causal Factors	Certain Cases	%	Probable Cases	%	Possible Cases	%
Recognition delays--reason identified	71	58%	15	12%	3	2%
Inattention	18	15%	4	3%	5	4%
Road signs, signals	14	11%	1	1%	2	2%
Improper lookout	48	39%	13	11%	1	1%
Entering traffic from street	43	35%	12	10%	1	1%
Recognition delays -- other, unknown reasons	6	5%	5	4%	6	5%
Decision errors	36	30%	26	21%	19	16%
False assumption	10	8%	9	7%	2	2%
Improper maneuver	10	8%	3	2%	4	3%
Improper driving technique	9	7%	5	4%	2	2%
Driving technique - Inadequately defensive	3	2%	17	14%	11	9%
Adjusted car's speed	1	1%	6	5%	8	7%
Inadequate signal	1	1%	5	4%	7	6%
Improper evasive action	3	2%	10	8%	4	3%
Indirect human causes	3	2%	7	6%	20	16%
Mental or emotional	2	2%	3	2%	9	7%
Environmental causes	8	7%	29	24%	15	12%
Environmental causes-except slick roads	7	6%	27	22%	13	11%
Highway related causes	7	6%	26	21%	9	7%
View obstructions	6	5%	23	19%	7	6%
Roadside structures and growth	2	2%	17	14%	0	0%

Perpendicular Crossing Path Crashes (98 cases)

Crash causes at more detailed levels for PCP crashes are provided below. Human factors were cited as certain, or probable causes in 96 of the 98 cases. Recognition errors were most frequently cited (79 cases; 81 percent). Ten vehicular factors were indicated for PCP crashes; 8 of those are cited as possible causes.

Causal Factors	Certain cases	Certain %	Probable cases	Probable %	Possible cases	Possible %
Vehicular factors	2	2%	0	0%	**8**	**8%**
Human causes	81	83%	15	15%	2	2%
Direct human causes	81	83%	15	15%	2	2%
Recognition errors	65	66%	14	14%	6	6%
Driver fail observe, stop sign	23	23%	0	0%	1	1%
Recognition delays-reason identified	54	55%	14	14%	3	3%
Inattention	17	17%	4	4%	4	4%
Road signs, signals	14	14%	1	1%	1	1%
Event in car--e.g., sudden noise	6	6%	4	4%	0	0%
Improper lookout	33	34%	11	11%	1	1%
Entering traffic from street	33	34%	11	11%	1	1%
Recognition delays -- other, unknown reasons	6’	6%	4	4%	5	5%
Decision errors	23	23%	23	23%	16	16%
False assumption	6	6%	7	7%	1	1%
Improper driving technique	5	5%	4	4%	2	2%
Driving technique - Inadequately defensive	3	3%	13	13%	7	7%
Adjusted car’s speed	1	1%	3	3%	6	6%
Cautious, speed adherence	1	1%	8	8%	1	1%
Excessive speed	6	6%	1	1%	3	3%
Improper evasive action	3	3%	9	9%	2	2%
Indirect human causes	2	2%	6	6%	16	16%
Physical or Physiological	1	1%	2	2%	7	7%
Mental or emotional	1	l%	2	2%	9	9%
Environmental causes	5	5%	27	28%	13	13%
Environmental causes-except slick roads	5	5%	25	26%	11	11%
Highway related causes	5	5%	24	24%	7	7%
View obstructions	4	4%	22	22%	7	7%
Roadside structures and growth	2	2%	16	16%	0	0%

Left Turn Across Path Crashes (8 cases)

The crash causes at more detail levels for the LTAP crashes provided below. Human factors were cited as certain, probable or possible causes in all eight cases (100 percent). Recognition errors are most frequently cited as certain or probable causes (5 cases; 62 percent). No vehicular factors are indicated for LTAP crashes.

Causal Factor	Certain		Probable		Possible	
	cases	%	cases	%	cases	%
Human causes	7	88%	1	13%	0	0%
Direct human causes	7	88%	1	13%	0	0%
Recognition errors	5	63%	0	0%	0	0%
Driver fail observe, stop sign	1	13%	0	0%	0	0%
Recognition delays--reason identified	5	63%	0	0%	0	0%
Inattention	0	0%	0	0%	1	13%
Road signs, signals	0	0%	0	0%	1	13%
Event in car-e.g., sudden noise	1	13%	0	0%	0	0%
Internal distraction	1	13%	0	0%	0	0%
Improper lookout	4	50%	0	0%	0	0%
Entering traffic from street	3	38%	0	0%	0	0%
Improper lookout - other	1	13%	0	0%	0	0%
Recognition delays -- other, unknown reasons	0	0%	0	0%	1	13%
Cross-flowing traffic	0	0%	0	0%	1	13%
Decision errors	3	38%	2	25%	2	25%
Misjudgment distance, closure rate	1	13%	0	0%	0	0%
False assumption	2	25%	2	25%	1	13%
Assume driver required stop, yield	1	13%	1	13%	0	0%
Assume driver would stop, yield	1	13%	0	0%	0	0%
False assumption - other	0	0%	1	13%	1	13%
Improper maneuver	0	0%	0	0%	1	13%
Improper driving technique	1	13%	0	0%	0	0%
Driving technique - Inadequately defensive	0	0%	2	25%	1	13%
Adjusted car's speed	0	0%	1	13%	1	13%
Cautious, speed adherence	0	0%	1	13%	0	0%
Inadequate signal	0	0%	1	13%	0	0%
Failure to use horn to warn	0	0%	1	13%	0	0%

Causal Factor	**Certain**		**Probable**		**Possible**	
	cases	**%**	**cases**	**%**	**cases**	**%**
Indirect human causes	**0**	**0%**	1	13%	2	25%
Physical or Physiological	**0**	**-0%**	0	0%	1	13%
Reduced vision	**0**	**0%**	0	0%	1	13%
Mental or emotional	**0**	**0%**	1	13%	0	0%
Driver "in hurry"	**0**	**0%**	1	13%	0	0%
Experience or Exposure	**0**	**0%**	0	0%	1	13%
Road, area unfamiliarity	**0**	**0%**	0	0%	1	13%
Environmental causes,	1	13%	1	13%	0	0%
Environmental causes-except slick roads	1	13%	1	13%	0	0%
Highway related causes	1	13%	1	13%	0	0%
View obstructions	1	13%	0	0%	0	0%
Stopped traffic	1	13%	0	0%	0	0%
Design problems	0	0%	2	25%	0	0%
Intersection design problems	0	0%	2	25%	0	0%
Ambience related causes	0	0%	0	0%	1	13%
Vision limitation	0	0%	0	0%	1	13%
Glare from sun	0	0%	0	0%	1	13%

Readers interested in causal factors involved in ICP crashes are also referred to the three Volpe Center problem definition/countermeasure assessment reports on Signalized Intersection/Straight Crossing Path Crashes (Tijerina et al, 1994), Unsignalized Intersection/Straight Crossing Path Crashes (Chovan et al, 1994a), and Left Turn Across Path Crashes (Chovan et al, 1994b).

APPENDIX A: PROBLEM SIZE AND DESCRIPTIVE STATISTICS

Target crash problem size assessments and descriptive statistics are based on counts and estimates accessed from available crash datafiles. For target crash problem size assessment, raw statistics are typically manipulated statistically to provide more usable and comprehensive problem size statistics. This appendix describes the datafiles accessed and the statistical measures that are derived from those estimates.

A.1 Crash Datafiles and Other Information Sources Accessed

The following data sources have been used. to estimate intersection crossing path crash and "all crashes" problem size and descriptive statistics:

A.l.l NHTSA General Estimates System (GES)

GES, one of the two major subsystems of the current National Accident Sampling System (NASS), is a survey of approximately 43,000 Police Accident Reports (PARS) from 60 geographic sites (jurisdictions) in the U.S. The PAR is the only source of data for GES. A data coder reviews the PAR and then codes the GES variables. GES is a comprehensive crash data file, addressing all vehicle and crash types and crash severities. Since the GES sample size is moderate (rather than large like the Crash Avoidance Research Data file; CARDfile), its reliability is greatest when relatively large crash problems are examined. For low-frequency crashes, the reliability of GES data may be questionable.

Crashes and injuries presented in this report have generally been rounded to nearest 1,000. As a result of rounding, some table entries may not sum to the posted totals. In addition, percentage estimates and the derived statistics in the tables were calculated before numbers were rounded.

Appendix C of this report is excerpted from a publication entitled "Technical Note for 1989, 1990, 1991 National Accident Sampling System General Estimates System" (DOT HS 807 796). Appendix C provides tables for estimating the standard errors of GES estimates. Although point estimates are provided in this report, it is. critical to realize that each GES estimate (whether of crashes, vehicles, or injuries) has an associated sampling error. The tables in Appendix C can be used to derive, through interpolation, the standard error of each GES estimate (or the standard error of statistics derived from GES estimates). Estimation reliability improves with increasing crash/vehicle/injury numbers; i.e., standard errors are smaller, relative to the estimate, for larger estimates.

A.1.2 NHTSA Fatal Accident Reporting System (FARS)

FARS is a census of data on all fatal crashes in the U.S. FARS contains descriptions of each fatal crash using 90 coded variables characterizing the accident, vehicle, and people involved. The PAR is the primary source of information on each fatal crash, although supplementary information is also used, such as medical reports on blood alcohol content. FARS statistics are crash/vehicle/fatality counts, not estimates. There is no associated standard error.

A.1.3 NHTSA NASS Continuous Sampling Subsystem (CSS)

The NASS Continuous Sampling Subsystem (CSS) was a nationwide accident data collection program sponsored by NHTSA. During the 1982-86 timeframe, NASS CSS data were collected from 50 sites selected to be representative of the continental U.S. NASS crash investigations were regarded as "Level II" investigations; i.e., they were far more in-depth than police accident reports (Level I), but were not comprehensive in-depth investigations (Level III). NASS investigations emphasized crashworthiness and occupant protection concerns; but also collected useful information relating to crash causation. Approximately 12,000 cases were investigated each year. The sampling error problem discussed above for GES is even greater for NASS statistics. Therefore, the CSS is generally not a good source of statistics relating to problem size of low-frequency crash types. NASS CSS data are not cited in this report.

A.l.4 NHTSA NASS Crashworthiness Data System (CDS)

The NASS CDS is a nationally-representative sample of police-reported crashes occurring throughout the U.S. involving at least one towed passenger car, light truck; van or utility vehicle. CDS was implemented in 1988'as a follow,-on to the NASS CSS (see above). CDS investigates about 5,000 crashes annually, proving detailed information on injuries and injury mechanisms. Consistent with its specific emphasis on crashworthiness, CDS provides more detailed information than CSS on vehicle damage and associated occupant injuries, but less information on accident circumstances (e.g., environmental conditions, collision scenarios). (Note, however, that CDS has added new variables on pre-crash events beginning with the 1992 data collection year).

CDS data are not cited in this report, but have been used as part of the related intersection crossing path "problem definition/countermeasure technology assessment" program described in Chapter 1.

A.1.5 Tri-Level Study of the Causes of Traffic Accidents

The Indiana Tri-Level Study (Treat et al, 1979a), was an in-depth study of crash causes conducted in the late 1970s by Indiana University. The term "Tri-Level" referred to the collection of three qualitatively-different types of data: mass data (e.g., driver license data including past violations), on-scene crash data (e.g., driver interviews, photography of skidmarks and vehicle fmal rest positions), and follow-up reconstructions, which included a consideration of human, vehicle, and environmental factors contributing to the crash. Although the study sample size was small (i.e., 420 in-depth cases) and geographically limited (i.e., rural Indiana), it employed an elaborate and insightful taxonomy of crash causal factors. The recent addition of CARDfile accident type codes to the Indiana sample by NHTSA has made it possible to use the Tri-Level fmdings on causal factors in conjunction with CARDfile and other databases. In this report, the Tri-Level data are not used to quantify problem sizes, but are used to provide insights on causes of crash types.

A.1.6 FHWA Statistics on Registration, Mileage, and Driver Licenses

Statistics on vehicle registrations and vehicle miles traveled (VMT) were obtained from the Federal Highway Administration (FHWA) publication Highway Statistics 1991 (FHWA-PL-92-025). Table VM-1 of this publication provides summary statistics on registrations and VMT by vehicle type. Registration statistics are used to calculate annual likelihoods of involvement and probabilities of involvement over vehicle life. VMT statistics are used to calculate rates of crash involvement. In addition, driver age and sex involvement patterns were calculated for 1990 using two different statistical metrics: rate (per 100 million VMT) and likelihood (involvements per 1,000 registered drivers). The number of licensed drivers for various age and sex groups was obtained from Table DL-22 of Highway Statistics 1990 (FHWA-PL-9l-003).

A.2 Statistical Measures of Problem Size

Target crash problem size assessments are intended to estimate the total number of crashes, fatalities, injuries, and delay hours resulting from target crashes. This includes all fatalities/injuries sustained in all vehicles (and non-vehicles) involved in the target crash. For example, for the "left turning combination-unit truck", the fatality/injury counts include both the occupants of the truck and any other involved vehicles and non-motorists (e.g., pedestrians).

For most target crash types (including intersection crossing path crashes), problem size estimates are provided for three vehicle type categories: all vehicle types combined, passenger vehicles (automobiles, light trucks, vans), and combination-unit trucks. In addition, for intersection crossing path crash problem size statistics are provided for medium-heavy single-unit trucks and motorcycles. The following statistical measures of problem size are derived and reported in the problem size assessments:

1. Annual Number of Police-Reported (PR) Target Crashes — ***Accessed from GES***

- **Injury Crashes** — ***Includes fatal crashes***

- **Property-Damage Only (PDO)** — ***Includes crashes of unknown severity***

Explanation: The annual number of PR crashes is estimated from one of several crash datafiles. The selection of which datafile to use depends primarily on the "match" between coded data element definitions and the target crash type under consideration. For intersection crossing path crashes, the estimate is from the 1991 GES. As noted above, GES estimates have an associated standard error of estimate. These are provided for major statistical estimates (e.g., total number of target crashes), and the reader may determine the approximate standard error for any GES estimate contained in this report by using the tables in Appendix C.

2. Annual Number of Vehicle Involvements — ***Accessed from GES***

Explanation: This is the number of vehicles of this type involved in target crashes. For example, an ICP crash involving two passenger vehicles which is counted as one crash but two passenger vehicle involvements.

3. Annual Number of Injuries in PR Crashes — ***Accessed from GES***
Sum = K+A+B+C

- **KABCO Scheme:** — ***Severity scheme used in GES and most other dataflles (e.g.,*** FARS)
  - **Fatality (K)**
  - **Incapacitating Injury (A)**
  - **Nonincapacitating Injury (B)**
  - **Possible Injury (C); includes "injured, unknown severity"**
  - **No Injury (0); includes other unknowns**

Explanation For intersection crossing path crashes, injuries are assessed based on GES data. Totals include all injuries (i.e., K+A+B+C injuries in GES) resulting from target crashes (all involved vehicles/non-vehicles). Because of the relatively small number of fatalities (and resulting unreliability of fatality estimates), "K" and "A" injury estimates are aggregated. As noted previously, GES estimates have an associated standard error of estimate. These are provided for major statistical estimates (e.g., total number of injuries), and the reader may determine the approximate standard error for any GES estimate contained in this report by using the tables in Appendix C.

4. Annual Total Fatal Crash Equivalents (FCEs)

Total Fatal Crash Equivalents (per GES crash severity), whereby fatal crashes are assigned a value of 1.0, and non-fatal crashes are assigned relative severity values between 0 and 1.

Explanation: "Harm" is an abstract concept referring to the total societal loss (e.g., deaths, injuries, property damage) associated with crashes (Malliaris et al, 1982). Here, the statistic "fatal crash equivalent" (FCE), which is similar to Harm, is used to capture total societal loss. FCE is derived from target crash severities. Crash severity is measured in terms of the most severe police-reported crash injury (the widely-used "KABCO" scheme). The KABCO value is then converted to an FCE value so that crashes of different severities can be measured and assessed on a single ratio scale. Using the FCE scale, two different crash types (e.g., a high severity/low frequency type with a low severity/high frequency type) can be compared directly in terms of their total effect on society.

Table A-l (based on Miller, 1991) shows how the "fatal crash equivalent" scale is derived from police: reported crash severity ("KABCO"). Note that the use of FCEs cancels out the dollar values so that only *relative* values assigned to crashes of various severities are factored into the severity reduction calculations. Note also the sharply increasing "Willingness to Pay" value of crashes with increasing KABCO severity, and thus the sharply increasing FCE value. For example, in the analysis, one "A" crash will carry the same weight as approximately nine "C" crashes. Thus, the more severe crashes will tend to "drive" the cumulative "fatal crash equivalents" values.

For consistency, unless otherwise noted, the coded GE8 fatal and non-fatal crash severity (i.e. A-incapacitating, B-Non-incapacitating, C-Possible injury, O-No injury and K-Fatality) are used to determine total FCEs for all crashes and for ICP crashes. Final values of total FCEs are rounded to nearest unit.

TABLE A-l: CONVERSION TABLE FOR DERIVING "FATAL CRASH EQUIVALENTS" FROM POLICEREPORTED CRASH SEVERITY (from Miller, 1991)

"FATAL EQUIVALENTS" CRASH SEVERITY SCALE		
Crash Severity (Most severely-injured occupant, KABCO)	**Comprehensive $ Value Per Crash (1988 Dollars, 4% Discount Rate)**	**Fatal Crash** Equivalent ("FCE")
Fatality (K,4)	$2,722,548	1.0000
Incapacitating (A,3)	$228,568	0.0840
Non-incapacitating (B,2)	$48,333	0.0178
Possible (C,1)	$25,228	0.0093
No Injury (O,0)	$4,489	0.0016
Unreported	$4,144	0.0015

5. Percentage of All Police-Reported (PR) Crashes — ***Percentage of the total number of crashes for subject vehicle type) represented by this crash type***

Percentage of All Crash FCEs — ***Percentage of the total crash fatal crash equivalents for subject vehicle type represented by this crash type***

Explanation: These statistics relate this crash type to the overall traffic crash problem for the vehicle type in question. Comparison of the three percentages provides one measure of crash severity relative to crashes in general. For example, ICP crashes represent a high percentage of crashes, and crash FCEs.

Crashes are assigned FCE values with regard to severity (most severely injured person) only and regardless of the number of vehicles involved, crash type, or vehicle type. Thus the measure may be somewhat unreliable for "exceptional" crash types such as combination-unit truck crashes.

6. Involvement Rate Per 100 Million Vehicle Miles Traveled — ***Calculated from target PR crashes and VMT***

Explanation: Involvement rates per 100 million vehicle miles traveled are calculated from annual target crash estimates and annual VMT estimates (**see Table A-2** below). When the problem is defined for a particular vehicle role (e.g., lefi turning vehicle in a left turn across path crash or backing vehicle in the backing crashes), the involvement rate is based on involvements *in that* role only. It may then be termed the **subject vehicle;** i.e., the crash-involved vehicle that, if equipped with the countermeasure, could potentially have avoided the crash. Other involvement rates provided do not specify a vehicle role; these include involvements in all crashes and involvements in intersection crossing path crashes. For each involvement rate provided, this report will specify whether the rate is based on "subject vehicle involvements only" or "all involvements." Note that the passenger vehicle mileage data in Table A-2 includes both passenger cars *and* 2-axle, 4-tire single-unit trucks (i.e., pickup and vans). The single-unit truck data shown does not include 2-axle, 4-tire trucks and thus corresponds to the "Other Single-Unit Trucks" column of Table VM-1 of *Highway Statistics.*

TABLE A-2: 1990 AND 1991 VEHICLE MILES TRAVELED (IN MILLIONS) FOR VARIOUS VEHICLE CATEGORIES
***(Source: Highway Statistics, 1991,* FHWA, Table VM-1)**

ANNUAL VEHICLE MILES TRAVELED (VMT, in millions)		
Vehicle Category:	**1990**	**1991**
All Vehicle Types	2,147,501	2,172,214
Passenger Vehicles	1,982,197	2,006,553
Combination-Unit Trucks	**96,482**	**96,949**
Single-Unit Trucks	53,522	53,791
Motorcycles	**9,557**	**'9,178**

Average annual miles traveled per vehicle in 1991 were as follows for these five vehicle type categories:

All vehicle types: 11,281 miles
Passenger vehicles: 11,032 miles
Combination-u& trucks: 60,429 miles
Single-unit trucks: 12,656 miles.
Motorcycles: 2,197 miles.

7. Annual "Likelihood" of Involvement (Annual Involvements Per 1,000 Vehicles)

Calculated from target PR crashes and vehicle registrations

Explanation: This statistic provides a useful annual perspective on "likelihood" of involvement in target crashes (as the subject vehicle). It is determined by the following formula:

$$\text{Annual Involvements Per 1,000 Vehicles} = \frac{\text{1,000 X Target Crashes}}{\text{\# Registered Vehicles}}$$

Like involvement rate per 100 million VMT, this statistic may be calculated based on all involvements (e.g., all crashes, all intersection crossing path crashes) or based upon a particular vehicle role in the crash (e.g., left turning vehicle in a left turn across path crash). Note that the passenger vehicle registration data in Table A-3 includes both passenger cars *and* 2-axle, 4-tire single-unit trucks (i.e., pickup and vans). The single-unit truck data shown does *not* include 2-axle, 4-tire trucks and thus corresponds to the "Other Single-Unit Trucks" column of Table VM-1 of *Highway Statistics.*

TABLE A-3: 1990 AND 1991 VEHICLE REGISTRATIONS FOR VARIOUS VEHICLE CATEGORIES *(Source: Highway Statistics, 1991*, FHWA, Table VM-1)

VEHICLE REGISTRATIONS		
Vehicle Category:	**1990**	**1991**
All Vehicle Types	192,914,924	192,548,972
Passenger Vehicles	182,201,372.	181,885,983
Combina'tion-Uni Trucks	1.607.183	1.604.335
Single-Unit Trucks	4,219,920	**4,250,338**
Motorcycles	**4,259,462**	4,177,037

8. Expected Number of Involvements During Vehicle Life

Calculated from target PR crashes, vehicle registrations, and average vehicle life

Explanation: The expected number of crash subtype involvements during the vehicle life is determined by the following formula:

$$\text{Expected Number} = \frac{\text{Annual Involvements in Target Crashes X Average Vehicle Life}}{\text{\# Registered Vehicles}}$$

Like the previous two statistics, this statistic may be calculated based on all involvements (e.g., all crashes, all intersection crossing path crashes) or based upon a particular vehicle role in the crash (e.g., left turning in a left turn across path crash). For specific crash types (and especially for specific vehicle roles in specific crash types), this value is typically low; i.e., less than 0.2. For such low values, the statistic can be treated as an approximate *probability* estimate to answer the question, "What is the probability that a vehicle will "need" the subject countermeasure during its life?" This statistic can also be used to derive per-vehicle-produced target crash "value" (average crash value times expected number during vehicle life).

Statistical constants used to make these calculations include the following:

- Vehicle registrations: same values as used above (Item 7)
- Vehicle life, all vehicle types combined: 13.13 years. This value was derived from Miaou (1990) based on a weighted average of the average operational lives of passenger cars (11.77 years) and "all trucks" (15.84 years). The relative weights for calculating the weighted mean were based on 5-year averages (1987-91) of U.S. retail sales for these two vehicle categories (MVMA, 1992).
- Vehicle life, passenger vehicles: 13.01 years. This value was derived from Miaou (1990) based on a weighted average of the average operational lives of passenger cars (11.77 years) and light trucks (16.05 years). The relative weights for calculating the weighted mean were based on 5-year averages (1987-91) of U.S. retail vehicle sales for these two vehicle categories (MVMA, 1992).
- Vehicle life, medium/heavy trucks (both combination-unit and single-unit): 14.70 years (Miaou, 1990). Miaou's data did not separate combination-unit and single-unit trucks. A possible future refinement of this analysis would employ separate life values for these two vehicle types.
- Vehicle life, motorcycles: 7.5 (estimated from vehicle age data in Motorcycle Statistical Annual 1992).

Note also that Miaou's estimated vehicle life values are based on analyses of the registration period from 1978 to 1988 (or 1989). Miaou's data show a trend toward longer vehicle lives for more recent time periods (e.g., 1978-88 versus 1966-73). If this trend continues, vehicles purchased now and in the coming decade will have somewhat longer operational lives than the values used here. A trend toward longer vehicle life is corroborated by R. L. Polk and Company data, cited in Davis and Morris (1992), showing that the average age of both automobiles and trucks in use has increased steadily over the past 20 years.

9. Estimated Annual Number of Non-Police-Reported (NPR) Target Crashes

Estimated per algorithm described below

- **Injury Crashes** — ***Estimated to be 11. 8% of NPR target crashes***
- **Property-Damage Only (PDO)** — ***Estimated to be 88.2 % of NPR target crashes***

Explanation: The estimate of Non-Police Reported (NPR) crashes is based on the known number of PR PDO crashes and the estimated total number of NPR crashes nationally. Specifically, the following equation is used to estimate target NPR crashes:

$$\text{Target NPR Crashes} = \frac{\text{Target PR PDO Crashes X All NPR Crashes}}{\text{All PR PDO Crashes}}$$

Statistical constants used to make these calculations include the following:

- All NPR crashes, all vehicle types: (7.77 million (Miller, 1991)
- All NPR crashes, passenger vehicles: 7.66 million (estimated from Miller, 1991, and proportion of passenger vehicle involvements in PR PDO crashes).
- All NPR crashes, combination-unit trucks: 0.29 million (estimated from Miller, 1991, and proportion of combination-unit truck involvements in PR PDO crashes).
- All NPR crashes, single-unit trucks: 0.19 million (estimated from Miller, 1991, and proportion of single-unit truck involvements in PR PDO crashes).
- Percentage of NPR crashes with injuries: 11.8 percent (Greenblatt et al, 1981; same value used for all vehicle type categories).

NPR crash problem size estimations resulting from the above algorithm should not be accepted uncritically. The algorithm assumes proportionality between NPR crashes and PR PDO crashes, which are generally more severe than NPR crashes. The algorithm likely overestimates NPR crashes for crash types that are often serious and thus not likely to go unreported. Examples include head-on crashes and rollovers. On the other hand, the algorithm likely underestimates NPR crashes for crash types that are usually minor in severity and thus less likely to be reported. Examples include rear-end crashes and backing crashes. Single vehicle crashes is general may be less likely to be reported to police, since there is no “not at fault” driver with an incentive to report the crash to police to ensure prosecution and/or liability compensation. As this program progresses, it may be possible to develop a more sophisticated NPR crash estimation algorithm or to incorporate findings from other sources (e.g., insurance claim data) to better estimate NPR crashes.

Miller (1991) estimated the average comprehensive value of unreported crashes to be $4,144, corresponding to a fatal crash equivalent (“FCE”) value of 0.0015. However, the FCE associated with NPR crashes is not incorporated into the FCE estimates of this report.

10. Estimated Total Annual Target Crashes	***Total target crashes (UDH + Non-UDH)***
• Urban-Divided Highway (UDH)	***Total PR + NPR***
- PR	***Accessed and imputed from datafile***
- NPR	***Estimated based on PR UDH target crashes***
• Non-Urban Divided Highway	***Total PR + NPR***
- PR	***Accessed and imputed from datafile***
- NPR	***Estimated based on PR Non-UDH target crashes***

Explanation: The UDH/non-UDH breakout is used to estimate delay caused by target crashes (see item #11 below). Target UDH NPR values are estimated from PR values as follows:

$$\text{Target UDH NPR Crashes} = \frac{\text{Target UDH PR Crashes X Target NPR Crashes}}{\text{Target PR Crashes}}$$

GES classifies its geographic Primary Sampling Units (PSUs) using a "Percent Rural" scale based on 1980 U.S. Census data (not Federal Roadway classification). In GES there are 11 urban/rural categories: Urban, 10 percent Rural, 20 percent Rural, etc. Within a PSU that is part urban and part rural, specific crashes cannot be identified as "urban" or "rural." Disaggregated "urban" and "rural" crash estimates are obtained by an imputation process, as follows:

- 0% of "Urban" crashes are counted as "rural."
- 10% of "10% of Area is Rural" crashes are counted as "rural."
- 20% of "20% of Area is Rural" crashes are counted as "rural."; etc.

This tabulation is performed separately for divided highway and "other" crashes to obtain two estimates for PR crashes: UDH and Non-UDH (i.e., all other). Then the NPR estimates are generated based on the PR estimates.

The PR and NPR breakouts for UDH and Non-UDH crashes are not shown in the crash problem size tables, but are used to estimate vehicle-hours of delay (see below).

The urban vs. rural disaggregation provided by the GES "Percent Rural" variable should be regarded as a rough estimate. Since this variable is determined at the GES PSU level, standard errors for these estimates are based on a sample size of 60 (the number of PSUs) not 43,000 (the number of crashes). The resulting relative errors for these estimates (standards error divided by the estimate) range from 3 to 5 times as great as the relative errors given in Appendix C.

11. Estimated Annual Vehicle-Hours of Crash-Caused Delay — *Estimated from calculations based on UDH vs. Non-UDH breakout*

Percent of All Crash-Caused Delay — *Delay caused by the target crash type as a percentage of all crash-caused delay (estimated here as 450.2 million vehicle hours for 1991).*

Explanation: Crash-caused congestion (delay) is strongly related to crash location and severity. In particular, UDH crashes cause far greater delay per crash than do non-UDH crashes. The following formula is used to estimate total vehicle-hours of delay caused by target crashes:

$$\begin{aligned}\text{Total Vehicle-Hours Delay} = {} & 300 \text{ X PR UDH Target Crashes} \\ & + 100 \text{ X NPR UDH Target Crashes} \\ & + 5 \text{ X PR Non-UDH Target Crashes} \\ & + 1 \text{ X NPR Non-UDH Target Crashes}\end{aligned}$$

The above co-efficients are working estimates based on several studies; e.g., Cambridge Systematics, 1990; Grenzeback et al, 1990. Using the above algorithm, the annual total crash-caused vehicle-hours of delay is estimated to be 450.2 million vehicle-hours for 1991. This value is used to calculate percentages of total crash-caused delay for specific crash types, including those for specific vehicle types. This percentage is intended to provide a sense of how much prevention of this crash type would affect crash-caused roadway congestion.

Crash-caused delay estimations resulting from the above algorithm should not be accepted uncritically. The algorithm assumes that delay is a function of just two factors:, crash location and crash severity. Other relevant factors (e.g., involved vehicle types, time of crash, weather conditions) are not incorporated at this time. Moreover, certain crash types are likely to cause greater lane blockage or more lengthy delays due to vehicle extrication efforts. For example, head-on crashes are likely to block multiple lanes, and rollover crashes are likely to require extra time for vehicle extrication. As this program progresses, it may be possible to develop a more sophisticated delay estimation algorithm to account for some of these additional factors.

A planned upgrade to the delay estimation algorithm is to use larger average delay values for crashes involving heavy trucks. Currently, this document uses the same delay values for heavy trucks as for other vehicle types. This is known to yield an underestimate of delay caused by truck crashes. Bowman and Hummer (1989) estimated the average delay caused by truck urban freeway crashes to be 914 vehicle-hours. They cited a study by Teal (1988) that estimated the value to be 1,179 vehicle-hours. The median estimate of these two studies is approximately 1,000 hours. Extending the urban freeway truck-car difference to all vehicle types, a better formula for estimating delay caused by truck crashes might be:

Total Vehicle-Hours Delay =		1,000	X	PR UDH Target Crashes
(Heavy Truck Crashes)	+	**300**	X	NPR UDH Target Crashes
	+	15	X	PR Non-UDH Target Crashes
	+	**3**	X	NPR Non-UDH Target Crashes

The above formula is likely to be more accurate for heavy truck crashes. Nevertheless, for simplicity, at present the same delay **estimation formula is used for all vehicle type categories.**

A.3 Descriptive Statistics

In addition to problem size assessment statistics, this document provides descriptive statistics relating to crash incidence. These are primarily univariate and bivariate (e.g., vehicle type category by other factor) distributions that characterize the component “subtypes” of the target crash type, conditions under which target crashes occur, and, when possible, statistics providing insights into the primary causes of crashes. The national crash databases described in Section A.2 provide very informative data on crash conditions and characteristics, but generally do not specify crash causes with sufficient precision and reliability to permit the identification of appropriate countermeasures or the estimation of countermeasure effectiveness. One important study, the Indiana Tri-Level Study (Treat et al, 1979a; see Section A. 1.6), does provide insightful data on crash causes, but is based on only 420 in-depth crashes occurring in rural Indiana. Its representativeness to current national crash problems is thus questionable. However, Indiana Tri-Level statistics are provided when there were a sufficient number of target crash cases to provide meaningful information on crash causes.

For the sake of brevity, only the most relevant statistical findings are provided in this report. Comprehensive statistical printouts of these data retrievals have been provided directly to NHTSA and contractor personnel studying the ICP crash problem.

A.4 Definitions of Vehicle Types

For most problem size data retrievals (including the intersection crossing path crash retrievals), three vehicle type categories are used:

- All vehicle types (combined)
- Passenger vehicles (automobiles, light trucks, light vans)
- Combination-unit trucks (generally tractor trailers or "bobtail" tractors)

In addition, for selected topics, crash data retrievals are presented for medium/heavy single-unit (straight) trucks and motorcycles.

In GES and FARS, discriminating combination-unit trucks from single-unit trucks (and both from light trucks) requires the use of two different vehicle variables: body type and vehicle trailering. The category "combination-unit truck" is considered to include all tractors (whether pulling a trailer or running bobtail) as well as other medium-heavy trucks that are known to be pulling a trailer. This includes a small number of trucks with single-unit designs that were in fact pulling a trailer at the time of the crash.

GES and FARS use the same element numbering scheme for the "trailering" variable (TRAILER in GES; TOW-VEH in FARS). The scheme is: 0 = no trailer; 1 = 1 trailer; 2 = 2 trailers; 3 = 3 or more trailers; 4 = pulling trailer(s), number unknown; 9 = unknown if pulling trailer.

Moreover, in GES there are a significant number of vehicles with unknown or partially-unknown body types (i.e. 49 = unknown light vehicle type; 69 = unknown truck type; and 99 = unknown body type). In the 1991 GES, for example, these totaled 54 percent of vehicles. This means that statistics on individual vehicle body types will underestimate involved vehicles of that type to the extent that vehicles of that type were coded as "unknown." To correct for. this effect, GES problem size statistics for specific body types use the GES variable Hotdeck Imputed Body Type (V51, BDYTVP-H). In the imputed body type variable, vehicles of unknown body type are distributed statistically across the known body types, thus correcting, as accurately as possible, the problem of the unknown vehicle types. The vehicle type unknown rate in FARS is low and has no significant impact on crash counts; thus, there are no "imputed" vehicle types in FARS.

Below is a summary of the definitions used and relevant caveats. For each GES statistic, the Hotdeck Imputed Body Type (V51, BDYTYP-H) variable is used for problem size assessment and the descriptive statistics.

GES Passenger Vehicle (Car/Lt.Trk/Van):

01 < Body Type < 49

GES Combination-Unit Truck:

Body Type = 60 (single-unit straight truck) & $1 \leq$ TRAILER ≤ 4
Body Type = 65 (truck-tractor, cab only or any number of trailers)
Body Type = 68 (unknown medium/heavy truck) & $1 \leq$ TRAILER ≤ 4
Body Type = 69 (unknown truck type) & $1 \leq$ TRAILER ≤ 4

GES Single-Unit Truck:

Body Type = 60 (single-unit straight truck) & TRAILER = 0 or 9 (unknown)
Body Type = 68 (unknown medium/heavy truck) & TRAILER = 0 or 9 (unknown)

GES Motorcycle:

$70 \leq$ Body Type ≤ 79

FARS Passenger Vehicle (Car/Lt.Trk/Van):

$01 \leq$ Body Type ≤ 49

FARS Combination-Unit Truck:

Body Type = 61 (single-unit straight truck, GVWR 10,000-19,500) & $1 \leq$ TOW_VEH ≤ 4
Body Type = 62 (single-unit straight truck, GVWR 19,500-26,000) & $1 \leq$ TOW_VEH ≤ 4
Body Type = 63 (single-unit straight truck, GVWR over 26,000) & $1 \leq$ TOW_VEH ≤ 4
Body Type = 64 (single-unit straight truck, GVWR unknown) & $1 \leq$ TOW_VEH ≤ 4
Body Type = 66 (truck-tractor; cab only or any number of trailers)
Body Type = 71 (unknown medium truck, GVWR 10,000-26,000) & $1 \leq$ TOW_VEH ≤ 4
Body Type = 72 (unknown heavy truck, GVWR over 26,000) & TOW_VEH > 0
Body Type = 78 (unknown medium/heavy truck) & TOW_VEH > 0
Body Type = 79 (unknown truck type) & $1 \leq$ TOW_VEH ≤ 4

FARS Single-Unit Truck:

Body Type = 61 (single-unit straight truck, GVWR 10,000-19,500) & TOW_VEH = 0 or 9
Body Type = 62 (single-unit straight truck, GVWR 19,500-26,000) & TOW_VEH = 0 or 9
Body Type = 63 (single-unit straight truck, GVWR over 26,000) & TOW_VEH = 0 or 9
Body Type = 64 (single-unit straight truck, GVWR unknown) & TOW_VEH = 0 or 9
Body Type = 71 (unknown medium truck, GVWR 10,000-26,000) & TOW_VEH = 0 or 9
Body Type = 72 (unknown heavy truck, GVWR over 26,000) & TOW_VEH = 0
Body Type = 78 (unknown medium/heavy truck) & TOW_VEH = 0

FARS Motorcycle:

$80 \leq$ Body Type ≤ 89

APPENDIXB: PROBLEM SIZE ASSESSMENT: ALL CRASHES

This chapter presents crash problem size assessment statistics for the “universe” of crashes. Primary estimates are provided based largely on 1991 GES and FARS data.

For each data source, estimates are provided for all vehicle types, crashes involving passenger vehicles (automobiles, light trucks, vans), and crashes involving combination-unit trucks, crashes involving medium/heavy single-unit trucks and crashes involving motorcycles. Note that the passenger vehicle, combination-unit truck, medium/heavy single-unit truck and motorcycle crash and injury counts do not sum to equal the “all vehicles” values. Some vehicle types (i.e., buses) are included in "all vehicles” but not either of the other two columns. Also, a crash (or injury/fatality occurring in a crash), for example, involving both a passenger vehicle and a combination-unit truck would be counted in both columns, but only once in the “all vehicles” column. This “double counting” would extend to the rate and likelihood statistics; a passenger vehicle/combination-unit truck crash would be counted in the numerators of both columns, but the associated denominators (VMT and registrations) would reflect only passenger vehicles and combination-unit trucks.

Appendix A described in detail the target crash problem size statistics used in this report and how they are derived. **Table B-l** summarizes key 1990 and 1991 statistical findings and associated estimates derived as described in Appendix A. Table B-l indicates that overall police-reported crashes, fatalities, non-fatal injuries and urban divided highway crashes (per the GES “Percent Rural” variable) decreased between 1990 and 1991. **Table B-2** provides more detailed 1991 statistics for all vehicles, passenger vehicles, combination-unit trucks, medium/heavy single-unit trucks and motorcycles.

Standard errors of estimate for 1991 GES-based statistics may be derived through interpolation of the values presented in the tables contained in Appendix, A.

TABLE B-l: SUMMARY OF KEY STATISTICS ANT.) ASSOCIATED ESTIMATES FOR ALL CRASHES, ALL VEHICLE TYPES

statistic	1990	1991
Police-Reported Crashes (GES)	6.46 million	6.11 million
Vehicles Involved in Police-Reported Crashes (GES)	11.3 million	10.7 million
Fatalities (FARS)	44,599	41,508
Non-Fatal Injuries in PR Crashes (GES)	3.33 million	3.10 million
Non-Police Reported Crashes (Miller, 1991)	7.77 million*	7.77 million*
Urban Divided Highway Crashes (PR+NPR; see Appendix A for Estimation Method)	2.23 million	2.22 million
Crash-Caused Vehicle-Hours Delay (PR+NPR; see Appendix A for Estimation Method)	460.2 million hours	450.2 million hours

* Same estimate used for 1990 and 1991 NPR crashes (from Miller, 1991)

In this appendix presenting statistics on all crash types combined, the involvement rate and "likelihood" statistics (i.e., involvement rate per 100 million VMT, annual involvements per 1,000 vehicles, and expected number of involvements over vehicle life) are based on all crash involvements, regardless of vehicle role. Note, statistics are based on subject vehicle involvements only. For any crash type, the subject vehicle is the crash-involved vehicle that, if equipped with the countermeasure, could potentially have prevented the crash (see Section A.2, Item 5). However, since the subject vehicle cannot be defined for all crash types combined, the involvement statistics in Table B-2 are based on all involvements, ***regardless of the vehicle's role.***

In comparing the crash experiences of the different vehicle types shown in Table B-2, motorcycles 'have the highest crash involvement rate (per 100 million vehicle miles traveled) and highest incidence of fatalities per crash. However, the most revealing statistics are those that contrast the passenger vehicle crash experience with that of combination-unit trucks. In 1991, combination-unit trucks had a crash involvement rate that was 40 percent of the passenger vehicle rate. In contrast, their likelihood of involvement in crashes (as shown by statistics on annual involvements per 1,000 vehicles and expected number of involvements during vehicle life) was 249 percent of the passenger vehicle likelihood.

This apparent paradox is due to the much greater crash exposure of trucks; i.e., their average annual vehicle miles traveled is approximately six times that of passenger vehicles. In addition, combination-unit truck crashes are more likely to be severe; in 1991 there were approximately 19.1 fatalities per 1,000 police-reported truck crashes, versus approximately. 6.3 fatalities per 1,000 police-reported passenger vehicle 'crashes. The greater likelihood of truck involvement in crashes, together with the greater average severity of these crashes, makes combination-unit trucks an attractive test bed for crash avoidance countermeasures.

TABLE B-2
PROBLEM SIZE ESTIMATE: ALL CRASHES
INVOLVED VEHICLE TYPES: ALL VEHICLES,
PASSENGER VEEIICLES, COMBINATION-UNIT TRUCKS AND SINGLE-UNIT TRUCKS

GES/FARS-Based Statistics (1991)		**All Vehicles**	**Passenger Vehicles**	**Combition-Unit -Trucks**	**Single-Unit Trucks**	**Motorcycle**
Annual # PR Crashes (GES)	Total:	6,110,OOO	5,966,000	190,008	130,000	103,000
	Injury:	2,037.000	1,981,000	45,000	34,000	79,000
	PDO:	4,073,000	3,985,000	146,000	96,000	25,000
Annual # Fatalities (FARS)		41,508	38,173	3,642	1.162	2,933
Ann. X PR injuries (GES)	Total:	3,130,000	3,059,000	66,000	49,000	93,000
	K"	33,000	32,000	3,000	1,000	1,000
	A:	442,000	425,000	14,000	7,000	25,000
	B:	879,000	846,000	19,000	13,009	42,000
	c:	1.775.000	1,757,OOO	30,000	28,000	24,000
Fatal crash Equivalents (FCEs)		84,399	81,017	3,843	1,705	3,793
Involvement Rate Per 100 Million VMT		493.1	508.6	204.4	244.2	1.135.4
Annual Involvements Per 1,000 Registered Vehicles		55.63	56.11	123.51	30.90	24.93
Expected # Involvements During Vehicle Life		0.7304	0.7299	1.8157	0.4543	0.1870
Estimated Annual # NPR Crashes	Total:	7.770,000	7.603.000	278,000	183.000	47,000
	Injury:	917000	897,000	33,000	22,000	6,000
	PDO:	6,853,000	6,706.OOO	245,000	161,000	41,000
Estimated Total Annual Crashes (PR + NPR)	Total:	13,880,OOO	13,569,000	468,000	313,000	150,080
	UDH:	2.223,000	2,180.000	144.000	51,000	18,000
	Non-UDH:	11,657,000	11.389,OOO	324,000	262.000	132.000
Crash-caused congestion (Delay)	Veh-Hours:	450.2 M	441.1 M	27.0 M	10.0 M	4.9

Legend:

A	Incapacitating Injuries	M	Million
B	Nonincapacitating Injuries	NPR	Non-Police Reported
C	Possible Injuries	PDO	Property Damage Only
FARS	Fatal Accident Reporting System	PR	Police Reported
FCE	Fatal Crash Equivalent	UDH	Urban Divided Highway
GES	General Estimates System	VMI	Vehicle Miles Travel
K	Fatality		

The statistic "Fatal Crash Equivalents" (FCEs) was defined in Appendix A (e.g. Table A-,1). The value of 84,398.7 FCEs shown in Table B-2 for all vehicles was derived from statistics on 1991 GES crash severity (various levels, fatal and non-fatal) as shown in Table B-3. Final value of total FCEs is rounded to the nearest unit.

TABLE B-3: FATAL CRASH EQUIVALENTS (FCEs) FOR ALL CRASHES, ALL VEHICLE TYPES

"FATAL CRASH EQUIVALENT"

Crash Severity	# of Crashes	FCE Value	Total FCEs
Fatality (K, 4)	**29,509**	**1.0000**	**29,509.0**
Incapacitating (A, 3)	327,046	0.0840	27,471.9
Non-incapacitating (B, 2)	620,214	0.0178	11,039.8
Possible Injury (C, 1)	1,060,375	0.0093	9,861.5
No injury (0, 0)	4,072,787	0.0016	6,516.5
All Crashes, All Vehicles	**6,109,931**		**84,398.7**

As noted in Appendix A, the statistics provided for non-police-reported (NPR) crashes, urban divided highway crashes (PR+NPR) and crash-caused delay are based on new estimation, techniques that have not been verified. Thus, they should be regarded as very rough estimates. Although these statistics are rough, they will be useful in comparing difficult-to-quantify aspects of the various crash types; i.e., the proportion of NPR crashes they represent and crash-caused traffic delay they cause.

In addition to the problem size assessment statistics presented in this appendix, various descriptive statistics of "all crashes" were derived and considered in relation to the SVRD crash statistics. A presentation of these statistics for "all crashes" is beyond the scope of this report. The reader is referred to the GES and FARS annual reports.

APPENDIX C: GENERALIZED ESTIMATED SAMPLING ERRORS FOR 1991 GES

This appendix presents tables for estimating sampling errors for 1991 GES estimates. These tables (and the narrative explanation below) are taken from the "Technical Note for 1989, 1990, 1991 National Accident Sampling System General Estimates System" (DOT HS 807 796, February, 1992).

The General Estimates System (GES) is based on a probability sample of approximately 43,000 motor vehicle police traffic accident reports selected on an annual basis. GES is nut a census of all 6.1 million police-reported crashes in the U.S. Consequently, GES estimates are subject to sampling errors, as well as nonsampling errors.

Sampling errors are the differences that can arise between results derived from a sample and those computed from observations of all units in the population being studied. Since GES data are derived from a probability sample, estimates of the sampling error can be made.

The tables provided in this appendix can be used to calculate confidence intervals about the GES estimates. Tables are provided for crash, vehicle, and people (e.g., number of injuries) estimates. The numbers in the tables represent estimates of one standard error. If all possible samples of PARS were selected (under the same conditions), then approximately 68 percent of the intervals from one standard error below the estimate to one standard error above the estimate would include the average of all possible samples. Thus, the interval between one standard error below the estimate and one standard error above the estimate constitutes a 68 percent confidence interval. An interval of two standard errors above and below the estimate is a 95 percent confidence interval.

The best method for calculating standard errors is to use the natural logarithmic function provided for each estimate type. However, linear interpolation may also be used. For example, from the crash (Table C-l) standard error values for 300,000 and 400,000, the standard error for 350,000 is approximated at 25,600. The 68 percent confidence interval for this estimate would be 350,000 + 25,600 or 324,400 to 375,600.

<u>TABLE C-1</u>:

1991 CRASH ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE)*	Estimate (x)	One Standard Error (SE)*
1,000	700	600,000	40,000
5,000	1,400	700,000	45,700
10,000	2,100	800,000	51,200
20,000	3,300	900,000	56,700
30,000	4,200	1,000,000	62,200
40,000	5,100	2,000,000	116,200
50,000	5,900	3,000,000	169,800
60,000	6,800	4,000,000	223,700
70,000	7,500	5,000,000	278,000
80,000	8,300	6,000,000	332,800
90,000	9,000	7,000,000	388,100
100,000	9,700	8,000,000	444,000
200,000	16,400	9,000,000	500,400
300,000	22,600	10,000,000	557,300
400,000	28,600	11,000,000	614,700
500,000	34,400	12,000,000	672,500

$$*SE=e^{\frac{a}{2}+\frac{b}{2}[\ln(x)]^2}, \text{where}$$
$$a=9.93401$$
$$b=0.06362$$

TABLE C-2:

1991 VEHICLE ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE)*	Estimate (x)	One Standard Error (SE)*
1,000	400	600,000	39,900
5,000	1,000	700,000	46,100
10,000	1,600	800,000	52,200
20,000	2,500	900,000	58,400
30,000	3,400	1,000,000	64,700
40,000	4,200	2,000,000	128,300
50,000	4,900	3,000,000	194,500
60,000	5,700	4,000,000	263,100
70,000	6,400	5,000,000	334,000
80,000	7,100	6,000,000	406,900
90,000	7,800	7,000,000	481,600
100,000	8,500	8,000,000	558,200
200,000	15,000	9,000,000	636,400
300,000	21,300	10,000,000	716,100
400,000	27,500	11,000,000	797,400
500,000	33,700	12,000,000	880,100

$$*SE=e^{\frac{a}{2}+\frac{b}{2}[\ln(x)]^2}, \text{where}$$
$$a=8.83524$$
$$b=0.06977$$

TABLE C-3:

1991 PERSON ESTIMATES AND STANDARD ERRORS

Estimate (x)	One Standard Error (SE)*	Estimates	One Standard Error (SE)*
1,000	400	600,000	34,800
5,000	1,000	700,000	40,100
10,000	1,500	800,000	45,300
20,000	2,400	900,000	50,600
30,000	3,100	1,000,000	55,800
40,000	3,900	2,000,000	108,800
50,000	4,500	3,000,000	163,200
60,000	5,200	4,000,000	219,100
70,000	5,800	5,000,000	276,400
80,000	6,500	6,000,000	335,000
90,000	7,100	7,000,000	394,900
100,000	7,700	8,000,000	455,900
200,000	13,400	9,000,000	518,100
300,000	18,900	10,000,000	581,300
400,000	24,300	11,000,000	645,500
500,000	29,600	12,000,000	710,600

APPENDIX D: REFERENCES

Bowman, B.L., and Hummer, J.E., 'Examination of Truck Accidents on Urban Freeways", Goodell-Grivas, Inc., FHWA-RD-89-201, 1989.

Cambridge Systematics, Incident Management Executive Summary, Trucking Research Institute, ATA Foundation, Inc., October, 1990.

Chovan, J., Tijerina, L., Pierowicz, J., and Hendricks, D., ***Analysis of Left Turn Across Path Crashes,*** Report for Volpe National Transportation Systems Center, Publication Number TBD, 1994.

Chovan, J., Tijerina, L., Pierowicz, J., and Hendricks, D., ***Analysis of Unsignalized Intersection Straight Crossing Paths Crashes,*** Report for Volpe National Transportation Systems Center, DOT HS 808 152, August, 1994.

Davis, ***S. C.,*** and Morris, M. D., ***Transportation Energy Data Book: Edition 12, Oak*** Ridge National Laboratory, ORNL-6710 (Edition 12 of ORNL-5198), March, 1992.

Federal Highway Administration. ***Highway Statistics*** 1990, Publication Number FHWA-PL-91-003.

Federal Highway Administration. ***Highway Statistics 1991,*** Publication Number FHWA-PL-92-025.

Greenblatt, J., Merrin, M.B., Morgan&in, D., Schwartz, S., ***National Accident Sampling System Nonreported Accident*** Survey, Westat, Inc., DOT HS 806 198, November, 1981.

Grenzeback, L.R. et al, "Urban Freeway Gridlock Study: Decreasing the Effects of Large Trucks on Peak-Period Urban Freeway Congestion", ***Transportation Research Record, No.*** 1256, Pp. 16-26, 1990.

Knipling, R.R., Wang, J.S., ***& Yin,*** H.M:, ***Rear-End Crashes: Problem Size Assessment and Statistical Description,*** NHTSA technical report, Publication Number DOT HS 807 994, May, 1993.

Lindley; 'J.A., "Urban Freeway Congestion: Quantification of the Problem and Effectiveness of Potential Solutions", ITE Journal. Institute for Transportation Engineers, 57, No. 1, Pp.27-32, January, 1987.

Malliaris, A.C., Hitchcock, R., and Hedlund, J., "A Search for Priorities in Crash Protection", Society of Automotive Engineers Technical Paper Number 820242, 1982.

Miaou, S.P., "Study of Vehicle Scrappage Rates," Oak Ridge National Laboratory, Oak Ridge, TN, August 1990.

Miller, T.R., Luchter, S., and Brinkman, C.P., "Crash Costs and Safety Investment", 32nd ***Annual Proceedings of the Association for the Advancement of Automotive Medicine,*** September, 1988.

Miller, T.R., et ***al., The Costs of Highway Crashes,*** Urban Institute, Contract No. DTFH61-85-C-00107, Report No. FHWA-RD-91-055, June, 1991.

Motor Vehicle Manufacturers Association. ***MVMA Motor Vehicle Facts & Figures '92,*** ISBN 0317050809, 1992.

Motorcycle Industry Council, ***Inc. Motorcycle Statistical Annual 1992.***

National Highway Traffic Safety Administration National Center for Statistics and Analysis. ***A Guide to Using the Fatal Accident Reporting System BAC Distribution Files,*** NHTSA Technical Report Number DOT HS 807 095, July 1986.

National Highway Traffic Safety Administration National Center for Statistics and Analysis. ***National Accident Sampling System Analytical User's Manual,*** 1982-86.

National Highway Traffic Safety Administration National Center for Statistics and Analysis. ***Fatal Accident Reporting System Coding and Validation Manual,*** 1990 and 1991.

National Highway Traffic Safety Administration National Center for Statistics and Analysis. ***General Estimates System Data Coding Manual,*** 1990 and 1991.

National Highway Traffic Safety Administration. ***Fatal Accident Reporting System 1991,*** NHTSA Technical Report Number DOT HS 807 954.

National 'Highway Traffic Safety Administration. ***Fatal Accident Reporting System 1991,*** NHT SA Technical Report Number DOT HS 807 954.

National Highway Traffic Safety Administration. ***General Estimates System 1990,*** NHTSA Technical Report Number DOT HS 807 781.

National Highway Traffic Safety Administration. ***General Estimates System*** 1991, NHTSA Technical Report.

National Highway Traffic Safety Administration National Center for Statistics and Analysis. "Technical Note for 1988, 1989, 1990 National Accident Sampling System General Estimates System", (DOT HS 807 796), February, 1992.

Pisarski, A.E., "Nationwide Personal Transportation Survey, Travel Behavior Issues in The 90's", Federal Highway Administration, Publication Number FHWA-PL-93-012, July 1992.

Teal, R.F., "Estimating the Full Economic Costs of Truck Incidents on Urban Freeways", for AAA Foundation for Traffic Safety, 1988.

Tijerina, L., Chovan, J., Pierowicz, J., and Hendricks, D., ***Analysis of Signalized Intersection Straight Crossing Paths Crashes,*** Report for Volpe National Transportation Systems Center, DOT HS 808 143, July 1994.

Treat, J.R. et al., "Tri-Level Study of the Causes of Traffic Accidents: Final Report Volume I: Causal Factor Tabulations and Assessments", Institute for Research in Public Safety, Indiana University, DOT HS 805 085, May 1979(a).

Treat, J.R. et ***al., Tri-Level Study of the Causes of Traffic Accidents: Final Report Volume II: Special Analyses,*** Institute for Research in Public Safety, Indiana University, DOT HS-805 ***085,*** May 1979(b).

Treat, J.R., and Romberg, R.A., ***Tri-Level Study: Modification; Task 1: Final Report on Potential Benefits of Various Improvements in Vehicle Systems in Preventing Accidents or Reducing Their Severity,*** Institute for Research in Public Safety, Indiana University, DOT HS-805 094, May 1979.

Wang, J.S. and Knipling, R.R., ***Backing Crashes: Problem Size Assessment and Statistical Description,*** NHTSA technical report, Publication Number DOT HS 808 074, January, 1994.

Wang, J.S. and Knipling, R.R., Lane ***Change/Merge Crashes: Problem Size Assessment and Statistical Description,*** NHTSA technical report, Publication Number DOT HS 808 075, January, 1994.

Wang, J.S. and Knipling, R.R., ***Single Vehicle Roadway Departue Crashes: Problem Size Assessment and Statistical Description,*** NHTSA technical report, Publication Number DOT. HS 808 113, March, 1994.