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13. ABSTRACT (Maximum 200 words)

This report examines contributing factors to single vehicle off-roadway, rear-end, and lane change crashes involving light vehicles (passenger cars, sport utility vehicles, vans, and pickup trucks). The analysis is based on crash data obtained from the National Automotive Sampling System's 1997-2000 Crashworthiness Data System (CDS) and 2000 General Estimates System (GES). Research on crash contributing factors was divided into three phases: phase one provides a comparison of CDS and GES contributing factor distributions; phase two examines crash severity in relation to contributing factors; and phase three determines contributing factors based on pre-crash scenarios. This report classifies crash severity into severe and less severe crashes based on whether or not the vehicle involved in a crash was towed from the scene due to damage. Results from phase one indicate that contributing factor distributions for the CDS and GES matched fairly closely; however, discrepancies were found for inattention and speeding. Phase two results found that contributing factors were similar in the majority of crash types regardless of the severity of the crash; however, the relative frequency of alcohol/drugs and sleepy/drowsy were found to be influenced by crash severity for single vehicle off-roadway and rear-end crash types. Phase three results showed that the contributing factors were influenced more by the critical event than the vehicle movement prior to the critical event in precrash scenarios leading to single vehicle off-roadway crashes.

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PREFACE

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

This report presents the results obtained for the analysis based on crash data obtained from the National Automotive Sampling System's 1997-2000 Crashworthiness Data System and 2000 General Estimates System crash databases.

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

The authors acknowledge the technical contribution of Dr. David L. Smith of NHTSA. Also acknowledged are Noble Bowie, Nancy Bondy, August Burgett, Joseph Kanianthra, Rose McMurray, Gina Thompson, and Stephen Wood of NHTSA and Dan Cohen of Mitretek for reviewing the report and providing valuable comments.

METRIC/ENGLISH CONVERSION FACTORS

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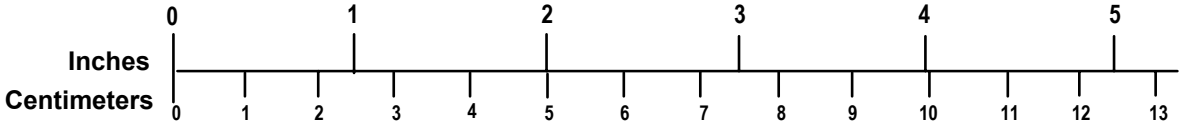

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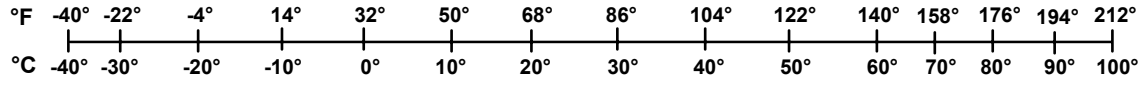

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF FIGURES

LIST OF TABLES

Table **Page**

LIST OF ACRONYMS

AEC	Adverse Environmental Conditions
BK	Backing
CDS	Crashworthiness Data System
CF	Contributing Factor
CL	Control Loss
DOT	Department of Transportation
GES	General Estimates System
ICP	Intersection Crossing Path
IRPS	Institute for Research in Public Safety
IVI	Intelligent Vehicle Initiative
LC	Lane Change
LCM	Lane Change/Merge
LTAP	Left Turn Across Path
LVD	Lead Vehicle Decelerating
LVM	Lead Vehicle Moving
LVS	Lead Vehicle Stopped
NASS	National Automotive Sampling System
NHTSA	National Highway Traffic Safety Administration
OD	Opposite Direction
PAR	Police Accident Report
PDO	Property Damage Only
POV	Principal Other Vehicle
PR	Police-reported
RE	Rear-End
RV	Reduced Visibility
SI/SCP	Signalized Intersection, Straight Crossing Path
SV	Subject Vehicle
SVOR	Single Vehicle Off-Roadway
SVRD	Single Vehicle Roadway Departure
UDA	Unsafe Driving Act
UI/SCP	Unsignalized Intersection, Straight Crossing Path

LIST OF CONTRIBUTING FACTORS

F1 Alcohol/Drugs
F2 Ill/Blackout
F3 Sleepy/Drowsy
F4 Vehicle Defect – Control Loss (CL)
F5 Vehicle Defect – Contributing Factor (CF)
F6 Inattention
F7 Driver's Vision Obscured By
F8 Speeding (CL)
F9 Speeding (CF)
F10 Successful Evasive Maneuver
F11 Hit & Run

EXECUTIVE SUMMARY

The U.S. Department of Transportation's Intelligent Vehicle Initiative is focused on improving the safety of the nation's highways through the continued development and deployment of advanced-technology crash avoidance systems. This research furthers the understanding of the critical event dynamics that precede specific types of crashes and quantifies the crash contributing factors for the crash types. In particular, this report is focused on single vehicle off-roadway, rear-end, and lane change crashes involving light vehicles (passenger cars, sport utility vehicles, vans, and pickup trucks). The analysis was based on crash data obtained from the National Automotive Sampling System's (NASS) 1997-2000 Crashworthiness Data System (CDS) and 2000 General Estimates System (GES). Both the CDS and the GES are created based on a selection of police-reported (PR) collisions. The GES is limited to data contained on the Police Accident Reports (PARs) of approximately 55,000 motor vehicle traffic crashes per year. The GES provides information on all types of crashes involving all types of vehicles. The CDS contains information from the PARs and detailed data collected by trained investigators for approximately 4,500 crashes per year involving at least one light vehicle towed from the scene due to damage. Through the analysis of the critical event dynamics and crash contributing factors, the development of performance specifications and anticipated benefits for collision avoidance systems can be better determined.

The research on crash contributing factors was divided into three phases. Phase one provides a comparison of the contributing factor distributions from the CDS and GES in order to assess which database contains more information about the selected factors (i.e., less coded unknowns in the variables of interest). Phase two examines the issue of crash severity to see if the contributing factors varied depending on the severity of the crash. Crashes were classified into severe and less severe based on whether or not the vehicle involved in the crash was towed from the scene due to damage. Phase three determines the contributing factors based on the pre-crash scenarios for each crash type. Crash contributing factors, cross-correlation charts, and priority scheme distributions were determined for each phase.

Significant observations based on the results of the research are detailed below:

- *Phase 1*: The contributing factor distributions for the CDS and GES matched fairly closely; however, discrepancies were found for two of the contributing factors: inattention and speeding. The 2000 GES data closely resembled the 1997-2000 CDS data for inattention in single vehicle off-roadway crashes. Conversely, the GES cited inattention as a contributing factor in more rear-end and lane change crashes than the CDS. The GES cited inattention in 65% of rear-end crashes and 50% of lane change crashes, compared to the CDS which reported 39% and 33% respectively. The GES was also found to cite speeding as a contributing factor more often than the CDS.

- *Phase 2:* Regarding the issue of crash severity, the contributing factors were similar for the majority of the crash types regardless of the severity of the crash. However, the relative frequency of alcohol/drugs and sleepy/drowsy was found to be influenced by the crash severity for the single vehicle off-roadway and rear-end crash types. Moreover, the relative frequency of speeding and evasive maneuver to a previous

critical event, was affected by the crash severity for single vehicle off-roadway crashes.

In general, the relative frequency of alcohol/drugs and speeding was found to be related to the crash severity. The effect of alcohol/drugs supports the current trend found in the Fatality Analysis Reporting System database, which reports that alcohol was involved in 40% of the fatal crashes in 2000 (*1*). Additionally, the speed the vehicle was traveling at prior to impact was also found to have a direct correlation with the severity of the crash. As the vehicle's speed increases, the driver has less time to perform an evasive action and the damage to the vehicle also increases, resulting in higher injury and fatality rates for the occupants.

- *Phase 3:* When analyzing the scenarios for each crash type, a few underlying trends were found in the contributing factor results. Looking at the results for the scenarios involving single vehicle off-roadway crashes, the contributing factors for the scenarios: *Traveling Straight and Control Loss* and *Negotiating a Curve and Control Loss* were very similar as were the contributing factors for the scenarios: *Traveling Straight and Road Edge Departure* and *Negotiating a Curve and Road Edge Departure*. Based on the results of the analysis, it was found that the contributing factors were influenced more by the scenario's *Critical Event* than the *Movement Prior to the Critical Event.* That is, the factors that might have contributed to the cause of the collision were affected more by the fact that the vehicle lost control or departed the road edge than that the vehicle was traveling straight or negotiating a curve.

  For rear-end crashes, a close resemblance between the distribution of contributing factors for the scenarios: *Lead Vehicle Decelerating* and *Lead Vehicle Stopped* was found. Additionally, a statistically significant difference between the distributions of contributing factors was found between the scenario, *Lead Vehicle Moving* and the other two scenarios. *Lead Vehicle Moving* crashes were less likely to be associated with driver inattention; however, they were more likely to involve alcohol/drugs or a vehicle defect resulting in control loss.

1. INTRODUCTION

This report analyzes the contributing factors for single vehicle off-roadway, rear-end, and lane change crashes involving light vehicles (passenger cars, sport utility vehicles, vans, and pickup trucks). Crash data were obtained from the National Automotive Sampling System's (NASS) 1997-2000 Crashworthiness Data System (CDS) and 2000 General Estimates System (GES). In 2000, an estimated 6,394,000 motor vehicle crashes were reported to the police. Of those crashes, 6,133,000 or 96 percent involved at least one light vehicle (*2*). Limiting the analysis to light vehicles will, therefore, still provide a reasonable estimate for the entire crash population.

This report was produced in support of the U.S. Department of Transportation's (DOT) Intelligent Vehicle Initiative (IVI). The focus of the IVI program is the continued development and deployment of advanced-technology crash avoidance systems to help avoid and reduce the severity of collisions on the nation's highways (*3*). Research conducted under the IVI program involves the following problem areas: rear-end, off-roadway, lane change, crossing paths, driver impairment, reduced visibility, vehicle instability, pedestrian, and pedalcyclist crashes. This report provides an in-depth analysis of three of the four crash types: rear-end, off-roadway, and lane change as well as providing primary contributing factors and crash circumstances for each crash type. The purpose of this research is to further the understanding of the critical event dynamics that precede specific types of crashes and to quantify the crash contributing factors. Through the analysis of the critical event dynamics and crash contributing factors, the development of performance specifications for collision avoidance systems and anticipated benefits for collision avoidance systems can be better determined (*3*).

The research on crash contributing factors was divided into three phases. Phase one provides a comparison of the CDS and GES in order to assess which database contains more information about the selected factors (i.e., less coded unknowns in the variables of interest). Since the CDS only contains information on cases involving light vehicles towed from the scene due to damage, the analysis of the GES was restricted to include similar cases.

Phase two of the project examined the issue of crash severity. Severe and less severe crashes were examined in order to see if the contributing factors varied depending on the severity of the crash. This report classifies crash severity into severe and less severe crashes based on whether or not the vehicle involved in a crash was towed from the scene due to damage. Based on the results of phase one, the GES was found to provide similar or more information on the distribution of contributing factors than the CDS; therefore, only the 2000 GES data were used for the analysis in phase two.

For phase three, 2000 GES data were utilized to obtain crash factors for the most frequently occurring pre-crash scenarios. Pre-crash scenarios represent the vehicle dynamics immediately prior to a collision. The two severity categories from phase two were combined in order to examine the contributing factors based on each scenario for all light vehicle crashes (i.e., *towed due to damage* and *other*). Contributing factors for each scenario were identified. By analyzing each scenario, a better understanding of the factors associated with a particular crash type/scenario could be determined.

1.1 PREVIOUS WORK

The National Highway Traffic Safety Administration (NHTSA) conducted an early study on crash contributing factors to identify the factors that influence the sequence of events that result in motor vehicle collisions and to determine the relative frequency of the factors (*4*). Based on a series of in-depth investigations of police reports and on-scene investigations, human factors were found to be the definite cause for 70.7% of the crashes. Moreover, environmental factors were determined to be the definite cause in 12.4% of the cases and vehicle factors were identified as the definite cause in 4.5% (*4*). Additionally, drivers were found to be totally non-responsible in approximately 2% of the collisions.

One limitation of the previous study was that causal factors were not assigned to "specific" crash types. However, a later study analyzed the crash causal factors of nine target crash types. The nine crash types included: (1) rear-end; (2) backing; (3) single vehicle roadway departure; (4) lane change/merge; (5) signalized intersection, straight crossing path; (6) unsignalized intersection, straight crossing path; (7) intersection, left turn across path; (8) reduced visibility; and (9) opposite direction (*5*). Each of the target crash types was investigated to determine crash characteristics, crash size, causal factors, and possible Intelligent Transportation Systems collision avoidance systems. Crash causal factors were identified for each of the nine target crash types based on an analysis of 687 cases from the 1991-1993 GES and CDS. The distribution of crash causal factors found, divided by crash type, is shown in Table 1.

Table 1. Target Crash Causes *(5)*

	Rear-End	Backing	Single Vehicle Roadway Departure	Lane Change/ Merge	Signalized Intersection/ Straight Crossing Path	Unsignalized Intersection/ Straight Crossing Path	Left Turn Across Path	Opposite Direction
Inattention	56.7%	0.0%	15.5%	3.8%	36.4%	22.6%	1.4%	17.8%
Looked-Did Not See	0.0%	60.8%	0.0%	61.2%	0.0%	36.7%	23.2%	0.0%
Obstructed Vision	0.0%	0.0%	0.0%	0.0%	4.3%	14.3%	24.4%	0.0%
Tailgating/Unsafe Passing	26.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
Misjudged Gap/Velocity	0.4%	0.0%	0.0%	29.9%	0.0%	12.2%	30.0%	5.9%
Excessive Speed	0.0%	26.6%	17.8%	2.2%	0.0%	0.0%	0.0%	0.0%
Tried to Beat Signal/POV	0.0%	0.0%	0.0%	0.0%	16.2%	0.0%	11.2%	0.0%
Failure to Control Vehicle	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Evasive Maneuver	0.0%	0.0%	13.7%	2.6%	0.0%	0.0%	0.0%	18.6%
Violation of Signal/Sign	0.0%	0.0%	0.0%	0.0%	23.2%	3.4%	7.4%	0.0%
Deliberate Unsafe Driving Act	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Miscellaneous	1.1%	0.1%	0.0%	0.0%	5.9%	0.0%	1.7%	1.0%
Drunk	2.1%	3.0%	10.1%	0.0%	12.6%	2.7%	0.4%	31.7%
Asleep	0.0%	1.9%	11.8%	0.0%	0.0%	0.0%	0.0%	0.0%
Ill	9.6%	0.0%	3.5%	0.0%	0.0%	0.0%	0.0%	1.1%
Vehicle Defects	1.2%	5.7%	5.3%	0.3%	1.6%	0.0%	0.0%	4.5%
Bad Roadway Surface Cond.	2.3%	0.0%	20.2%	0.0%	0.0%	7.0%	0.0%	18.3%
Reduced Visibility/Glare	0.1%	0.0%	0.0%	0.0%	0.0%	1.1%	0.1%	0.0%
TOTAL:	100%	100%	100%	100%	100%	100%	100%	100%

Another study, conducted by the Volpe National Transportation Systems Center in 2001, looked specifically at off-roadway crashes and presented a set of crash-imminent scenarios and causal factors to objectively test countermeasure systems for light vehicles. Approximately 992,000 off-roadway crashes were analyzed from the 1998 GES database to determine the involvement of 5 contributing factors: alcohol/drugs, driver impairment, driver distraction, speeding, and hit and run (*6*).

After the involvement of each possible crash contributing factor was determined, a priority scheme was used to narrow down the factors until one dominant contributing factor was present for each crash. The priority scheme analysis was based on a rank of contributing factors in descending order; higher rank represents a higher dominance. The rank of factors used in the analysis was:

1. Alcohol/Drugs
2. Driver Impairment
3. Driver Distraction
4. Speeding
5. Hit and Run

The study found that speeding was the leading primary contributing factor for off-roadway crashes, accounting for 34.0% and 22.6% respectively of freeway and non-freeway crashes. Second to speeding, alcohol/drugs were found to be a primary contributing factor in off-roadway crashes (*6*).

A later study looked at the frequency of unsafe driving acts from four sites in Pennsylvania, Tennessee, Colorado, and Washington (*7*). Crashes were randomly selected to determine specific driver behaviors that lead to crashes as well as the situational, driver, and vehicle characteristics associated with the driver behaviors. The leading causes of light vehicle crashes were inattention (22.7%), vehicle speed (18.7%), and alcohol consumption (18.2%) (*7*).

Additional information on prior crash contributing factor research is provided in Appendix A.

1.2 ANALYSIS DATABASES

The NASS is composed of the CDS and the GES. Both the CDS and the GES are created based on a selection of police-reported (PR) collisions. The GES is limited to data contained on the Police Accident Reports (PARs) of approximately 55,000 motor vehicle traffic crashes per year. The CDS contains information from the PARs and detailed data collected by trained investigators for approximately 4,500 crashes per year.

1.2.1 Crashworthiness Data System

The CDS contains detailed information on a nationally representative sample of 4,500 PR crashes involving at least one light vehicle towed from the scene due to damage. The cases in the CDS encompass a broad range of injuries, from property damage only (PDO) to fatal. The information for the database is collected by field research teams located throughout the country. The teams visit the crash site and obtain detailed data on the crash location and surrounding environment including skid marks, spilled fluids, broken glass, and damage to the roadside hardware. The vehicles involved in the crash are also located and a thorough investigation of the vehicle's interior and exterior damage is conducted. Additionally, the field research teams interview the victims in order to gain further insight into the cause of the crash. The data obtained from the CDS are used for a variety of purposes including (*8*):

- Assessing the overall state of traffic safety, and identifying existing and potential traffic safety problems.
- Obtaining detailed data on the crash performance of passenger cars, light trucks, vans, and utility vehicles.
- Evaluating vehicle safety systems and designs.
- Increasing knowledge about the nature of crash injuries, specifically about the relationships between the type and seriousness of a crash and the resultant injuries.

- Assessing the effectiveness of motor vehicle and traffic safety program standards, including the alcohol and safety belt use programs.
- Evaluating the effect of societal changes, such as increased traffic flow and increased large truck traffic.

1.2.2 General Estimates System

The GES provides information on all types of crashes involving all types of vehicles. The GES provides a nationally representative sample of approximately 55,000 PR crashes a year (*9*). Like the CDS, the GES examines all levels of injuries from PDO to fatal. Crash information is collected from 400 police agencies within 60 different geographical sites in the United States. The 60 sites were selected to provide a representative sample of the roadways in the United States through their unique geography, mileage, population, and traffic density. In order for a crash to be eligible for the GES, a police accident report must have been filed, at least one motor vehicle has to be traveling on a traffic way, and the crash must result in property damage, injury, or death. The data obtained from the GES are used to identify current problems in the area of highway safety and to supply a foundation for regulatory initiatives.

1.2.3 Associated Errors

As with any estimate from a sample used to represent the entire population, sampling errors will occur. For example, the 55,000 cases in the GES are being used to represent the entire population of PR motor vehicle traffic crashes for that given year, so in this case, the "sample" is the 55,000 cases and the "entire population" is all the qualifying crashes that occurred that year. These 55,000 cases are only some of the many cases that could have been chosen from the entire population of crashes. If a different sample of cases were chosen, the results may differ slightly from the actual cases chosen for the GES. Sampling errors are a measure of the variability between all of the possible samples. The degree of variability can be estimated from the results obtained. Using the standard error, confidence intervals can be calculated in order to determine a range that the true value falls within.

Sampling errors for the GES were provided in the NASS GES Analytical User's Manual. Standard errors for the crash, vehicle, and person characteristics were calculated separately and can be found in Appendix B. For example, if the estimated number of crashes in 2000 were 300,000, the standard error would be 20,800. The 95th percent confidence interval can be calculated as shown (*9*):

$$300{,}000 \pm 1.96\,(20{,}800) = 259{,}232 \;\; to \;\; 340{,}768$$

Therefore, with a 95% confidence level, the actual number of crashes would fall between 259,232 and 340,768.

A comparison of the estimated number of CDS and GES crashes for 2000 is shown in Figure 1 by crash type. Crash types represented include Single Vehicle Off-Roadway (SVOR), Rear-End (RE) and Lane Change (LC). For this comparison, GES cases were restricted to light vehicle crashes with at least one light vehicle towed from the scene due to damage. Ideally, the

estimated number of crashes, by crash type, would be similar for both CDS and GES. The two databases match closely for the LC crash type. However, if the confidence intervals were examined for both databases, there is a good chance that no statistical significant difference would exist within any of the crash types.

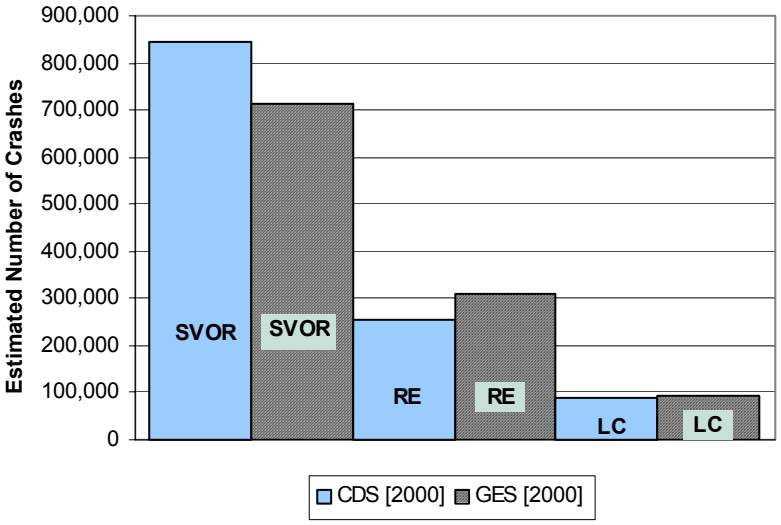


Figure 1. Overall Comparison by Crash Type

1.2.4 Data Collection Issues

The ability to correctly identify crash contributing factors relies largely on the accuracy of the data provided in the CDS and GES. Both the CDS and GES are coded from PARs. Trained CDS investigators conduct interviews and site visits to collect additional information as well as to verify the information with the PAR. The GES is coded straight from the PARs without any additional investigation. Both databases, the GES more so, rely heavily on the quality of information reported in the PARs. It is up to the police officer's discretion to charge a driver with a violation even if the violation occurred. Speeding is a prime example of an often-occurring variable that is not always observed/reported by the officer. Furthermore, inattention is generally under-represented because it is difficult for officers to report without any witness statements, and drivers rarely admit to being distracted immediately prior to the crash. With this stated, it must be understood that the data presented hereafter is obtained from coded information in the CDS and GES; the data may underestimate the occurrence of certain factors from what actually occurs in the real world.

2. METHODOLOGY

This analysis was conducted in three phases. Phase one determined the contributing factors from the CDS and the GES databases for each of the three crash types: Single Vehicle Off-Roadway (SVOR), Rear-End (RE), and Lane Change (LC). The goal of phase one was to see which database contains more information about the selected factors (i.e., less coded unknowns in the variables of interest). Since the CDS only contains information on cases involving light vehicles towed from the scene due to damage, it was imperative that the correct cases from the GES (i.e., light vehicles towed from the scene) were being used in the comparison. In phase two, the issue of crash severity was examined. This report classifies crash severity into severe and less severe crashes based on whether or not the vehicle involved in crash was towed from the scene due to damage. Since all the GES cases used in phase one were towed from the scene due to damage, it is justifiable to say that these crashes were generally severe collisions. The remaining light vehicles in the GES database for that crash type (i.e., *other*) were also used in phase two. Since these vehicles were not towed from the scene due to damage, they generally represent the less severe crashes. The contributing factors were then compared for the severe and less severe cases to see which factors were affected by the crash severity. Phase three involved an examination of crash scenarios for all the GES cases (*towed due to damage* and *other*) to determine contributing factors for each scenario.

2.1 PHASE 1: COMPARE CDS TO GES

The main task of phase one was to examine crashes within the CDS and the GES to see which database contained more information about the selected factors. The same population of crashes was extracted from each database and the reported contributing factors were examined to see if any discrepancies existed. Historically, it has been shown that the CDS provides more accurate information and less coded unknowns than the GES particularly for the contributing factor driver distraction/inattention (*6*). The GES 2000 data, however, were found to cite distraction/inattention as a contributing factor in more crashes than the CDS 1997-2000 data.

2.1.1 Contributing Factors

Contributing factors for the target crashes were determined based on an in-depth examination of the CDS and GES databases. The factors identified are provided below:

- Alcohol/Drugs
- Ill/Blackout
- Sleepy/Drowsy
- Vehicle Defect - Control Loss (CL)
- Vehicle Defect - Contributing Factor (CF)
- Inattention
- Driver's Vision Obscured
- Speeding (CL)
- Speeding (CF)
- Successful Evasive Maneuver
- Hit & Run

The CDS is a crashworthiness database and provides detailed information on the relative safety of the vehicle and its ability to prevent injury to its occupants. Since the CDS is primarily concerned with the crashworthiness of the vehicle, it contains a plethora of information needed to reconstruct the crash, as well as detailed information about the resulting damage. It does not, however, contain all of the general information on the crash as the GES does; therefore, some of the information needed for the contributing factors could not be determined from the CDS. A chart showing which factors were available from each database is provided in Table 2.

Table 2. Factors Found in CDS and GES

	CDS (1997-2000)	GES (2000)
F1-Alcohol/Drugs	X	X
F2-Ill/Blackout		X
F3-Sleepy/Drowsy	X	X
F4-Vehicle Defect (CL)	X	X
F5-Vehicle Defect (CF)		X
F6-Inattention	X	X
F7-Driver's Vision Obscured		X
F8-Speeding (CL)	X	X
F9-Speeding (CF)		X
F10-Successful Evasive Maneuver	X	X
F11-Hit & Run		X
Adverse Environmental Conditions	X	X

The factors vehicle defect and speeding are separated into two categories: those that resulted in a loss of control and those that were a contributing factor to the crash. For the factor vehicle defect, all control loss cases are included in the vehicle defect (CF) factor. Control loss cases encompass situations in which the vehicle defect was a critical factor leading to the control loss of the vehicle. A blow out or flat tire would be an example of a vehicle defect that may lead to a control loss of the vehicle. On the other hand, a defective headlight may have been a contributing factor to a crash, but it did not result in a control loss of the vehicle. For speeding (CF), only control loss cases due to excessive speed (travel speed > speed limit) are included in the contributing factor category. Control loss cases that result from speeding on poor roadway conditions (e.g., icy) are not included in the contributing factor category.

2.1.2 Redistribution of Unknowns

A large number of unknowns for some individual variables were found in both databases. To provide a more accurate picture of the crash situation, a univariate imputation procedure was conducted on variables with a large proportion of unknowns. The procedure redistributed the unknowns based on the original distribution found for that attribute. For the case of this study, unknowns were defined to include cases coded "unknown" and "not reported." Hit and run cases

were not included in the unknowns. An example of the univariate imputation procedure is provided below. It is acknowledged that there could be some error in this approach; however, a similar procedure is used in the GES database and the univariate imputation procedure was determined to be the most reasonable method to account for the unknowns.

Example: *CDS [SVOR, 1997-2000] Police-Reported Alcohol Presence*
The original crash weights were obtained and the distributions were calculated.

SVOR, LV Crash Weight	NO ALCOHOL Crash Weight	ALCOHOL Crash Weight	NOT REPORTED Crash Weight	UNKNOWN Crash Weight
3,314,000	2,367,000	562,000	208,000	173,000
	71%	17%	6%	5%

Grouping of the unknowns:

SVOR, LV Crash Weight	NO ALCOHOL Crash Weight	ALCOHOL Crash Weight	UNKNOWN Crash Weight
3,314,000	2,367,000	562,000	381,000
	71%	17%	11%

Redistribution of unknown cases:

Alcohol Present:

$$\left[\frac{562{,}000}{3{,}314{,}000 - 381{,}000}\right] = 19\%$$

No Alcohol Present:

$$\left[\frac{2{,}367{,}000}{3{,}314{,}000 - 381{,}000}\right] = 81\%$$

2.1.3 Special Use Vehicles

Special use vehicles are vehicles that are typically driven for a particular use, including taxis, buses, military vehicles, police vehicles, ambulances, fire trucks, farm or construction equipment, and hearses. See Appendix C for additional information on special use vehicles. Due to differences in the driving styles of special use vehicles, they were removed from the analysis of all crash types.

2.1.4 Environmental Conditions

Based on the Indiana Tri-Level Study, environmental factors where shown to play a definite role in 12.4% of all roadway crashes (*4*). The environmental conditions recorded at the scene of a crash are the lighting conditions, the roadway surface conditions, and the atmospheric conditions. Lighting conditions describe the ambient, artificial, or natural sources of light at the time of the crash. The roadway surface conditions describe the surface conditions of the roadway immediately prior to the location of the vehicle's critical pre-crash event. The atmospheric

conditions at the time of the crash attempt to depict any precipitation or particle dispersion that may have affected the driver's visibility or the vehicle's control. Additional information about the environmental conditions can be found in Appendix C.

To determine if environmental factors played a role in the crash, each case was examined to determine if the collision occurred under adverse environmental conditions. From the three variables on environmental conditions, only three of the codes were determined *not* to depict adverse conditions: daylight (lighting condition), dry pavement (roadway surface condition), and clear weather (atmospheric condition). It is important to note that all crashes were considered to occur under adverse environmental conditions unless all three environmental factors were non-adverse. For example, a case would be coded as having adverse environmental conditions if it occurred on dry pavement, in clear atmospheric conditions, but at night. All cases were initially examined to see if any of the contributing factors (listed in Section 2.1.1) were present. The environmental conditions were examined second to identify circumstances for crashes that did not contain any of the initial contributing factors. This examination asserts whether adverse environmental conditions might have played a role in those crashes that were not associated with any of the contributing factors.

2.1.5 Cross-correlation of Multiple Factors

Multiple factors often contribute to the occurrence of a crash. For example, a crash may occur while a driver is speeding and adjusting the car radio. The question arises as to whether the crash was caused by the vehicle's speed or by the inattentive driver. Cross-correlation charts were created to account for the crash contributing factors in scenarios that involve multiple factors. First, an initial contributing factor was chosen, and then cases which involved this contributing factor were extracted from the database. These extracted cases were later examined to see what additional factors might have contributed to the crash.

A sample cross-correlation chart is shown in Figure 2. The contributing factors listed on the X-axis (horizontal axis) are cross-correlated with the ones on the Y-axis. For example, in examining the contributing factors for F1, look across the row associated with F1. Block A represents all of the cases that include contributing factor F1. Block B represents all of the cases that involve contributing factors F1 and F2, block C all cases involving factors F1 and F3, and block D all cases associated with F1 and F4. The striped block for factors (F2, F3) represents a cross-correlation that cannot be determined. In the GES and CDS databases, there are some factors that were determined from the same variable such as vehicle defect (CL) and speeding (CL) using the critical pre-crash event variable. In this case, the interrelationship between the variables cannot be shown.

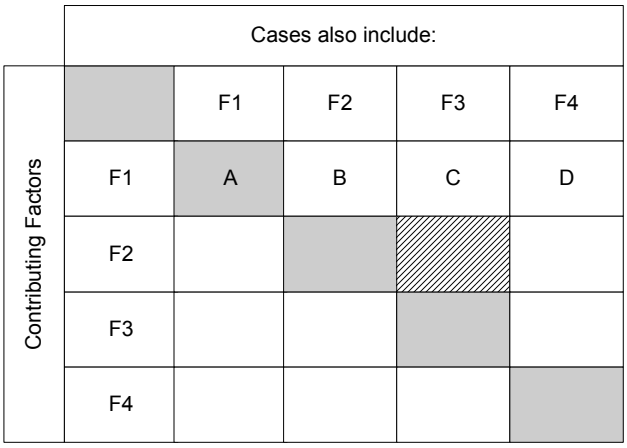


Figure 2. Sample Cross-correlation Chart

Block A represents all cases that include contributing factor F1. It might be assumed that the sum of block B + block C + block D would be equal to or less than the total of block A; however, this is not always the case. For some crash types, the sum of the contributing factor blocks exceeds the total of the shaded block. As previously stated, multiple factors often contribute to the occurrence of a crash; combinations of three or more factors may occur. For example, a crash may occur with factors F1, F2, and F3 and would be included in blocks A, B, and C. Thus, this case would be counted twice when summing the total of blocks B and C.

Due to the large number of unknowns in some factors, unknowns were redistributed using the same method described in Section 2.1.2. Since the distribution of the contributing factors is not exact (i.e., it is not known whether each case has two, three, or more contributing factors), the unknowns were only redistributed to the shaded blocks. Since the frequency of unknowns for the shaded blocks is known, the unknowns could be redistributed. However, for the other blocks, the net frequencies are not known. For example, in block B in Figure 2, the frequency of unknowns for factors F1 and F2 are known; however, block B may also include cases with contributing factors F3 and F4.

2.1.6 Prioritization of Factors

Looking at the cross-correlation charts, it is clear that collisions often occur with multiple factors. The interrelationship between the various factors is important to understand; however, it is also important to determine a primary contributing factor for each case. By determining the distribution for the primary contributing factors, better collision countermeasures can be developed and their potential safety benefits can be projected for individual crash types. Primary contributing factors were established for each crash type through the use of a priority scheme that was previously developed based on the expert opinions of researchers (*10*).

The priority scheme enables the researcher to attribute one primary contributing factor to each case. While it is beneficial to understand all of the factors affecting each case, it is useful for the development of crash countermeasure systems to understand the primary cause to be addressed by the system. The priority scheme attempts to break down the cases with multiple factors and

assigns one contributing factor that overrides the others. The priority scheme positions the factors in descending order by their degree of influence on a possible collision. Since the priority scheme determines one primary contributing factor for each crash, the sum of the resulting distribution adds to 100%, confirming that none of the collisions were counted twice. Furthermore, the methodology enables the researcher to address the contributing factors of primary concern; and thus, improve the safety of the nation's highways.

The descending order of the contributing factors used in the priority scheme was:

1. Alcohol/Drugs
2. Ill/Blackout
3. Sleepy/Drowsy

Driver incapacitation/impairment

4. Vehicle Defect (CL)
5. Vehicle Defect (CF)

Vehicle defects

6. Inattention
7. Driver's Vision Obscured
8. Speeding (CL)
9. Speeding (CF)

Speeding

10. Successful Evasive Maneuver
11. Adverse Environmental Conditions
12. Hit & Run

The first three factors all represent the incapacitation or impairment of the driver. These factors clearly take precedence over all other factors. Within the incapacitation/impairment grouping, the factors were ranked based on their effect on the other factors. Alcohol/drugs was positioned at the top of the ranking. Since it is possible that a driver may blackout as a result of alcohol/drugs; therefore, alcohol/drugs takes precedence over ill/blackout.

The fourth and fifth factors can be grouped together into a vehicle defect category. In the case of a defective vehicle, a collision or evasive maneuver is likely to occur no matter how, for example, attentive the driver is. After all cases involving incapacitation or defects were taken out, the factor inattention, followed by the driver's vision being obscured, became the primary factors. The process continued in descending order through factor ten.

The first 10 factors in the priority scheme were used to provide information on the primary factor of the collisions. Using the priority scheme, cases coded as having one of the first 10 primary contributing factors were extracted from the group of target crashes. Information about these factors on the remaining target crashes was not available; therefore, each case was examined to see if adverse environmental conditions existed at the time of the collision and might have played a role in the collision. Since minimal information on hit and run crashes was available, the factor was placed after the adverse environmental conditions variable in the priority scheme. By placing the factor last, hit and run cases with known adverse environmental conditions were accounted for in the adverse environmental conditions variable, thus reducing the amount of unknown information.

The analysis for the priority scheme was conducted first by extracting all of the cases within that crash type. Next, all of the cases involving alcohol/drugs were determined providing the percentage for the first primary contributing factor. Note that the unknowns were not redistributed for the purpose of prioritization. (Unknowns were not counted and were placed into the "undetermined" category.) A process of elimination was used; alcohol/drug cases were extracted from the analysis and the remaining cases were examined for signs of ill or blacked-out drivers. These cases were removed and the remaining cases were searched for sleepy/drowsy drivers. The same method was used until all remaining primary contributing factors and variables were analyzed. All remaining cases not linked to any of the contributing factors were put into an "undetermined" category.

2.2 PHASE 2: EXAMINE ISSUE OF SEVERITY (GES *OTHER* CASES)

In phase one of the analysis, the GES was compared to the CDS. For an accurate comparison with the CDS, the cases for each crash type in the GES had to be restricted to light vehicles that were towed from the scene due to damage. Since at least one vehicle had to be towed from the crash scene due to damage, these cases were classified as severe collisions. The remaining cases in the GES database for that crash type were defined as *other*. The *other* category contains cases where the vehicle was driven from the scene or towed from the scene not due to damage. Reasons for a vehicle being towed not due to damage may include mechanical failure or a driver who sustained a minor injury that need medical attention (e.g., broken arm). Since none of the vehicles in the *other* category were towed from the scene due to damage, this group represents crashes that were on average less severe. Using these definitions, phase two of the analysis examines the issue of crash severity. It is important to note that two assumptions were made in segregating the crashes by the manner in which they left the scene. First, it was assumed that if a driver were seriously injured as a result of the crash, the damage to the vehicle would require it to be towed. On the other hand, if a driver had a heart attack and rear-ended another vehicle, the crash might be included in the *other* category. The second assumption was that the investigating officer did not bias the contributing factors reported by the crash severity. It is assumed that certain contributing factors like alcohol and speed were reported with the same consistency in severe and less severe crashes.

Contributing factors were compiled and analyzed for the severe and less severe cases. The same method for the determination of the contributing factors used in phase one was followed for phase two. The definitions for the contributing factors, specialty vehicles, and environmental conditions remained consistent and the unknowns were redistributed in the same manner. Additionally, the analysis was similar to phase one, the only change was that rather than comparing the CDS to the GES, the GES *towed due to damage* cases were compared to the *other* cases.

2.3 PHASE 3: EXAMINE CRASH SCENARIOS

Phase three involved an examination of crash scenarios for all 2000 GES light vehicle cases (*towed due to damage* and *other*). Several 2000 GES crash types were partitioned into scenarios. Contributing factors for each scenario were identified. By analyzing each scenario, a better understanding of the factors associated with a particular crash type/scenario could be determined. GES estimates that there were 1,126,000 SVOR PR cases in 2000, representing 18% of all light

vehicle crashes (*2*). Based on all GES reported light vehicle PR crashes, the crash type was partitioned into four scenarios:

- Traveling Straight and Control Loss
- Traveling Straight and Road Edge Departure
- Negotiating a Curve and Control Loss
- Negotiating a Curve and Road Edge Departure

GES estimates that there were 1,513,000 PR two-vehicle rear-end (RE) crashes in 2000 representing 25% of all light vehicle crashes (*2*). RE crashes have been partitioned into three scenarios:

- Lead Vehicle Decelerating (LVD)
- Lead Vehicle Stopped (LVS)
- Lead Vehicle Moving (LVM) at lower constant speed

Nine percent of all light vehicle crashes in 2000 were lane change crashes. A total of 565,000 crashes were reported to the police involving a vehicle performing a lane change maneuver (*2*). Sixty-three possible scenarios exist for 2-vehicle, lane change crashes; however, only 33 are found to exist in the 2000 GES data in significant numbers. Due to the large number of possible scenarios, the percentage of the largest scenario was examined and found to contribute to only 4.1% of the entire crash type (*2*). Therefore, the entire crash type was analyzed as one scenario, Lane Change Maneuver, to provide better statistical reliability.

Contributing factors were established for each of the eight scenarios using the same procedure used for phases one and two. An analysis of the results between each of the scenarios was conducted after the contributing factor distributions, cross-correlation tables, and priority schemes were determined for each scenario. Error bars, depicting the 95^{th} percentile confidence interval, were added to the tables in order to determine differences between scenarios.

3. SINGLE VEHICLE OFF-ROADWAY CRASH TYPE – PHASE 1

3.1 DEFINITION OF CASES

Single vehicle off-roadway (SVOR) crashes are defined as crashes in which the vehicle leaves the roadway as a first harmful event. The crash type does not include cases of roadway departure that result from a collision with another vehicle on a travel lane. Cases were selected from the CDS and GES based on *Accident Type* variable codes 01-12 and 14-16. In order to accurately match crashes between the two databases, the GES had to be further restricted since the CDS only involves cases where a light vehicle was towed from the scene due to damage. Further information on the crash type definition can be found in Appendix D.

3.2 RESULTS

3.2.1 SVOR Crash Contributing Factors

The contributing factors for SVOR crashes were determined by an in-depth examination of 5,788 CDS files and 8,521 GES PARs. Since the data from the CDS and GES were obtained from a sample of the population, each crash was weighted in order to estimate national levels for the crash characteristics. After the cases were weighted, the results represented a total of 3,314,000 CDS PR crashes and 715,000 GES PR crashes. The results obtained from the contributing factor analysis are shown below and in Figure 3:

CDS (1997-2000)

- The leading contributing factors were speeding resulting in a control loss (25%), inattention (25%), and alcohol/drugs (21%). The breakdown of driver inattention is provided in Appendix E. Distraction by outside was the most specific inattention factor cited.[1]

- Drowsy/sleepy drivers and vehicle defects resulting in a control loss contributed to 10% and 4% of the crashes, respectively.

- Adverse environmental conditions were present in 72% of the SVOR crashes.

GES (2000)

- The 2 leading crash contributing factors involved speeding in 43% of crashes and resulting in a control loss in 41% of crashes. It should be noted that speeding (CF)

[1]Due to the large interest in the driver inattention factor, the distributions for each crash type are provided in Appendix E. The relative frequencies for each individual category (i.e., looked/did not see, distracted by other occupant, distracted while talking on cell phone, etc.) were rounded to the nearest percent. Due to rounding error, the sum of the relative frequencies provided in Appendix E may not total the frequency of the factor presented in the body of the report.

encompasses all control loss cases due to excessive speed (travel speed > speed limit) and does not include control loss cases due to speeding on poor roadway conditions (e.g., icy). Moreover, coding for speeding as a contributing factor does not exist in the CDS. However, this can be deduced from the speed limit and PR travel speed. Unfortunately, the latter variable is scarcely coded.

- Inattention contributed to 35% of the SVOR collisions. Drivers under the influence of alcohol/drugs were involved in 21% of SVOR collisions. The breakdown of driver inattention can be found in Appendix E. Distracted/lost in thought was the most specific inattention factor cited.

- Drowsy/sleepy drivers contributed towards 8% of the SVOR collisions.

- Vehicle defects as a contributing factor and vehicle defects resulting in a control loss contributed to 5% and 3% of the collisions, respectively. It should be noted that vehicle defect (CF) encompasses all cases also reported as vehicle defect (CL).

- 8% of the crashes were hit and run.

- Driver's obstructed vision was reported in 3% of the crashes.

- Contributing factors for the remaining crashes included the driver being ill or blacking out (2%) and a collision occurring as the result of a successful evasive maneuver to prior or previous critical event (1%).

- 70% of the SVOR crashes occurred under adverse environmental conditions.

3.2.2 Comparison of CDS and GES

The primary goal of phase one of the study was to compare the contributing factor distributions from the CDS and GES to assess which database contains more information about the selected factors (i.e., less coded unknowns in the variables of interest). Figure 3 portrays a comparison of the results from the CDS and GES contributing factors.

The results obtained from the CDS and the GES matched extremely well for all of the factors except speeding resulting in a control loss (F8) and driver inattention (F6). Due to the different nature and purposes of the databases, the GES has historically provided more information on speeding than the CDS. Furthermore, the GES also provided more information on driver distraction for SVOR crashes than the CDS. The CDS and GES matched for all of the other factors within plus or minus 2%.

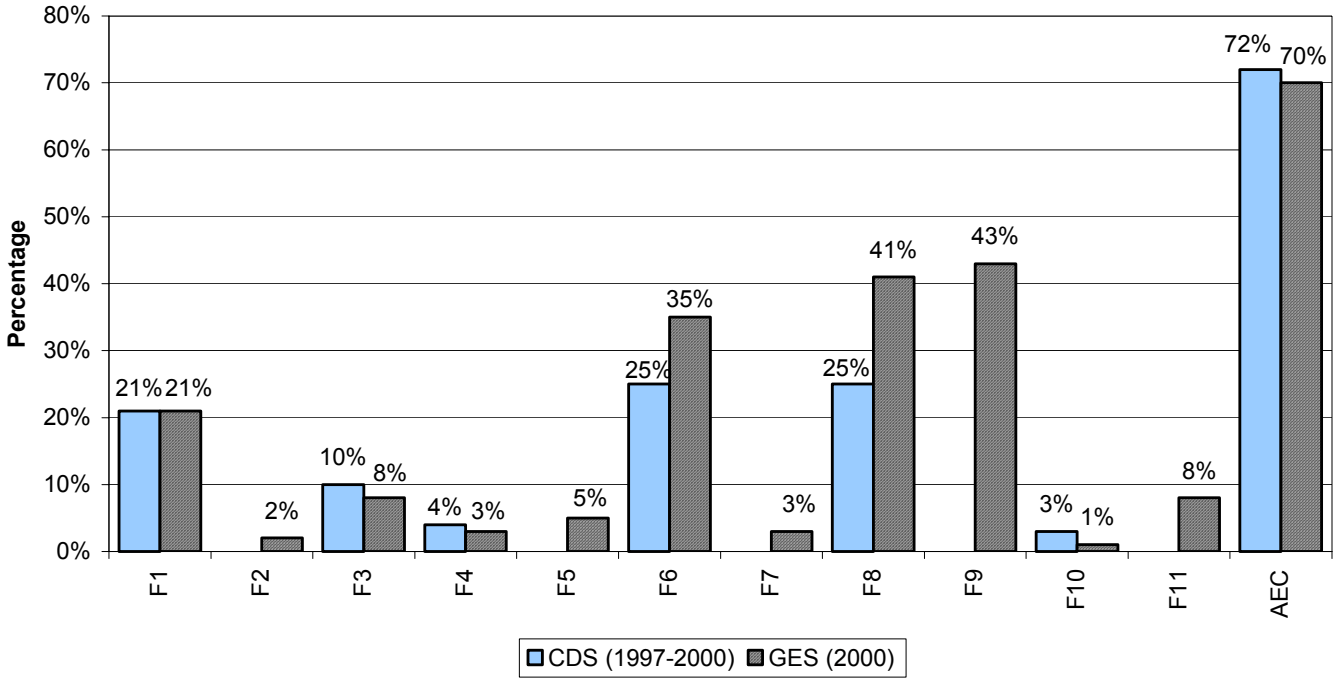


Figure 3. SVOR Comparison of CDS and GES Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

3.2.3 Cross-correlation of Multiple Factors

Since multiple factors often contribute to a crash, cross-correlation charts were created for the SVOR crash type. The relative frequency cross-correlation charts are provided for both databases in Figures 4 and 5.

Using the cross-correlation charts, it is possible to examine the interrelationships among the factors that might have collectively contributed to the cause of the collision. Notable findings from the cross-correlation charts include:

CDS (1997-2000)

- 1% of the SVOR cases in the CDS involved a driver who is under the influence of alcohol/drugs and is also sleepy/drowsy.

- Alcohol/drugs were combined with:
  - Inattentive driver (2% of crashes)
  - Vehicle which lost control as a result of speeding (2% of crashes)
  - Vehicle traveling under adverse environmental conditions (15% of crashes)

- In 4% of the crashes that occurred under adverse environmental conditions, the driver was also sleepy/drowsy.

- A loss of control was caused by a vehicle defect in 2% of the cases that occurred under adverse environmental conditions.

- An inattentive driver was combined with:
  - Vehicle which lost control as a result of speeding (9% of crashes)
  - Vehicle which recently completed a successful evasive maneuver (2% of crashes)
  - Vehicle traveling in adverse environmental conditions (8% of crashes)

- The combination of a loss of control resulting from speeding and adverse environmental conditions contributed towards 22% of the SVOR crashes.

- 2% of the vehicles that performed a successful evasive maneuver under adverse environmental conditions departed the roadway.

GES (2000)

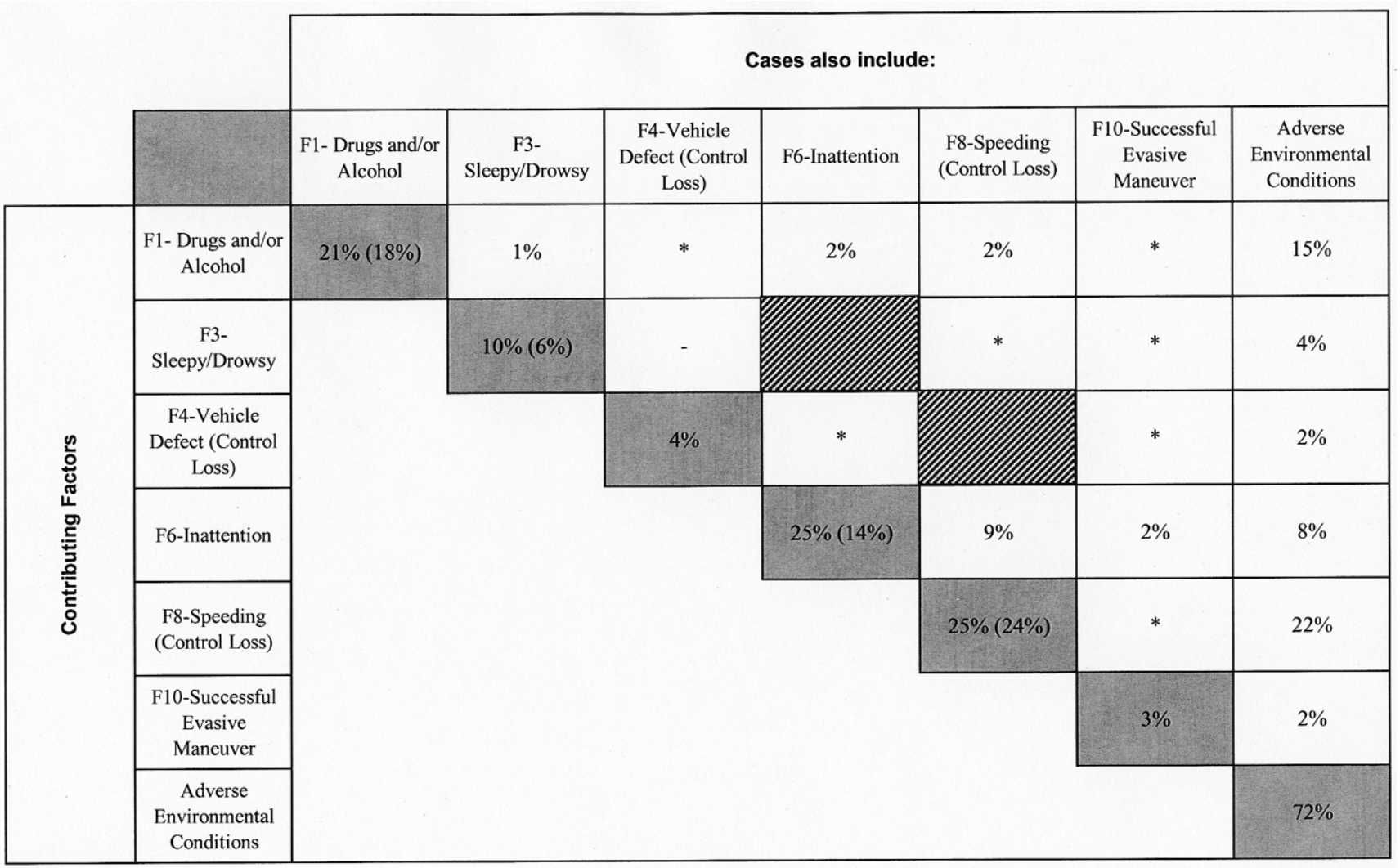
- Alcohol/drugs were combined with:
  - Sleepy/drowsy driver (1% of crashes)
  - Inattentive driver (5% of crashes)
  - Vehicle which lost control as a result of speeding (7% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (9% of crashes)
  - Vehicle traveling under adverse environmental conditions (18% of crashes)

- A sleepy/drowsy driver was combined with:
  - Vehicle which lost control as a result of speeding (1% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (2% of crashes)
  - Vehicle traveling under adverse environmental conditions (5% of crashes)

- An inattentive driver was combined with:
  - Driver whose vision was obscured (1% of crashes)
  - Vehicle which lost control as a result of speeding (6% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (8% of crashes)
  - Vehicle traveling under adverse environmental conditions (12% of crashes)

- 25% of the crashes involved a vehicle that lost control as a result of speeding and cases where speeding was also a contributing factor. Based on the definition of these two variables as explained earlier, the factor speeding (CF) encompasses all control loss cases due to excessive speed (travel speed > speed limit) and does not include control loss cases due to speeding on poor (e.g., icy) roadway conditions.

- A vehicle driving under adverse environmental conditions was combined with:
  - Vehicle which lost control as a result of speeding (33% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (30% of crashes)

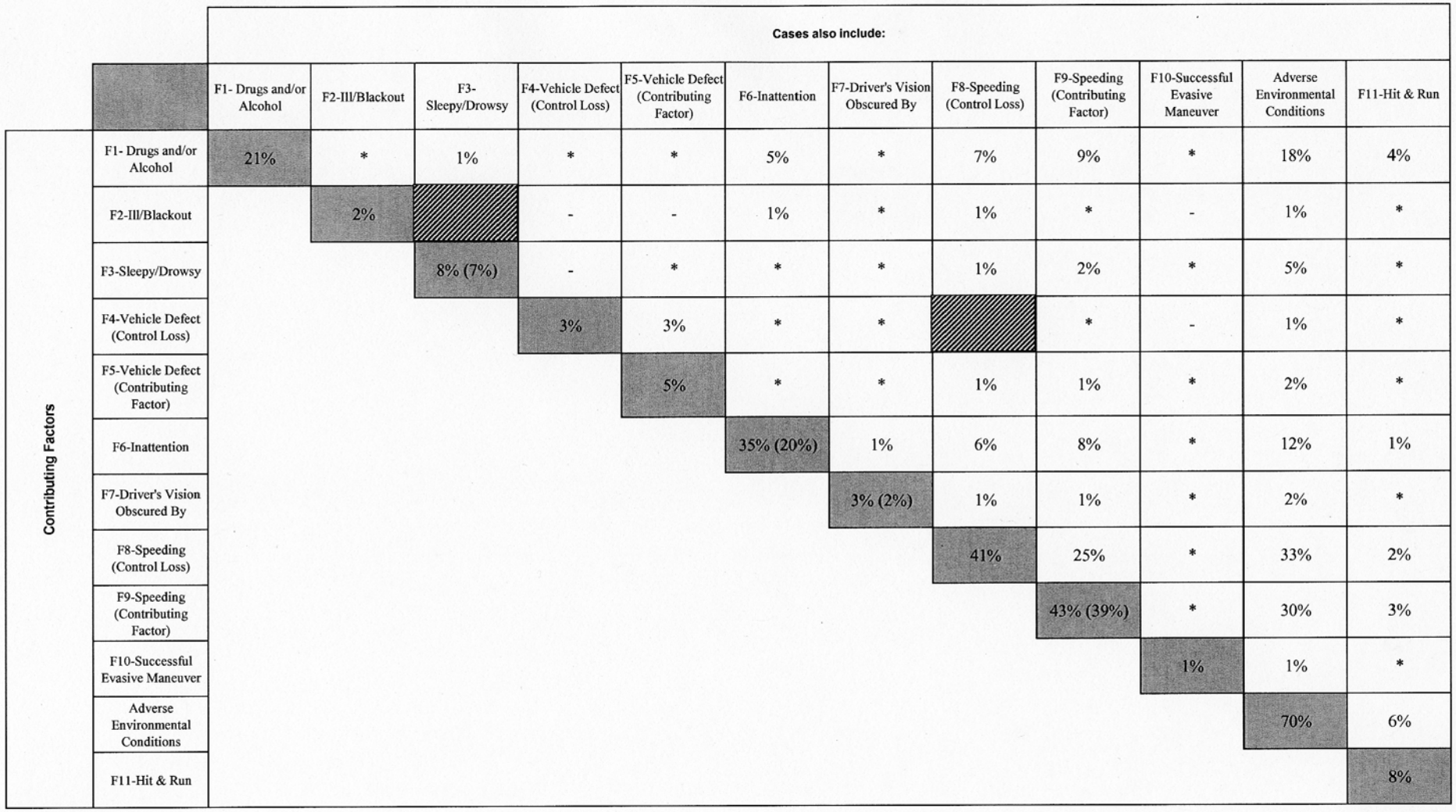


= determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 4. Relative Frequency Cross-correlation Chart for CDS (SVOR)



= determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 5. Relative Frequency Cross-correlation Chart for GES (SVOR)

The distribution for the primary factors (shaded blocks) for the CDS and GES is the same as shown in Figure 3. However, there were differences between the two databases for combinations of contributing factors as detailed below:

- As previously shown, the GES provides more detailed information on the factor speeding (CL) than the CDS. A crash involving a vehicle that loses control due to speeding and a driver under the influence of alcohol/drugs were found in 2% of the CDS cases, but in 7% of the GES crashes. Additionally, 22% of the cases in the CDS and 33% in the GES involved a control loss due to speeding and adverse environmental conditions.

Minor Differences:

- Inattentive drivers and adverse environmental conditions contributed to 8% of the crashes in the CDS, but 12% in the GES.

- The combination of alcohol/drugs and an inattentive driver occurred in 2% of the CDS cases, but 5% of the GES crashes.

- Crashes involving vehicles that lost control due to speeding and whose driver was inattentive were found in 9% of the CDS cases, but only in 6% of the GES crashes.

- 15% of the crashes in the CDS and 18% in the GES were attributed to a driver under the influence of alcohol/drugs driving under adverse environmental conditions.

3.2.4 Prioritization of Factors

Primary contributing factors were established using the prioritization procedure (previously described in Section 2.1.6). The priority scheme distribution for the CDS and GES is shown in Table 3.

The priority scheme shows that the determinable contributing factors account for 88% of the CDS cases and 93% of the GES cases. The top three primary contributing factors for both databases are: alcohol/drugs, inattention, and speeding (CL). Collectively, the three factors accounted for 51% of CDS cases and 62% of GES cases.

Table 3. SVOR Priority Scheme

	CDS (1997-2000)	GES (2000)
Alcohol/Drugs *(F1)*	18%	21%
Ill/Blackout *(F2)*	~	2%
Sleepy/Drowsy *(F3)*	5%	6%
Vehicle Defect (CL) *(F4)*	4%	3%
Vehicle Defect (CF) *(F5)*	~	2%
Inattention *(F6)*	12%	14%
Driver's Vision Obscured *(F7)*	~	2%
Speeding (CL) *(F8)*	21%	27%
Speeding (CF) *(F9)*	~	5%
Successful Evasive Maneuver *(F10)*	3%	0%
Adverse Environmental Conditions *(AEC)*	25%	11%
Hit & Run *(F11)*	~	0%
Undetermined	12%	7%
TOTAL:	100%	100%

~ = Factor not provided in the CDS.

To assist in examining the similarities and differences in the priority scheme distributions for the CDS and GES, a graphical representation of the results is provided in Figure 6.

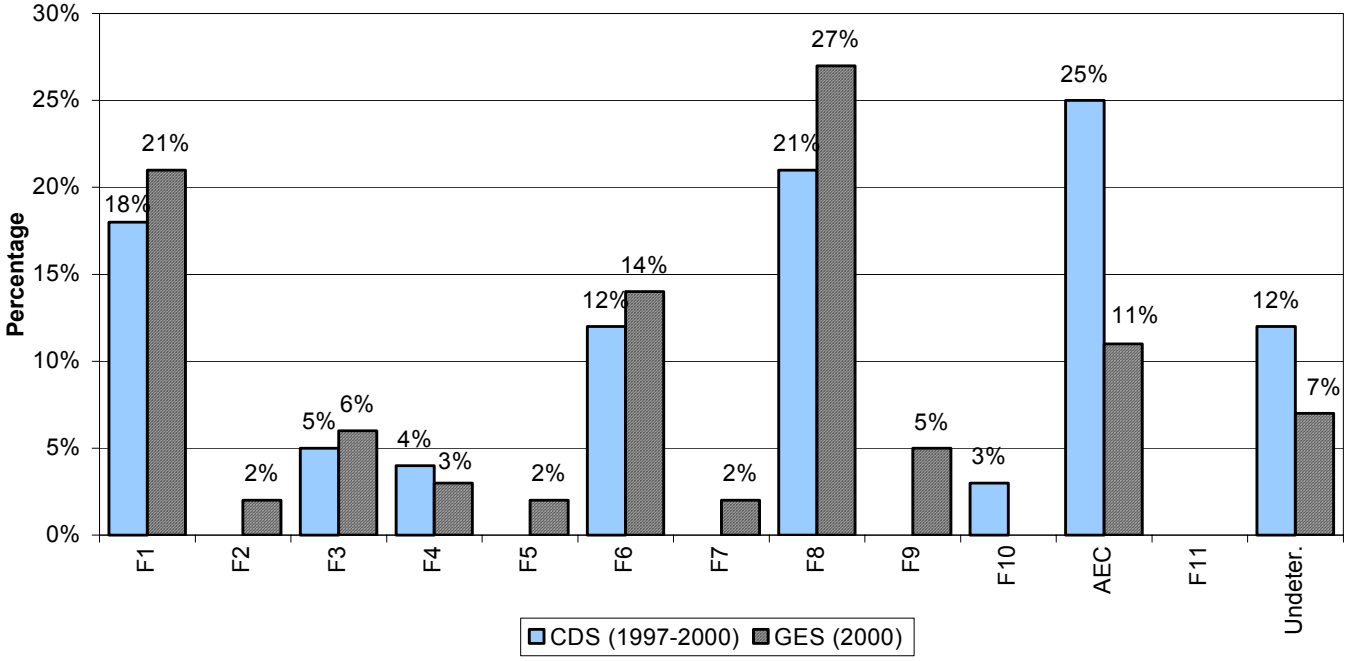


Figure 6. SVOR Crash Contributing Factors Using the Priority Scheme

The results from the priority scheme for the SVOR CDS and GES cases match very closely. Percentages for each of the factors are within plus or minus 5%, except for the factor F8 (Speeding-CL). A discrepancy also existed between the two databases when depicting adverse environmental conditions. The difference is most likely due to the method in which the cases were extracted for the priority scheme. Based on the definition of the priority scheme, one primary contributing factor was chosen for the cases with multiple casual factors using the ranking of the factors. Therefore, the 14% case discrepancy between the two databases may reflect GES cases where adverse environmental conditions existed but were not the primary factor in the crash.

4. REAR-END CRASH TYPE – PHASE 1

4.1 DEFINITION OF CASES

Rear-end (RE) crashes are defined as crashes in which the front of the following vehicle strikes the rear of a lead vehicle. Both vehicles must be traveling in the same lane. Cases were selected from the CDS and GES based on *Accident Type* variable codes 20-43. In order to accurately match the two databases, the GES had to be further restricted since the CDS only involves cases where a light vehicle was towed from the scene due to damage. To ensure that the correct contributing factors for each RE case are used, the striking vehicle had to be determined. Selection of the striking vehicle and the lead vehicle was established from the *general area of damage* attribute. In the case of three vehicle crashes, the striking and struck vehicle would be the following vehicle. However, since it was difficult to determine this information from the *general area of damage*, the analysis was restricted to two-vehicle crashes.

4.1.1 General Area of Damage

Due to limitations in the CDS database, the RE collision analysis was restricted to collisions involving two vehicles. Contributing factors were determined for only one of the vehicles involved in the crash, specifically the following vehicle. The appropriate vehicle was selected by determining which vehicle was the striking vehicle, and that vehicle was then examined to ensure it was a light vehicle.

The method for determining the striking vehicle varied based on each of the databases. For the GES database, the vehicle's role in the crash was determined based on the variable V22 *Vehicle Role* located in the Vehicle/Driver File. Additional information about this variable can be found in Appendix C. For the CDS however, there is not a vehicle role variable. Therefore, a method for determining the vehicle's role in the collision had to be determined. RE collisions were previously defined as crashes where "the front of the following vehicle strikes the rear of the lead vehicle, when all vehicles are traveling in the same lane." Based on this definition, both vehicles can be determined from the recorded area of damage for each vehicle. The codes for the *General Area of Damage* can be found on the Event Form separated by each vehicle. A vehicle coded as (F) Front, having frontal damage, would represent a striking vehicle in a two-car collision. A vehicle coded as (B) Back, having damage to its rear, would represent a vehicle that was struck. It should be noted that codes from the *Accident Type* variable were not used to identify the following vehicle because some codes refer to "specific other' or "specific unknown."

Given that the CDS database only involves vehicles that were towed from the scene due to damage, the vehicle that was the striking vehicle should be able to be determined based on the vehicle's damage. However, use of the codes for the *General Area of Damage* may result in a small error for collisions involving low impact velocities that produce limited or no visible damage and are thus not coded as sustaining front or rear damage. On the other hand, at least one of the vehicles was towed from the scene; therefore, it can be assumed that visible damage to

both vehicles should result in almost all cases. Since a *Vehicle Role* variable in the CDS does not exist, this method is required in order to distinguish between the striking and struck vehicle for each case. To eliminate the error caused by small impact velocities, it is recommended that the CDS database include a vehicle role variable similar to the GES.

4.2 RESULTS

4.2.1 RE Crash Contributing Factors

The contributing factors for RE crashes were determined by an in-depth examination of 1,080 CDS files and 4,477 GES PARs. Since the data from the CDS and GES were obtained from a sample of the population, each crash must be weighted to estimate national levels for the crash characteristics. After the cases were weighted, the results represented a total of 1,108,000 CDS PR crashes and 309,000 GES PR crashes. The results obtained from the contributing factor analysis are shown below and in Figure 7:

CDS (1997-2000)

- Inattention was the leading contributing factor, resulting in 39% of the collisions. The breakdown of driver inattention is provided in Appendix E. Distracted by outside was the most cited inattention factor.

- Alcohol accounted for 10% of the crashes and "other drugs" were cited for under 0.5%.

- 44% of the RE crashes occurred under adverse environmental conditions. The roadway surface was wet in 23% of the collisions and the lighting conditions were dark in 22%.

GES (2000)

- Similar to the CDS, inattention was the leading contributing factor, accounting for 65% of the crashes. The breakdown of driver inattention can be found in Appendix E. Distracted/lost in thought was the most cited inattention factor.

- Speeding was a contributing factor to 22% of the collisions.

- The driver was under the influence of alcohol in 7% of the cases, and drugs in 1%.

- The driver's obscured vision was a contributing factor in 4% of the crashes (rain/snow/smoke/sand/dust – 1%, glare, sunlight, headlights – 1%, moving vehicle – 1%).

- Failures in the vehicle's braking system contributed to 2% of the RE collisions.

- 40% of RE crashes occurred under adverse environmental conditions. The roadway surface was wet in 18% of the crashes and the lighting conditions were dark in 22% of the collisions.

4.2.2 Comparison of CDS and GES

A chart was created to compare the results of the contributing factors for RE crashes between the CDS and GES. Similar to the SVOR cases, the CDS and GES matched very well. As Figure 7 shows, inattention was the only factor in which the CDS and GES did not match within plus or minus 2%. For the case of inattention, the GES provided a higher representation on crashes caused by inattention, 65%, compared to 39% from the CDS. The CDS and GES databases also varied slightly for adverse environmental conditions.

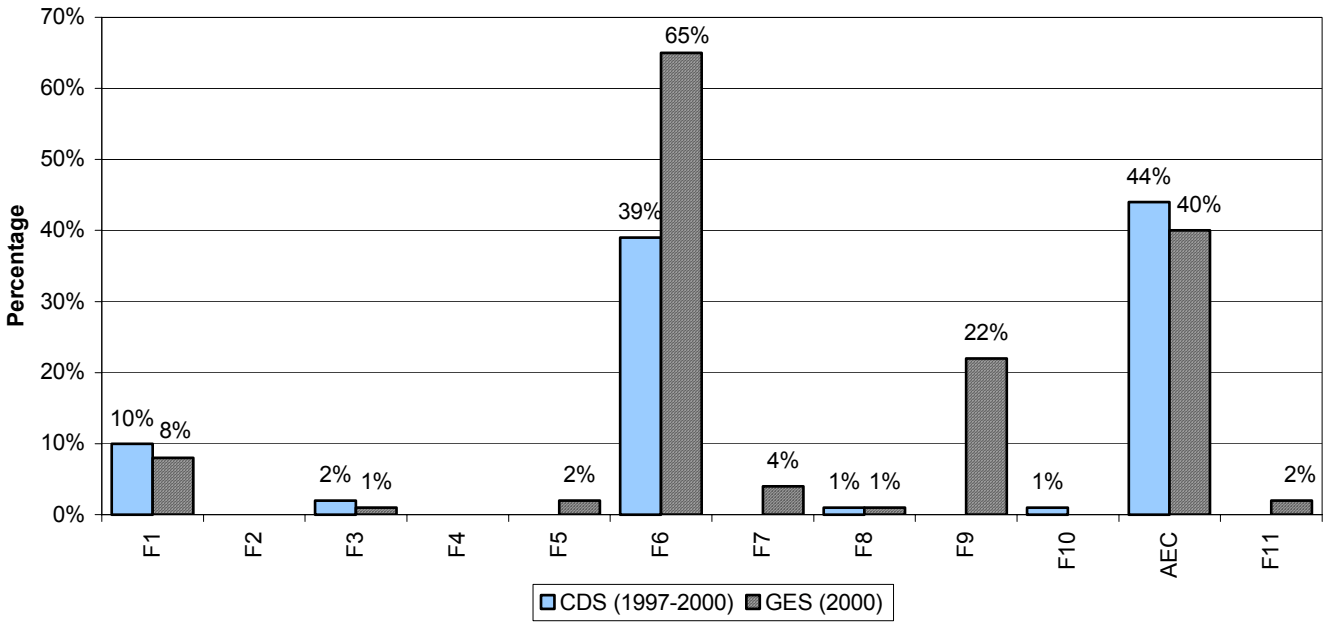


Figure 7. RE Comparison of CDS and GES Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

4.2.3 Cross-correlation of Multiple Factors

Since multiple factors often contribute to a crash, cross-correlation charts were created for the RE crash type. The relative frequency cross-correlation charts are provided for both databases in Figures 8 and 9.

Using the cross-correlation charts, it is possible to examine the interrelationships among the factors that might have collectively contributed to the collision. Notable findings from the cross-correlation charts include:

CDS (1997-2000)

- 1% of the RE cases involved a driver who was under the influence of alcohol/drugs and also inattentive.

- Alcohol/drugs were combined with adverse environmental conditions in 7% of the crashes.

- The combination of a sleepy/drowsy driver and adverse environmental conditions resulted in 1% of the collisions.

- An inattentive driver traveling under adverse environmental conditions contributed towards 6% of RE crashes.

- 1% of the crashes involving a loss of control resulting from speeding occurred under adverse environmental conditions.

GES (2000)

- Alcohol/drugs were combined with:
  - Inattentive driver (3% of crashes)
  - Vehicle losing control as a result of speeding (3% of crashes)
  - Vehicle traveling under adverse environmental conditions (5% of crashes)
  - Vehicle involved in a hit and run (1% of crashes)

- Adverse environmental conditions and vehicle defect existed in 1% of the RE crashes.

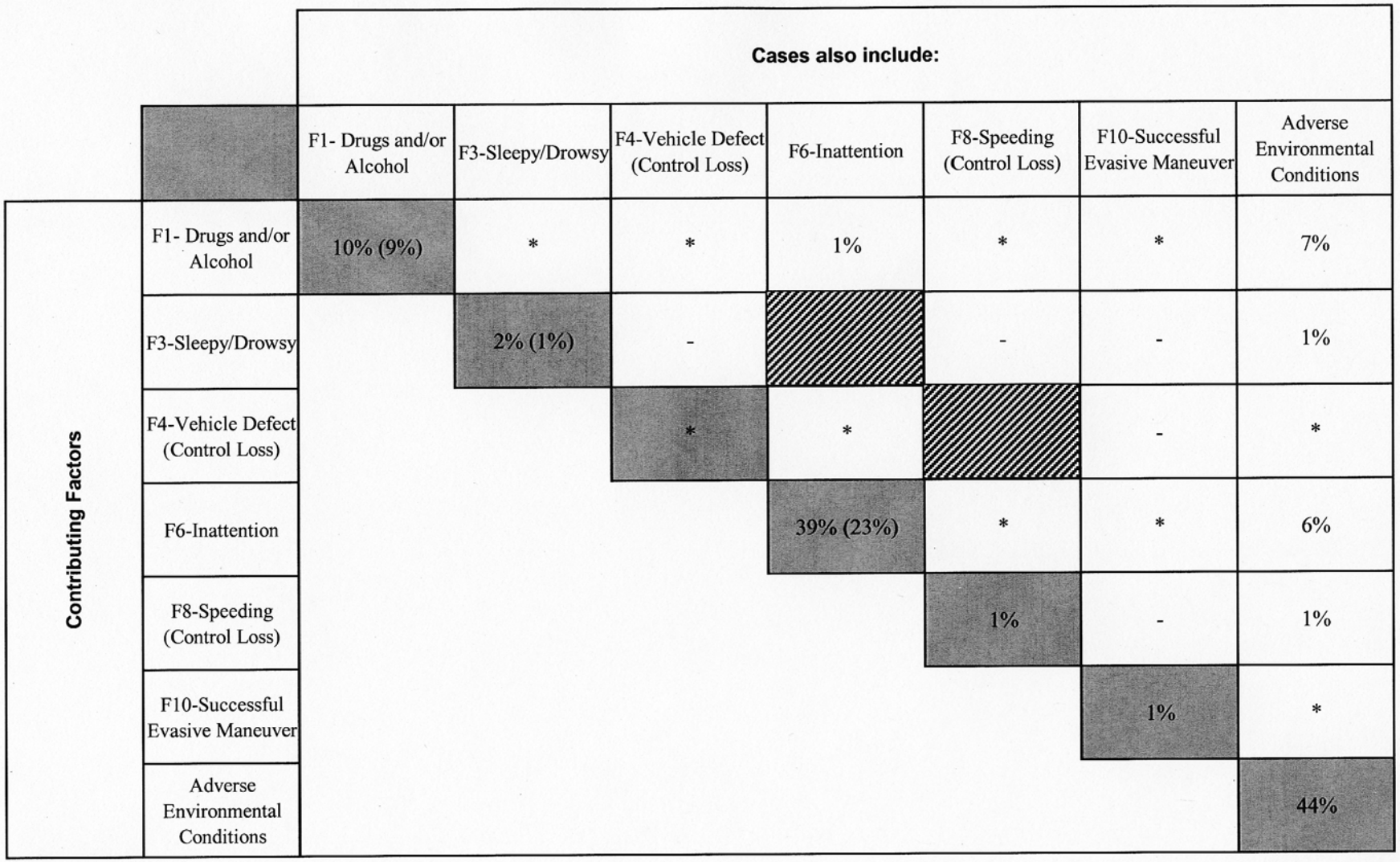
- An inattentive driver was combined with:
  - Driver whose vision was obscured (2% of crashes)
  - Vehicle losing control as a result of speeding (10% of crashes)
  - Vehicle traveling under adverse environmental conditions (14% of crashes)

- Speed was a contributing factor in 1% of the crashes where the driver's vision was obscured.

- Vehicles lost control as a result of speeding under adverse environmental conditions in 1% of crashes. On the other hand, speeding as a contributing factor under adverse environmental conditions was cited in 10% of crashes.

In the comparison of the CDS and GES contributing factors, small differences exist between some of the factors in the cross-correlation tables:

- As shown previously in Section 4.2.2, the GES was shown to provide more information on cases involving inattention. From the results of the cross-correlation charts, inattention and adverse environmental conditions occurred in 6% of the CDS cases, but in 14% of the GES cases.



= determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 8. Relative Frequency Cross-correlation Chart for CDS (RE)

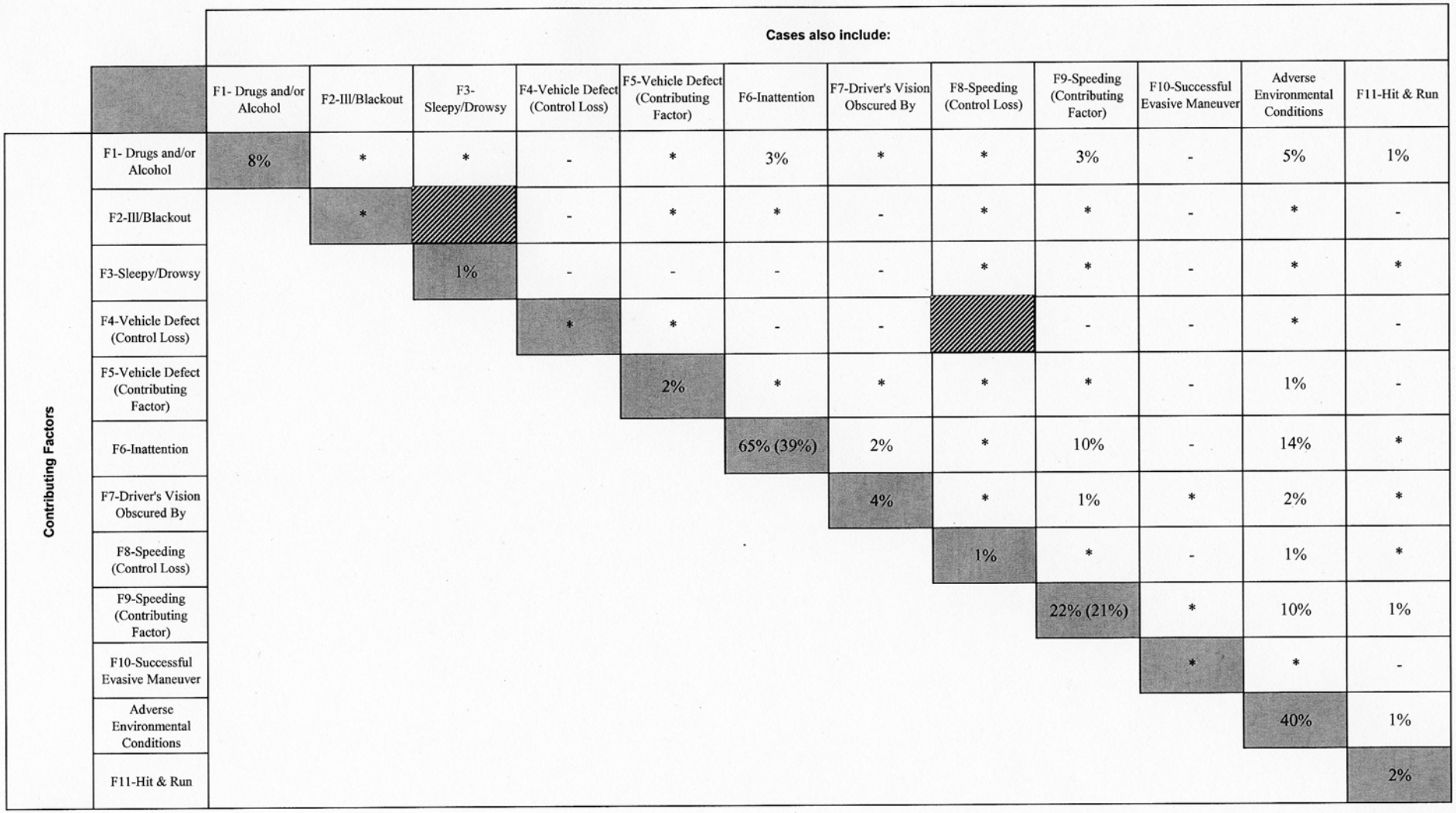


Figure 9. Relative Frequency Cross-correlation Chart for GES (RE)

Minor Differences:

- The combination of alcohol/drugs and an inattentive driver occurred in 1% of the CDS cases, but in 3% of the GES crashes.

- 7% of crashes in the CDS involved the combination of alcohol/drugs and adverse environmental conditions; however, only 5% of the GES cases did.

- A sleepy/drowsy driver was driving under adverse environmental conditions in 1% of the collisions in the CDS and in less than 0.5% in the GES.

4.2.4 Prioritization of Factors

Using the priority scheme, primary contributing factors were determined following the method described in Section 2.1.6. Table 4 provides the results of the priority scheme for the RE crash type.

Table 4. RE Priority Scheme

	CDS (1997-2000)	GES (2000)
Alcohol/Drugs *(F1)*	10%	8%
Ill/Blackout *(F2)*	~	0%
Sleepy/Drowsy *(F3)*	1%	1%
Vehicle Defect (CL) *(F4)*	0%	0%
Vehicle Defect (CF) *(F5)*	~	2%
Inattention *(F6)*	22%	35%
Driver's Vision Obscured *(F7)*	~	2%
Speeding (CL) *(F8)*	1%	1%
Speeding (CF) *(F9)*	~	8%
Successful Evasive Maneuver *(F10)*	1%	0%
Adverse Environmental Conditions *(AEC)*	30%	16%
Hit & Run *(F11)*	~	0%
Undetermined	35%	27%
TOTAL:	100%	100%

~ = Factor not provided in the CDS.

The analysis of the RE crash type with the priority scheme accounted for 65% of the CDS crashes and 73% of the GES crashes. The top two primary contributing factors for both the CDS and the GES were inattention and alcohol/drugs. Collectively, the two factors might have contributed to 32% of CDS cases and 43% of GES cases. A graphical representation of the results obtained from the priority scheme is shown in Figure 10. All of the percentages for each

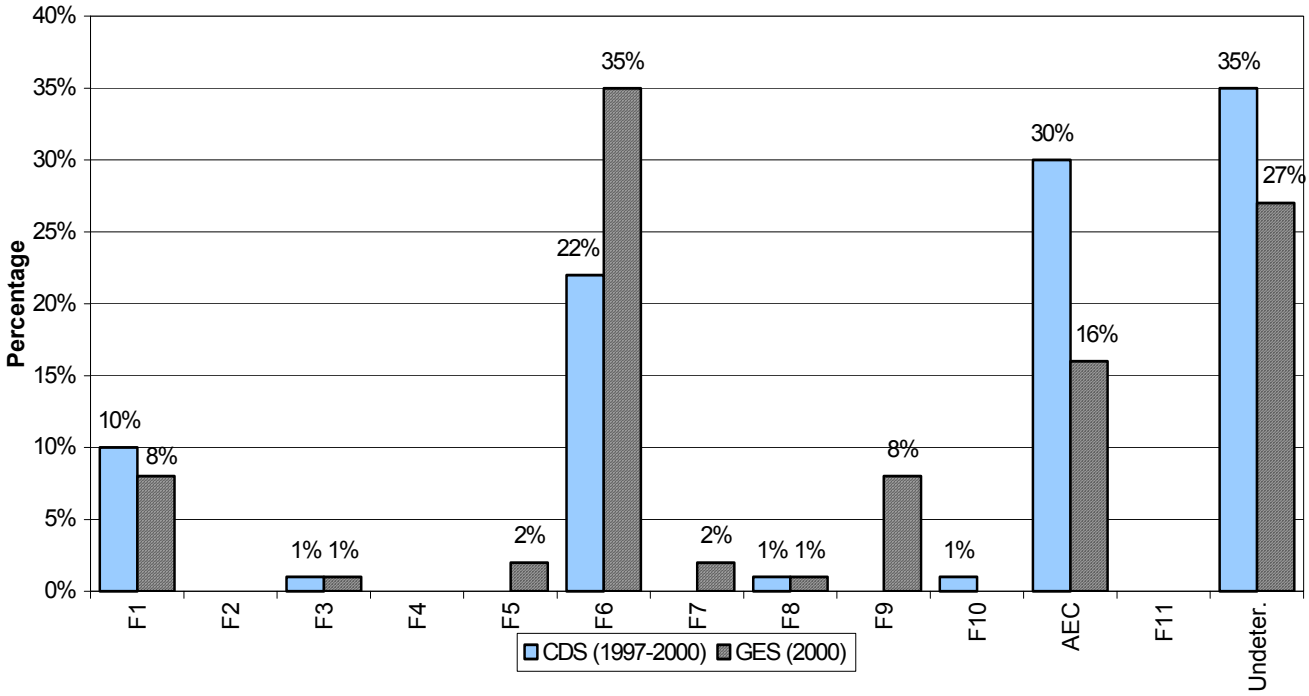


Figure 10. RE Crash Contributing Factors Using the Priority Scheme

factor are within plus or minus 5% except for the inattention factor (F6). Similar to the SVOR crash type, a discrepancy also existed in the variable adverse environmental conditions. As stated earlier, this difference is probably due to the method in which the cases were extracted using the priority scheme.

4.2.5 Differences in Prioritized Cases

The results from the priority scheme for the RE CDS and GES cases were found not to match as well as they did for the SVOR. Although only one of the factors has a discrepancy between the two databases of more than 5%, the priority scheme did not attribute a primary contributing factor to as many RE crashes as it did for SVOR crashes. The primary contributing factors for 35% and 27% of the RE cases in the CDS and GES were undetermined.

To gain more insight into this issue, the possibility of cases being incorrectly coded was examined. It is reasonable to assume that the following factors/variables have a very high probability of being coded correctly: adverse environmental conditions, alcohol/drugs (F1), vehicle defects (F4, F5), and control loss (F4, F8). The investigating team or police officers that respond to the crash are typically able to easily determine these six factors from an inspection of the crash scene, examination of the vehicle, and a breathalyzer/blood test. It is very difficult, however, for the investigating officer or the field research team to determine if the driver was ill or blacked out (F2), sleepy/drowsy (F3), inattentive (F6), or if their vision was obscured (F7). In these cases, they must rely on the information provided by the driver who is often reluctant to provide incriminating information. Therefore, it is quite possible that errors may exist in the

coding of these four factors. Table 5 provides the relative frequencies from the cross-correlation charts for each of these four factors.

Table 5. Select RE Cross-Correlation Data

	CDS (1997-2000)	GES (2000)
Ill/Blackout *(F2)*	~	*
Sleepy/Drowsy *(F3)*	2%	1%
Inattention *(F6)*	39%	65%
Driver's Vision Obscured *(F7)*	~	4%

~ = Factor not provided in the CDS.

* = Less than 0.5%

Looking at the distribution for the questionable variables, it is evident that the primary contributing factor for the majority of the cases was inattention. Driver's vision obscured is typically not a problem in RE crashes; obstructed vision usually plays a role in the lane change and crossing path crashes. Ill/blackout and sleepy/drowsy contributed respectively to less than 0.5% and 2% of the RE crashes. Therefore, due to a process of elimination, driver inattention probably was a contributing factor in the undetermined cases. It should be noted that some crash contributing factors such as "tailgating" or "following too closely," as reported in previous research (*5,7*), do not exist in the codes of any variable in both the CDS and GES.

5. LANE CHANGE CRASH TYPE – PHASE 1

5.1 DEFINITION OF CASES

Lane change (LC) crashes typically consist of a crash in which a vehicle attempts to change lanes, merge, pass, turn, leave/enter a parking position, or drifts and strikes, or is struck by another vehicle in the adjacent lane, both traveling in the same direction (*2*). Cases were selected from the CDS and GES based on *Accident Type* codes 44-49 and 70-73. To accurately match the two databases, the GES had to be further restricted since the CDS only involves cases where a light vehicle was towed from the scene due to damage. To ensure that the correct contributing factors for each LC crash are used, the vehicle that initiated the maneuver had to be determined.

A three-step priority approach was used to deduce which vehicle had initiated the maneuver in each crash.

Criterion 1: The analysis first selected the portion of crashes that involved a lane change (ACC_TYP: 44-49, 70-73). Both vehicles from the crash were analyzed. If either of the vehicles were coded with *Accident Type* 46, 47, 70, or 72, that vehicle was the initiating vehicle.

Criterion 2: If none of the vehicles met criterion 1, the variables *Univariate Imputed Movement Prior to Critical Event* for the GES, *Pre-Event Movement (Prior to Recognition of Critical Event)* for the CDS were analyzed to see if either vehicle contained the following codes:

8 – Leaving a Parked Position
9 – Entering a Parked Position
10 – Turning Right
11 – Turning Left
12 – Making a U-turn
15 – Changing Lanes
16 – Merging

The vehicle coded with the above codes was determined to have initiated the maneuver.

Criterion 3: If none of the vehicles met criterion 2, the variable *Critical Event* for the GES and *Critical Pre-Crash Event* for the CDS were examined. These variables were investigated to see which vehicle was coded as to having initiated the maneuver, codes 01-19. The vehicle meeting this criterion was determined to be the vehicle that initiated the maneuver.

The priority approach was adopted because using only the *Critical Event* variable would not have yielded the entire crash type. The *Critical Event* variable identifies the critical event which made the crash imminent, including whether the vehicle encroached into another vehicle's lane or if another vehicle encroached into its lane. Criterion 3 was not solely used to determine the initiating vehicle since in 1999, NASS removed the following codes: *Encroaching into Another*

Vehicle's Lane from Adjacent Lane (Same Direction) – Over Left Lane Line, From Adjacent Lane (Same Direction) – Over Right Lane Line, and From Parallel/Diagonal Parking Lane.

5.2 RESULTS

5.2.1 LC Crash Contributing Factors

The contributing factors for LC crashes were determined by an in-depth examination of 583 CDS files and 2,469 GES PARs. Since the data from the CDS and GES were obtained from a sample of the population, each crash must be weighted to estimate national levels for the crash characteristics. After the cases were weighted, the results represented a total of 464,000 CDS PR crashes and 95,000 GES PR crashes. The results obtained from the contributing factor analysis are shown below and in Figure 11:

CDS (1997-2000)

- Driver inattention contributed to a total of 33% of the crashes. Drivers who looked but did not see the surrounding vehicles contributed to the largest portion of the cases (23%), as seen in Appendix E.

- Alcohol accounted for 8% of the crashes and "other drugs" were cited in under 0.5%.

- A successful evasive maneuver and a control loss resulting from speeding resulted in 3% and 4% of the crashes, respectively.

- 54% of the LC collisions occurred under adverse environmental conditions. The top three adverse conditions were dark/lighted roadways 27%, wet road surface 25%, and rain 19%.

GES (2000)

- Inattention was the leading crash contributing factor accounting for 50% of the cases. The driver was distracted/lost in thought in 35% of the cases as shown in Appendix E.

- Speeding was a contributing factor in 13% of the crashes and caused the vehicle to lose control in 12%.

- A driver was under the influence of alcohol in 6% of the crashes and was under the influence of "other drugs" in 1%.

- Vehicle defects dealing with the tires (blowout/flat tire) contributed to 2% of the crashes.

- 7% of the crashes were hit and run.

- Similar to the CDS, a large portion of the LC crashes (42%) occurred under adverse environmental conditions. Moreover, the top three adverse conditions were dark/lighted roadways, wet road surface, and rain.

5.2.2 Comparison of CDS and GES

A comparison of the results obtained from the LC crash type analysis is shown in Figure 11. The two databases matched within 2% for all factors/variables except inattention (F6), speeding resulting in a control loss (F8), and adverse environmental conditions. The GES attributed a larger percentage of crashes to driver inattention and to a vehicle losing control as a result of speeding than the CDS. On the contrary, the CDS associated more crashes under environmental conditions than the GES.

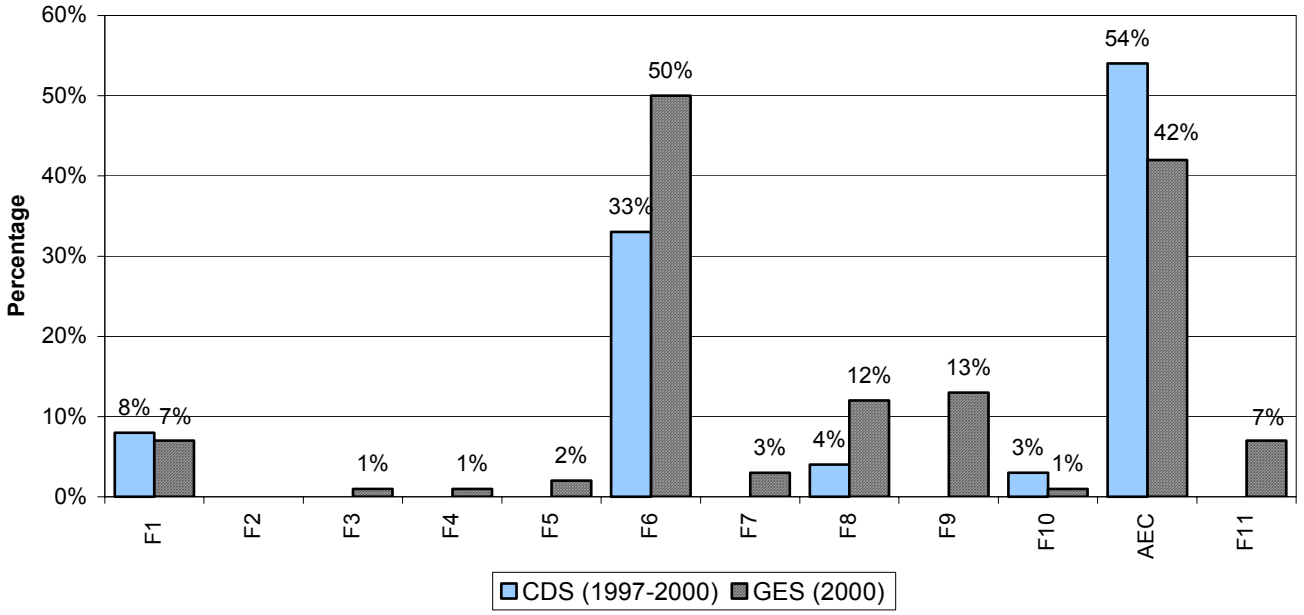


Figure 11. LC Comparison of CDS and GES Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

5.2.3 Cross-correlation of Multiple Factors

To account for the fact that multiple factors often contribute to a crash, cross-correlation charts were created for the LC crash type. The cross-correlation charts present any interrelationships that exist among the different variables. The relative frequency cross-correlation charts for the CDS and GES are provided in Figures 12 and 13.

CDS (1997-2000)

- Alcohol/drugs were combined with adverse environmental conditions in 3% of the crashes.

- 5% of the cases involved an inattentive driver driving under adverse environmental conditions.

- Adverse environmental conditions were combined with:
  - Vehicle which recently completed a successful evasive maneuver (1% of crashes)
  - Vehicle which lost control as a result of speeding (4% of crashes)

GES (2000)

- Alcohol/drugs were combined with:
  - Inattentive driver (2% of crashes)
  - Vehicle which lost control as a result of speeding (1% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (1% of crashes)

- An inattentive driver was a factor in:
  - Driver whose vision was obscured (1% of crashes)
  - Vehicle which lost control as a result of speeding (2% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (3% of crashes)
  - Vehicle was traveling under adverse environmental conditions (10% of crashes)

- 7% of the cases were coded to include both speeding resulting in a control loss and speeding as a contributing factor.

- A driver traveling in adverse environmental conditions was combined with:
  - Alcohol/drugs (5% of crashes)
  - Driver whose vision was obstructed (1% of crashes)
  - Vehicle which lost control as a result of speeding (8% of crashes)
  - Vehicle where speeding was as a contributing factor to the crash (7% of crashes)

An analysis was conducted to compare the crash contributing factor interrelationships between the two databases. The results of the analysis yielded a few noteworthy discrepancies:

- Inattention and adverse environmental conditions occurred in 5% of the CDS cases, but in 10% of the GES cases.

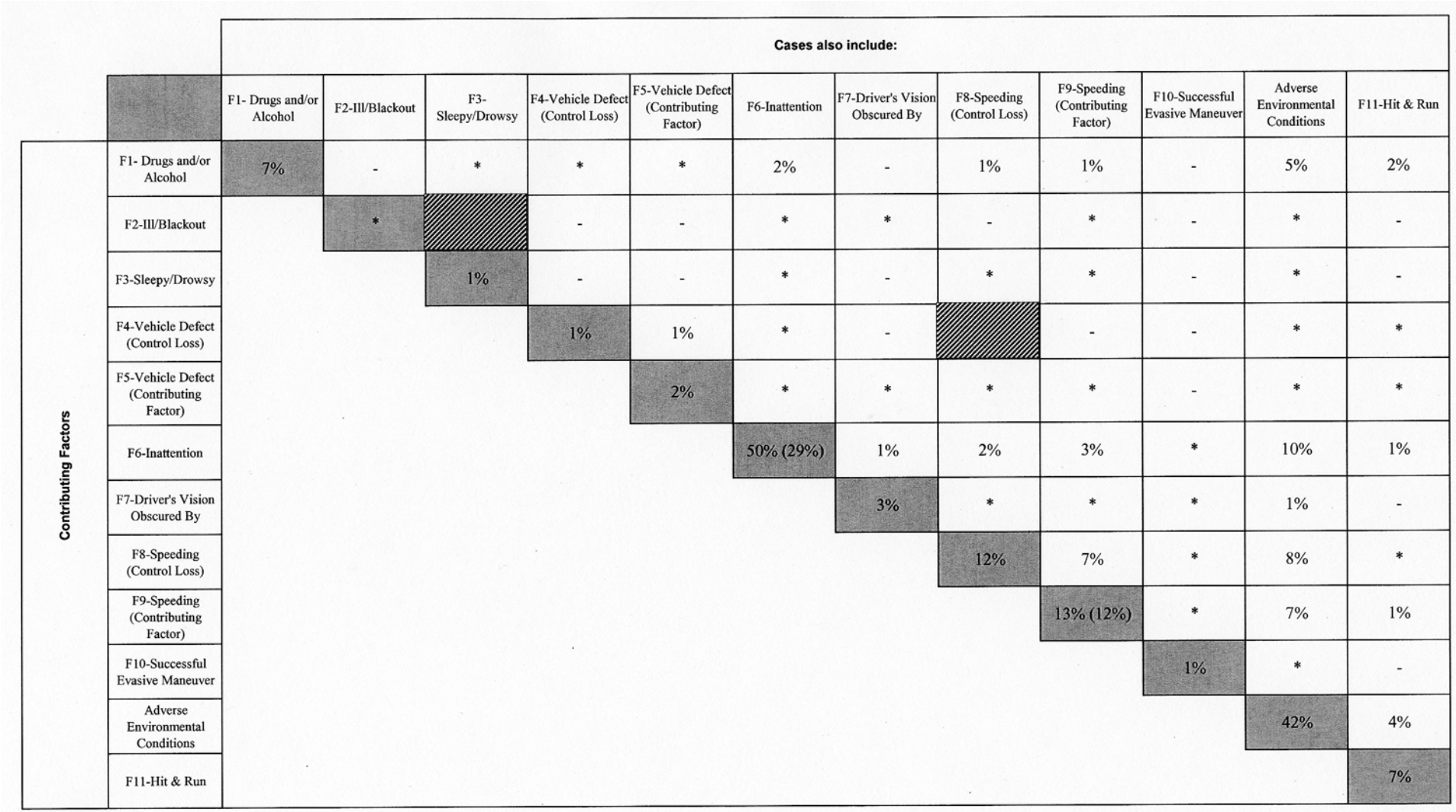
Contributing Factors	Cases also include: F1- Drugs and/or Alcohol	F3-Sleepy/Drowsy	F4-Vehicle Defect (Control Loss)	F6-Inattention	F8-Speeding (Control Loss)	F10-Successful Evasive Maneuver	Adverse Environmental Conditions
F1- Drugs and/or Alcohol	8% (6%)	*	-	*	*	*	3%
F3-Sleepy/Drowsy		*	-	[hatched]	*	-	*
F4-Vehicle Defect (Control Loss)			*	*	[hatched]	-	*
F6-Inattention				33% (12%)	*	*	5%
F8-Speeding (Control Loss)					4%	-	4%
F10-Successful Evasive Maneuver						3%	1%
Adverse Environmental Conditions							54%

[hatched] = determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 12. Relative Frequency Cross-correlation Chart for CDS (LC)



= determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 13. Relative Frequency Cross-correlation Chart for GES (LC)

Minor Differences:

- Adverse environmental conditions were combined with speeding control loss in 8% of the GES cases, but in only 4% of the CDS.

- 5% of crashes in the GES involved the combination of alcohol/drugs and adverse environmental conditions, as opposed to 3% of the cases in the CDS.

- The combination of alcohol/drugs and inattention occurred in less than 0.5% of the CDS cases, but in 2% of the GES crashes.

- An inattentive driver was combined with a control loss resulting from speeding in 2% of the GES cases and in less than 0.5% of the CDS.

5.2.4 Prioritization of Factors

Primary crash contributing factors were determined for each collision using the priority scheme previously described. The distribution for the priority scheme for LC crashes is shown in Table 6.

Table 6. LC Priority Scheme

	CDS (1997-2000)	GES (2000)
Alcohol/Drugs *(F1)*	6%	7%
Ill/Blackout *(F2)*	~	0%
Sleepy/Drowsy *(F3)*	0%	0%
Vehicle Defect (CL) *(F4)*	0%	1%
Vehicle Defect (CF) *(F5)*	~	1%
Inattention *(F6)*	12%	26%
Driver's Vision Obscured *(F7)*	~	1%
Speeding (CL) *(F8)*	4%	8%
Speeding (CF) *(F9)*	~	2%
Successful Evasive Maneuver *(F10)*	2%	0%
Adverse Environmental Conditions *(AEC)*	41%	19%
Hit & Run *(F11)*	~	1%
Undetermined	35%	34%
TOTAL:	100%	100%

~ = Factor not provided in the CDS.

The analysis conducted using the priority scheme accounted for 65% of the CDS and 66% of the GES primary contributing factors. Inattention was the largest primary contributing factor for the

LC crash type. Figure 14 graphically presents the results from Table 6. The distributions for the primary factors matched within 5% for all of the factors except for driver inattention (F6). Similar to the other two crash types, the GES attributed a larger percentage of collisions to driver inattention than the CDS. The discrepancy between the two databases in the adverse environmental conditions variable can be explained by the interrelationships that exist between the factors. The cross-correlation chart for the GES shows that 10% of the cases where inattention was a factor also involved adverse environmental conditions, which partially explains the 22% difference between the CDS and GES for the adverse environmental conditions variable.

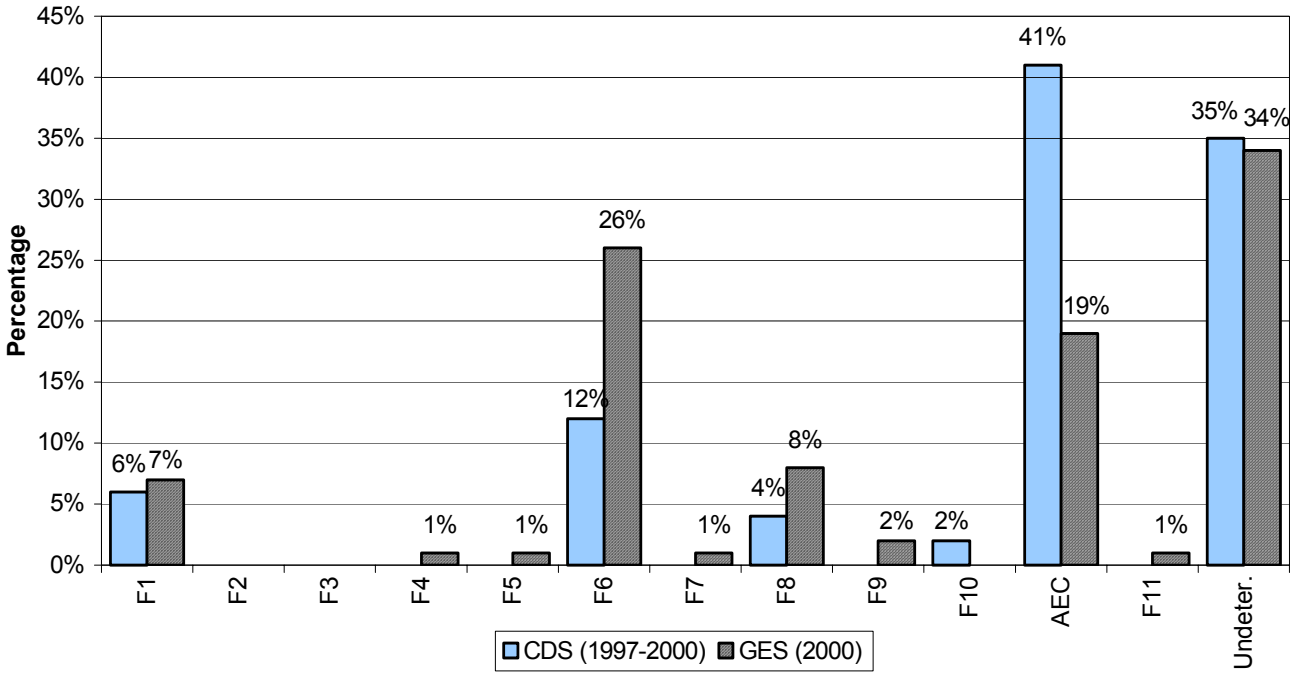


Figure 14. LC Crash Contributing Factors Using the Priority Scheme

5.2.5 Examination of Unknowns

One possible explanation for the large number of undetermined cases in the priority scheme may be the unknowns in each factor. An examination of the total number of unknowns, looking at all "unknown" and "not reported" cases was performed. Table 7 shows the total number of unknowns found in each factor, separated out by crash type and database. Some of the GES variables are referenced as "Imputed Variables." These variables have undergone a univariate imputation procedure that randomly assigns values to the unknowns in the same proportion as the known values for that one variable.

Looking at the total number of unknowns in the CDS and the GES, an exact match for the inattention factor was found for the SVOR and RE crash types. For the case of the LC crash type, a 20% discrepancy exists between the two databases. The CDS and GES match reasonably

well for all other factors except for alcohol/drugs (F1) and sleepy/drowsy (F3). In all of these cases, the CDS contains a larger percentage of unknowns than the GES. The discrepancies between the two databases in the number of unknowns are important to consider when picking a database for analysis. It is important that the database chosen provides a reasonable amount of information on the factors pertinent to the research.

Table 7. Comparison of Unknowns by Crash Type and Database

	SVOR		RE		LC	
	CDS	GES	CDS	GES	CDS	GES
Alcohol/Drugs (F1)						
Alcohol	12%	0%	6%	0%	20%	6%
Drugs	24%	14%	23%	10%	32%	14%
Ill/Blackout (F2)	~	5%	~	1%	~	4%
Sleepy/Drowsy (F3)	41%	5%	41%	1%	64%	4%
Vehicle Defect (CL) (F4)	3%	2%	1%	0%	2%	0%
Vehicle Defect (CF) (F5)	~	3%	~	2%	~	1%
Inattention (F6)	41%	41%	41%	41%	64%	44%
Driver's Vision Obscured (F7)	~	1%	~	0%	~	0%
Speeding (CL) (F8)	3%	2%	1%	0%	2%	0%
Speeding (CF) (F9)	~	9%	~	6%	~	14%
Successful Evasive Maneuver (F10)	3%	0%	0%	0%	10%	0%
Adverse Environmental Conditions (AEC)						
Roadway Surface Condition	0%	^	0%	^	0%	^
Lighting Condition	1%	^	0%	^	0%	^
Atmospheric Condition	0%	^	0%	^	0%	^
Hit & Run (F11)	~	^	~	^	~	^

~ = Factor not provided in the CDS.

^ = Imputed variable.

With a large percentage of unknowns in each category, the priority scheme is unable to detect the primary contributing factors for these cases. However, using the information provided in Table 7 and the distribution of contributing factors for each crash type, a prediction for the primary contributing factors for the undetermined cases can be made. The two factors with the largest percentage of unknowns in the databases are factor F3, sleepy/drowsy, and factor F6, inattention. The percentage of unknowns for the factors ranged from 41% to 64% in the CDS and from 41% to 44% in the GES. The distribution of F3 and F6 primary contributing factors is shown in Table 8.

Table 8. Primary Contributing Factor Distribution of F3 and F6 Without Redistribution of Unknowns

	CDS (1997-2000)	GES (2000)
Sleepy/Drowsy *(F3)*		
SVOR	5%	6%
RE	1%	1%
LC	0%	0%
Inattention *(F6)*		
SVOR	12%	14%
RE	22%	35%
LC	12%	26%

The primary distribution of contributing factors for the sleepy/drowsy factor varied from 0% to 6%, compared to the primary distribution of the inattention factor that varied from 12% to 35%. Since the inattention factor was a primary factor in a larger percentage of crashes than the sleepy/drowsy factor, it is reasonable to assume that inattention is the primary factor in a large percentage of the undetermined cases.

6. SINGLE VEHICLE OFF-ROADWAY CRASH TYPE – PHASE 2

6.1 DEFINITION OF CASES

Single vehicle off-roadway (SVOR) cases for phase two were selected from the GES based on *Accident Type* variable codes 01-12 and 14-16. The GES cases were further separated into the following categories: *towed due to damage* and *other*. The *other* category includes all cases where the vehicle was towed not due to damage or where the vehicle was driven from the scene.

6.2 RESULTS

The results for the GES SVOR *towed due to damage* cases were previously presented in Section 3.2.1. Therefore, results in this section will be presented for the GES SVOR *other* cases and a comparison between the severe and less severe crashes will be made.

6.2.1 SVOR *Other* Crash Contributing Factors

The contributing factors for SVOR *other* crashes were determined from an in-depth examination of 2,336 GES PARs. These crash reports were weighted to a total of 450,000 PR crashes to provide an estimate of the national level for the crash characteristics. The results obtained from the contributing factor analysis for the SVOR *other* cases are shown below and in Figure 15.

GES *OTHER* (2000)

- 37% of the SVOR *other* crashes involved an inattentive driver. Distracted/lost in thought was the most cited as provided in Appendix E.

- The second leading crash contributing factor was speeding resulting in a control loss (35%), followed by speeding as a contributing factor (33%). It should be noted that speeding (CF) encompasses all control loss cases due to excessive speed (travel speed > speed limit) and does not include control loss cases due to speeding on poor roadway conditions (e.g., icy).

- The driver was under the influence of alcohol/drugs in 14% of the crashes.

- 68% of the crashes occurred under adverse environmental conditions.

6.2.2 Comparison of the GES *Towed Due to Damage* and *Other* Cases

The primary goal of phase two is to examine the issue of severity. Contributing factors were determined for severe collisions (*towed due to damage*) and less severe collisions (*other*). A comparison between the contributing factors for the two categories is shown in Figure 15.

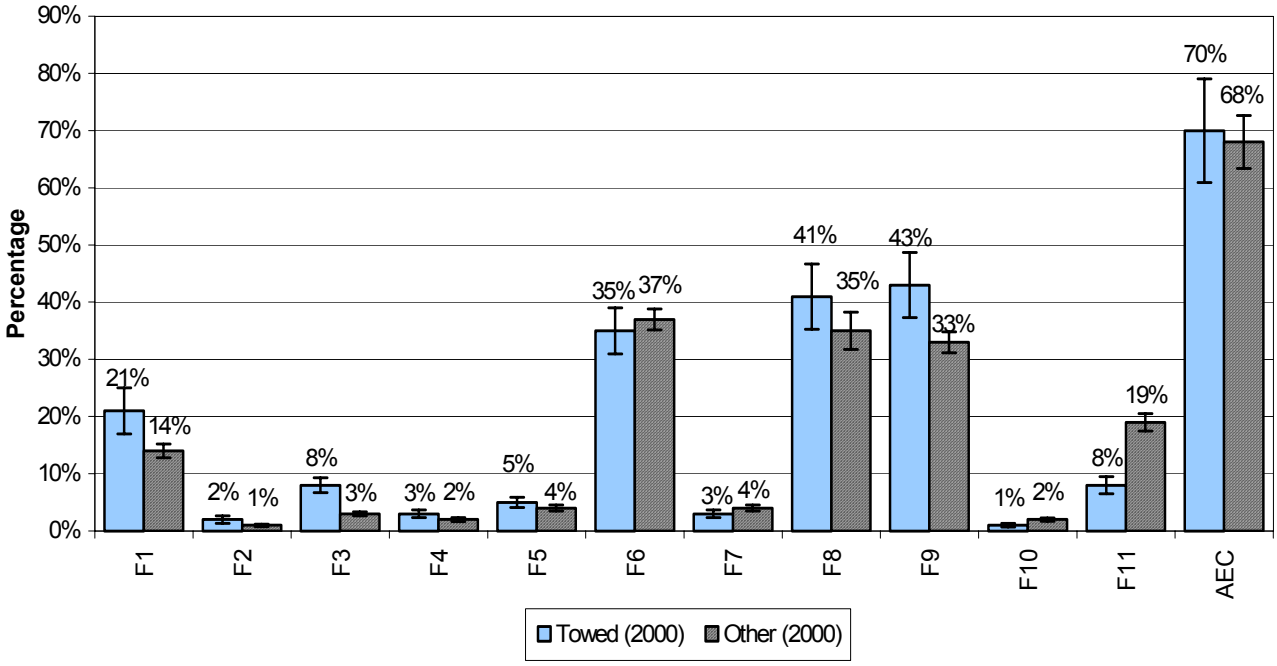


Figure 15: SVOR Comparison of GES *Towed Due to Damage* and *Other* Contributing Factors.

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

Error bars were added in order to determine if the difference between the *towed due to damage* and *other* contributing factors was statistically significant. The error bars represent the 95th percentile confidence interval for each contributing factor. In calculating the error, the estimated number of crashes in one year and the standard error are used. Additional information on the standard error can be found in Section 1.2.3. The varying length of error bars in Figure 15 is due to the differences in the total crash estimates for each category, *towed due to damage* and *other*. If the two error bars do not overlap for a particular contributing factor, the difference between the two crash categories is statistically significant.

Based on the results, the differences between the results of five contributing factors were found to be statistically significant (i.e., severity does play a role in these factors). The five factors are:

- Alcohol/Drugs (F1)
- Drowsy/Sleepy (F3)
- Speeding (CF) (F9)

- Successful Evasive Maneuver (F10)
- Hit & Run (F11)

Consistent with current research, the contributing factor alcohol/drugs was found to play a role in crash severity. Based on the FARS database, alcohol was reported in 40% of the fatal U.S. crashes in 2000 (*1*). When drivers are under the influence of alcohol/drugs, their ability to quickly respond to situations is impaired. As shown earlier in the cross-correlation table for the GES, the combination of alcohol/drugs and speeding (either resulting in a control loss or as a contributing factor) was found in 7% of the crashes. The speed the vehicle is traveling at prior to impact also has a direct correlation to the severity of the crash. As the vehicle's speed increases, the driver has less time to perform an avoidance maneuver and the damage to the vehicle also increases due to the higher impact speed. As a result of the higher impact speed, the injury and fatality rate for the occupants are also higher. The crash severity of collisions was also affected by cases involving sleepy/drowsy drivers. Similar to drivers under the influence of alcohol/drugs, the ability of drivers to react to an impending situation is greatly impaired if they are sleepy/drowsy. Drivers are less likely to be able to avoid the collisions or at least perform an evasive maneuver to reduce the severity of the collision.

6.2.3 Cross-correlation of Multiple Factors

In order to examine the interrelationships between the contributing factors for the GES *other* crash category, a relative frequency cross-correlation chart is shown in Figure 16. Based on the results of the cross-correlation chart, the following was determined:

GES *OTHER* (2000)

- The combination of alcohol/drugs and a sleepy/drowsy driver was a factor in 1% of the SVOR *other* cases.

- An inattentive driver was combined with:
  - Alcohol/drugs (3% of crashes)
  - Driver whose vision was obscured (1% of crashes)
  - Vehicle which lost control as a result of speeding (5% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (5% of crashes)

- 7% of the crashes combined alcohol/drugs and speed (3% losing control as a result of speeding and 4% where speed was a contributing factor).

- Speeding as a contributing factor and speeding resulting in a control loss were reported in 21% of the crashes.

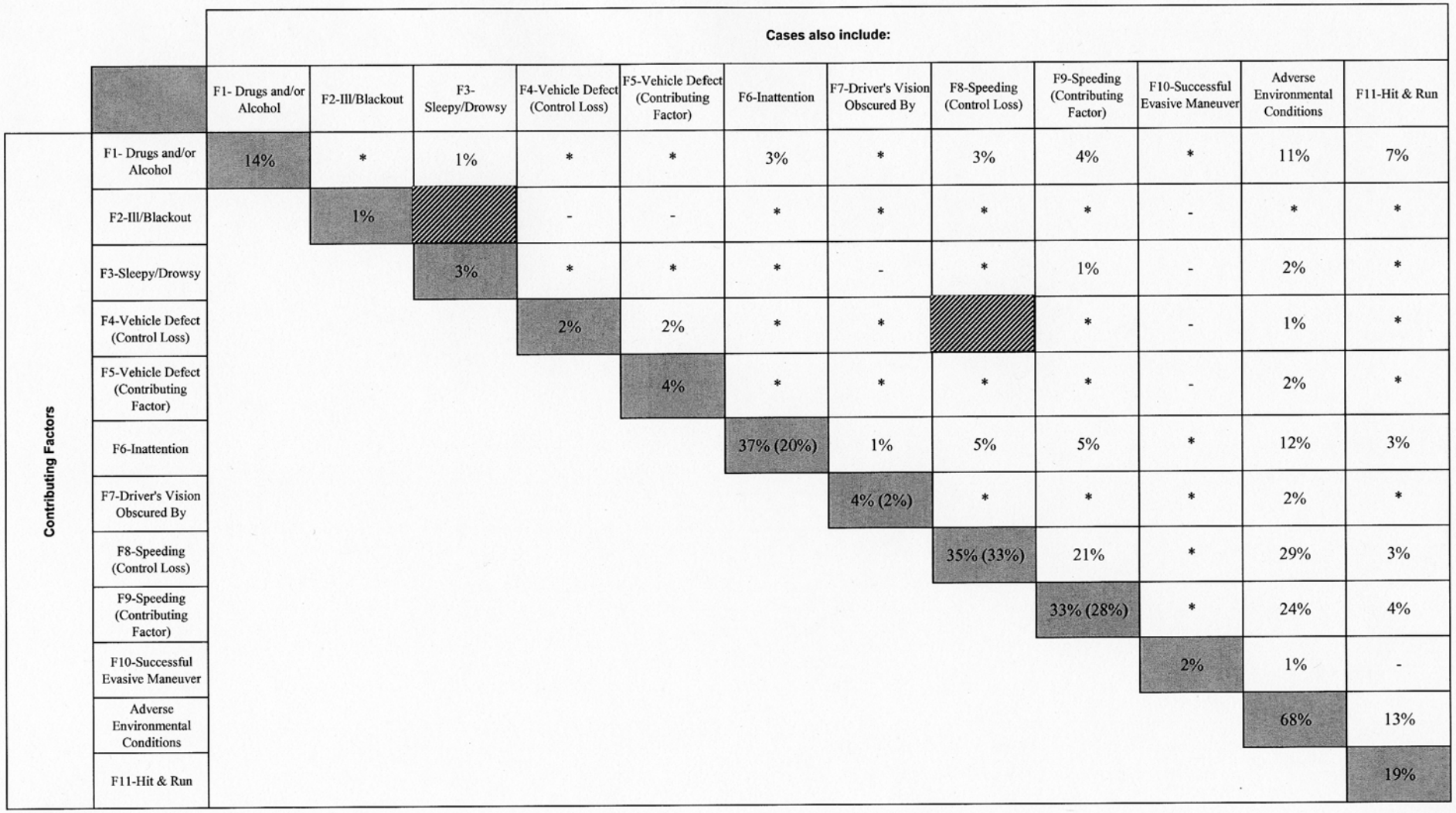


Figure 16. Relative Frequency Cross-correlation Chart for GES *Other* (SVOR)

- Adverse environmental conditions were combined with:
  - Alcohol/drugs (11% of crashes)
  - Sleepy/drowsy driver (2% of crashes)
  - Vehicle which lost control as a result of a vehicle defect (1% of crashes)
  - Vehicle with a defect that was a contributing factor in the crash (2% of crashes)
  - Inattentive driver (12% of crashes)
  - Driver whose vision was obstructed (2% of crashes)
  - Vehicle which lost control as a result of speeding (29% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (24% of crashes)
  - Vehicle which recently completed a successful evasive maneuver (1% of crashes)

In the comparison of the SVOR GES *towed due to damage* and *other* contributing factors, a number of the cross-correlations varied slightly between the two crash categories:

- As previously discussed, the vehicle's speed had a large effect on the severity of the crash. This point is further emphasized by the difference found between the *towed due to damage* and *other* crash categories shown in the cross-correlation of alcohol/drugs and speeding resulting in a control loss or speeding as a contributing factor. A crash involving a vehicle which loses control due to speeding and a driver under the influence of alcohol/drugs were found in 3% of the *other* cases, but in 7% of the *towed due to damage* crashes. The combination of speeding as a contributing factor and alcohol/drugs was found in 4% of the *other* cases compared to 9% of the *towed due to damage* cases.

- Speeding as a contributing factor and adverse environmental conditions were attributed to 30% of the *towed due to damage* crashes, compared to 24% of the *other* crashes.

- 18% of the GES *towed due to damage* crashes involved the combination of alcohol/drugs and adverse environmental conditions, as opposed to only 11% of the *other* cases.

Minor Differences:

- The combination of speeding resulting in a control loss and as a contributing factor was found in 25% of the *towed due to damage* cases, compared to 21% of the *other* cases.

- 33% of the *towed due to damage* crashes occurred when a vehicle lost control as the result of speeding under adverse environmental conditions. On the other hand, 29% of the other crashes occurred under the same conditions.

It is important to note that for all of the differences described above between the two crash categories, at least one, if not both of the factors included alcohol/drugs or speeding.

6.2.4 Prioritization of Factors

Primary crash contributing factors were determined for SVOR *other* crashes using the priority scheme previously described, as shown in Table 9.

Table 9. SVOR *Other* Priority Scheme

	GES *OTHER* (2000)
Alcohol/Drugs *(F1)*	14%
Ill/Blackout *(F2)*	1%
Sleepy/Drowsy *(F3)*	2%
Vehicle Defect (CL) *(F4)*	2%
Vehicle Defect (CF) *(F5)*	1%
Inattention *(F6)*	17%
Driver's Vision Obscured *(F7)*	2%
Speeding (CL) *(F8)*	25%
Speeding (CF) *(F9)*	3%
Successful Evasive Maneuver *(F10)*	1%
Adverse Environmental Conditions *(AEC)*	17%
Hit & Run *(F11)*	3%
Undetermined	12%
TOTAL:	100%

Using the priority scheme analysis, primary contributing factors were identified for 88% of the SVOR *other* crashes. The top three primary contributing factors for the SVOR GES *other* crashes are speeding resulting in a control loss, inattention, and alcohol/drugs. A graphical comparison between the priority scheme for the GES *towed due to damage* and *other* crash categories is shown in Figure 17.

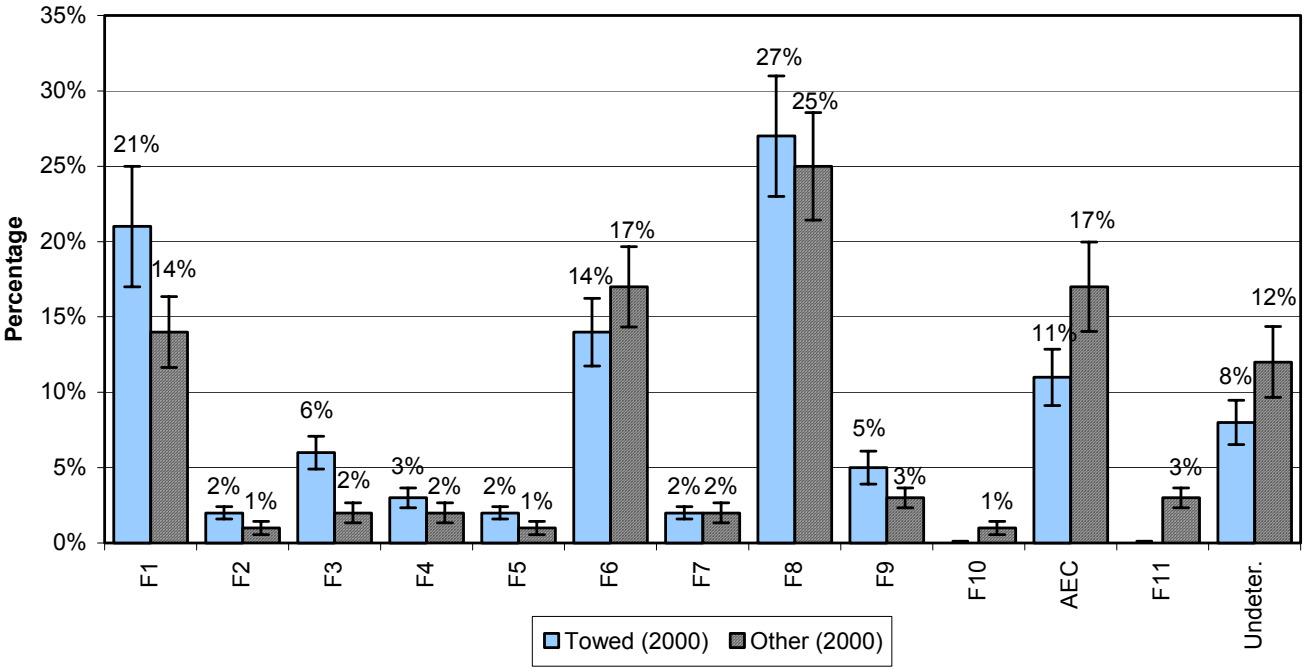


Figure 17. SVOR Severity Crash Contributing Factors Using the Priority Scheme

Based on the priority scheme analysis, alcohol/drugs (F1), sleepy/drowsy drivers (F3), speeding as a contributing factor (F9), successful evasive maneuver (F10), and hit and run crashes (F11) were found to play a role in crash severity (i.e., the difference between these factors was found to be statistically significant). Crashes involving vehicles that were towed from the scene due to damage were more likely to involve alcohol/drugs than crashes involving *other* vehicles. Crashes associated with sleepy/drowsy drivers or speeding as a contributing factor typically were severe crashes.

7. REAR-END CRASH TYPE – PHASE 2

7.1 DEFINITION OF CASES

Rear-end (RE) cases for phase two were selected from the GES based on *Accident Type* variable codes 20-43. Cases from the GES were further separated by severity. Severe crashes were defined as collisions that involved vehicles towed from the scene due to damage. Less severe crashes encompassed crashes where the vehicle was towed not due to damage or was driven from the scene.

7.2 RESULTS

Results for the *towed due to damage* RE crash type were previously presented in Section 4.2.1. The following sections will therefore present the data for the GES *other* crash category only. Comparisons will then be made between the two crash categories.

7.2.1 RE *Other* Crash Contributing Factors

The contributing factors for 2-vehicle RE *other* crashes were determined from an in-depth examination of 5,653 GES PARs. The crashes were weighted to a total of 1,132,000 GES PR crashes to provide an estimate of the national level for the crash characteristics. The results obtained from the contributing factor analysis for the RE *other* cases are shown below and in Figure 18.

GES *OTHER* (2000)

- Driver inattention was the leading crash contributing factor in 66% of the collisions. Distracted/lost in thought was the most cited as provided in Appendix E.
- Speeding was a contributing factor in 15% of the crashes.
- 4% of the collisions occurred while the driver was under the influence of alcohol/drugs.
- 6% of the crashes were hit and run.
- The driver's vision was obscured in 3% of the cases. Vehicle defects as a contributing factor and speeding resulting in a control loss accounted for 1% of the crashes each.
- 38% of the collisions occurred under adverse environmental conditions.

7.2.2 Comparison of the GES *Towed Due to Damage* and *Other* Crashes

The results of crash contributing factors for RE crashes where the vehicle was towed from the scene due to damage and cases where the vehicle was not towed due to damage are compared in

Figure 18. Error bars were added to determine whether or not the results were statistically significant. Based on the results portrayed in Figure 18, crash severity was found to play a role in the relative frequencies of the following contributing factors:

- Alcohol/Drugs (F1)
- Drowsy/Sleepy (F3)
- Vehicle Defect (CF) (F5)
- Speeding (CF) (F9)
- Hit & Run (F11)

As previously discussed in the analysis of the SVOR *other* crashes, the relative frequency of crashes cited with alcohol/drugs was found to vary based on the crash severity. Prior research has proven that crash severity and alcohol/drugs are directly related (*1*). The severity of the crash was also shown to be affected by the contributing factor speeding (CF) due to the higher impact speed. Through the RE severity analysis, crashes involving a sleepy/drowsy driver or a vehicle defect were also shown to be slightly more severe.

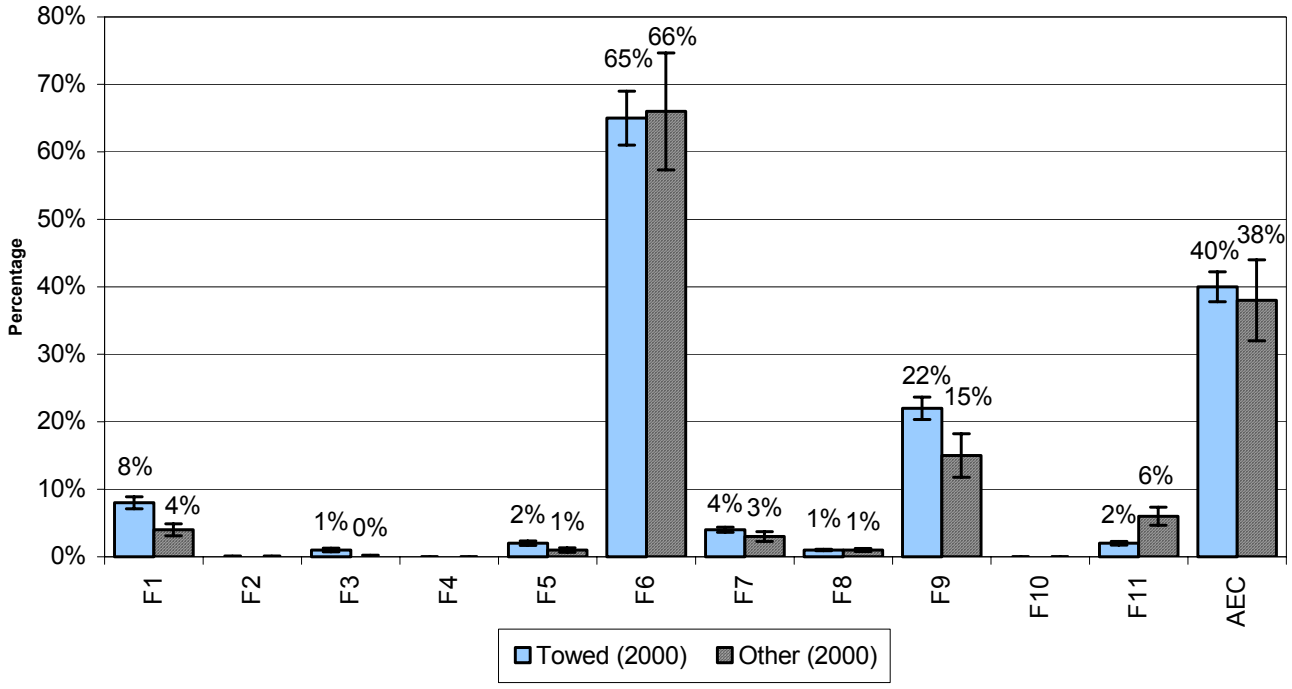


Figure 18. RE Comparison of GES *Towed Due to Damage* and *Other* Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

7.2.3 Cross-correlation of Multiple Factors

Cross-correlation charts were created in order to clarify the crash contributing factors for collisions occurring with more than one factor. The relative frequency cross-correlation chart for

the GES *other* crash category is provided in Figure 19 to examine the interrelationships between the contributing factors for the RE crash type. Notable interrelationships among the contributing factors include:

GES *OTHER* (2000)

- The combination of alcohol/drugs and inattention was a factor in 1% of RE *other* cases.

- The combination of alcohol/drugs and speeding as a contributing factor was involved in 1% of the crashes.

- An inattentive driver was combined with:
  - Vehicle where speeding was a contributing factor to the crash (6% of crashes)
  - Driver whose vision was obscured (1% of crashes)
  - Vehicle traveling under adverse environmental conditions (11% of crashes)

- A driver traveling in adverse environmental conditions was combined with:
  - Alcohol/drugs (2% of crashes)
  - Vehicle with a defect that was a contributing factor in the crash (1% of crashes)
  - Driver whose vision was obscured (1% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (5% of crashes)

By comparing RE GES *towed due to damage* to *other* contributing factors, a few of the cross-correlations varied slightly between the two crash categories as follows:

- Speeding as a contributing factor and adverse environmental conditions accounted for 10% of the *towed due to damage* crashes compared to 5% of the *other* crashes.

Minor Differences:

- Contrary to the severity analysis for the SVOR cases which found that alcohol/drugs and speeding (CF) played a large role in the severity of the crash; the severity of RE crashes were directly related to crashes involving an inattentive driver and speeding as a contributing factor. 6% of the *other* crashes included inattentive drivers and speeding compared to 10% of the *towed due to damage* crashes.

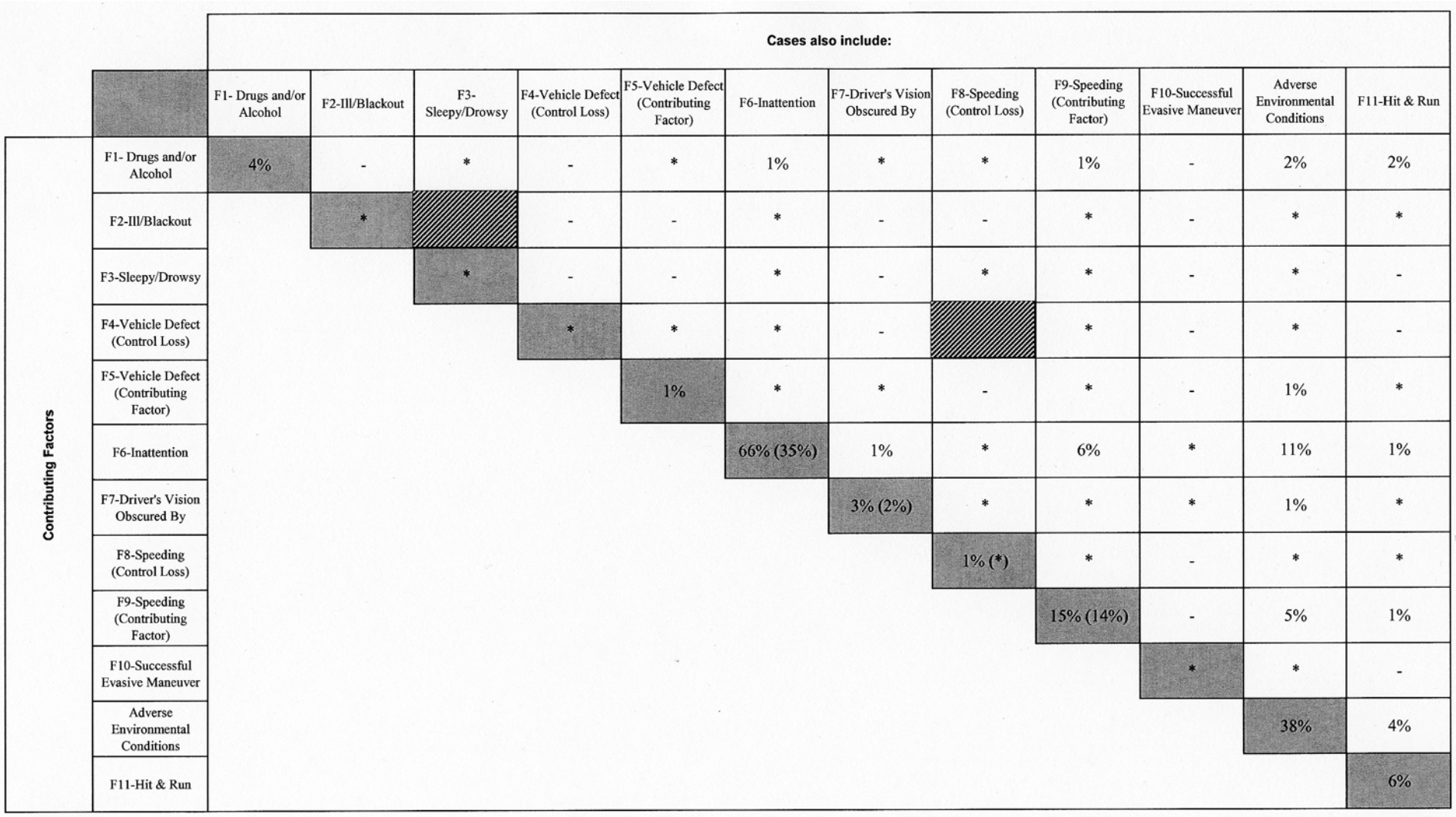


Figure 19. Relative Frequency Cross-correlation Chart for GES *Other* (RE)

- Collisions involving inattentive drivers traveling through adverse environmental conditions were found in 11% of the *other* crashes, compared to 14% of the *towed due to damage* crashes.

- 5% of GES *towed due to damage* crashes involved the combination of alcohol/drugs and adverse environmental conditions, as compared to only 2% of the *other* cases.

7.2.4 Prioritization of Factors

Primary crash contributing factors were determined using the priority scheme previously described for RE *other* crashes as shown in Table 10.

Table 10. RE *Other* Priority Scheme

	GES *OTHER* (2000)
Alcohol/Drugs *(F1)*	4%
Ill/Blackout *(F2)*	0%
Sleepy/Drowsy *(F3)*	0%
Vehicle Defect (CL) *(F4)*	0%
Vehicle Defect (CF) *(F5)*	1%
Inattention *(F6)*	35%
Driver's Vision Obscured *(F7)*	1%
Speeding (CL) *(F8)*	0%
Speeding (CF) *(F9)*	7%
Successful Evasive Maneuver *(F10)*	0%
Adverse Environmental Conditions *(AEC)*	20%
Hit & Run *(F11)*	1%
Undetermined	31%
TOTAL:	100%

Using the priority scheme analysis for the RE *other* crashes, primary contributing factors were identified for 69% of the crash category. Driver inattention, speeding as a contributing factor, and alcohol/drugs were the three primary contributing factors for RE *other* crashes. Adverse environmental conditions might have contributed to 20% of the *other* crashes. Additionally, 31% of the collisions with undetermined factors occurred during daylight hours on dry pavement in clear weather. A comparison between the primary contributing factors for the RE *towed due to damage* and *other* crash categories is shown in Figure 20.

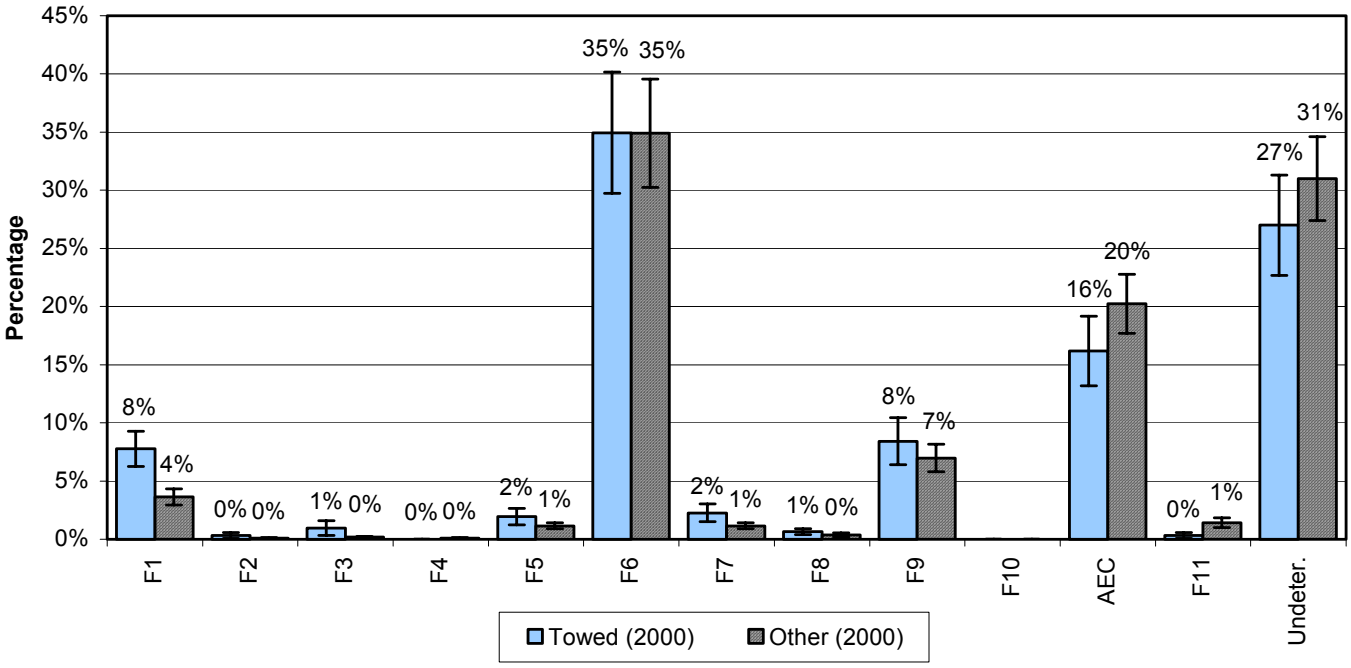


Figure 20. RE Severity Crash Contributing Factors Using the Priority Scheme

Based on the priority scheme analysis, alcohol/drugs (F1), sleepy/drowsy (F3), and hit and run (F11) were found to correlate with the severity of the crash. As seen in Figure 20, a collision involving a driver who was under the influence of alcohol/drugs tended to be a more severe crash (i.e., more vehicles had to be towed from the scene due to damage). Crashes involving sleepy/drowsy drivers typically were severe crashes. Hit and run crashes were found to be less severe collisions.

8. LANE CHANGE CRASH TYPE – PHASE 2

8.1 DEFINITION OF CASES

Lane change (LC) cases for phase two were selected from the GES based on *Accident Type* variable codes 44-49 and 70-73. Similar to the analysis from phase one, the vehicle which initiated the maneuver was determined using the priority analysis previously described in Section 5.1. The GES cases were further separated by severity into the following categories: *towed due to damage* and *other*. The *other* category includes all cases where the vehicle was towed not due to damage or was driven from the scene.

8.2 RESULTS

The results for the GES LC *towed due to damage* cases were previously presented in Section 5.2.1. Results will therefore only be presented for the GES LC *other* cases and then a comparison between the *towed due to damage* and *other* crashes will be made.

8.2.1 LC Other Crash Causes

The contributing factors for LC *other* crashes were determined from an in-depth examination of 2,001 GES coded PARs. The crashes were weighted to a total of 412,000 GES PR crashes to provide an estimate of the national level for the crash characteristics. The results obtained from the contributing factor analysis for the LC *other* cases are shown below and in Figure 21.

GES *OTHER* (2000)

- Driver inattention was the leading crash contributing factor in 62% of the collisions. Distracted/lost in thought was the most cited as shown in Appendix E.
- 14% of crashes were hit and run.
- 5% of the crashes were cases where the vehicle's speed was a contributing factor, and 4% involved a vehicle losing control as a result of speeding.
- A driver under the influence of alcohol/drugs was cited in 4% of the crashes.
- Driver's obscured vision was reported in 4% of the collisions.
- 1% of crashes had vehicle defect as a contributing factor.
- Adverse environmental conditions were reported in 39% of the collisions.

8.2.2 Comparison of the GES *Towed Due to Damage* and *Other* Crashes

Figure 21 provides a comparison graph of the factors between severe collisions (*towed due to damage*) and less severe collisions (*other*). Error bars were added to the figure in order to determine if the difference between the two crash severities was statistically significant. A statistically significant difference was found in the following crash factors:

- Drowsy/Sleepy (F3)
- Speeding (CL) (F8)
- Speeding (CF) (F9)
- Hit & Run (F11)

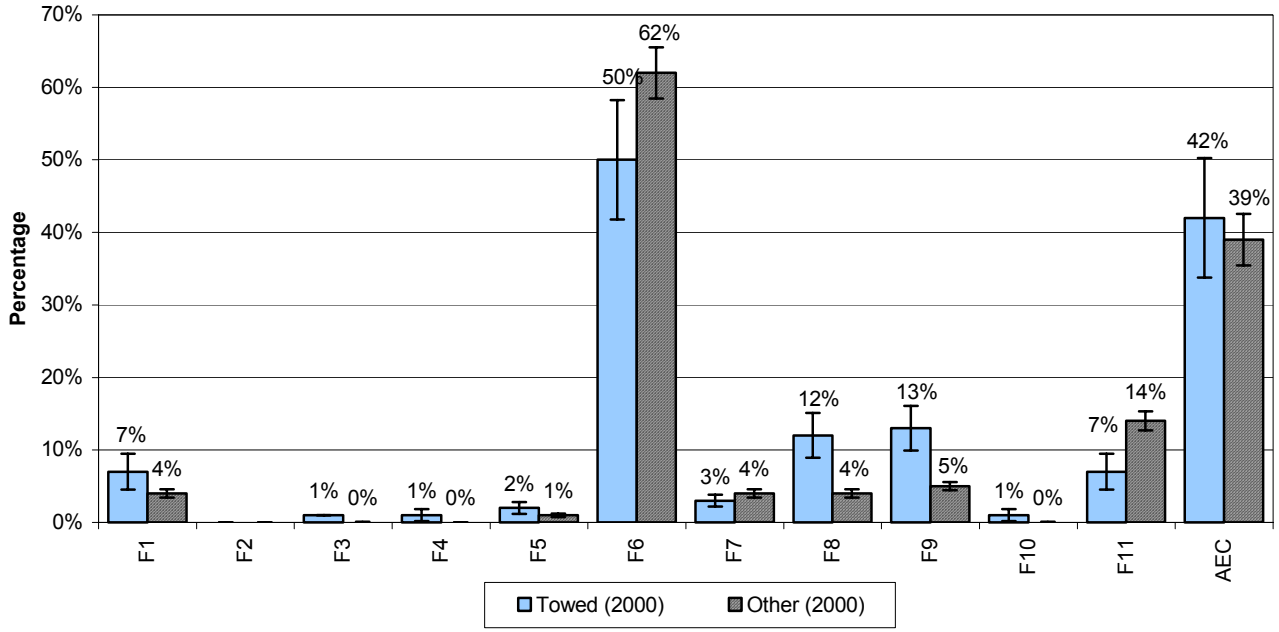


Figure 21. LC Comparison of GES *Towed Due to Damage* and *Other* Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

A larger percentage of crashes in the GES *towed due to damage* crash category than in the GES *other* category involved the following contributing factors: a drowsy/sleepy driver, speeding resulting in a control loss, and speeding as a contributing factor. Crashes involving these contributing factors tended to be more severe collisions. Furthermore, it was found that a smaller number of crashes were coded as hit and run in the *towed due to damage* category than in the *other* category.

8.2.3 Cross-correlation of Multiple Factors

The relative frequency cross-correlation chart for the GES *other* crash category is provided in Figure 22. Notable findings from this chart include:

GES *OTHER* (2000)

- An inattentive driver was combined with:
  - Alcohol/drugs (1% of crashes)
  - Driver whose vision was obstructed (2% of crashes)
  - Vehicle which lost control as a result of speeding (1% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (1% of crashes)
  - Vehicle traveling under adverse environmental conditions (12% of crashes)

- Speeding as a contributing factor and resulting in vehicle loss of control was reported in 3% of the collisions.

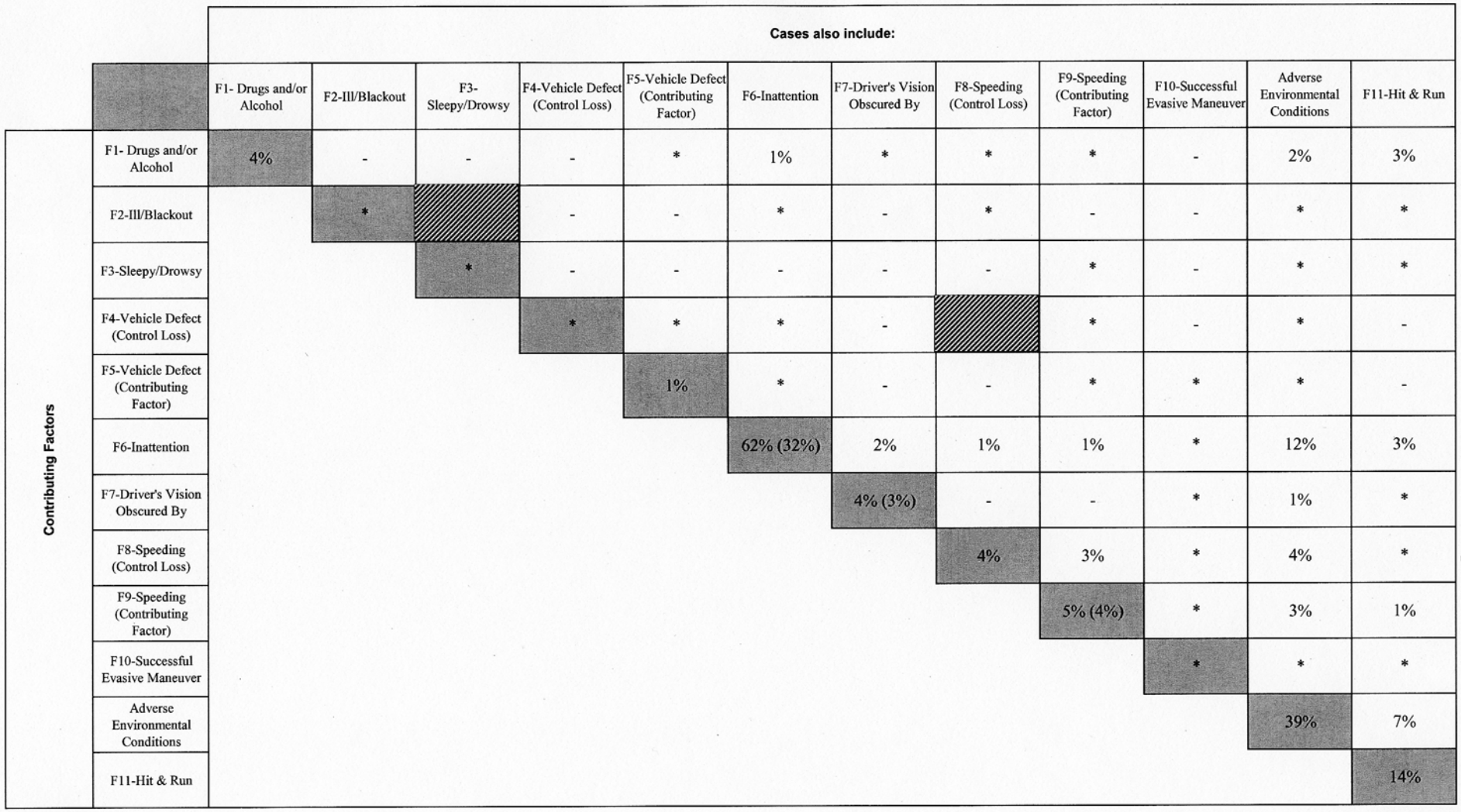
- A driver traveling in adverse environmental conditions was combined with:
  - Alcohol/drugs (4% of crashes)
  - Driver whose vision was obstructed (1% of crashes)
  - Vehicle which lost control as a result of speeding (4% of crashes)
  - Vehicle where speeding was a contributing factor to the crash (3% of crashes)

In the comparison of the GES *towed due to damage* (severe) and *other* (less severe) contributing factors, a small variance exists between some of the factors in the cross-correlation tables. Minor differences found include:

- A driver under the influence of alcohol/drugs traveling under adverse environmental conditions was cited in 5% of the *towed due to damage* cases, and in 2% of the *other* crashes.

- The vehicle's speed had a large effect on the severity of the crash. The combination of a crash occurring as a result of speed being a contributing factor and resulting in a control loss was found in 7% of the severe crashes compared to 3% of the less severe cases. About 8% of the severe crashes occurred when a vehicle lost control as the result of speeding under adverse environmental conditions. On the other hand, 4% of the less severe crashes occurred under the same conditions.

- Speeding was a contributing factor in 7% of the towed due to damage cases which occurred when traveling through adverse environmental conditions, compared to 3% of the other crashes.



= determined based on same code

* = less than 0.5 %

( ) = Distribution before unknowns were redistributed.

Figure 22. Relative Frequency Cross-correlation Chart for GES *Other* (LC)

8.2.4 Prioritization of Factors

Primary contributing factors were determined for LC *other* crashes based on the priority scheme analysis described in Section 2.1.6. The distribution of these factors is shown in Table 11.

Table 11. LC *Other* Priority Scheme

	GES *OTHER* (2000)
Alcohol/Drugs *(F1)*	4%
Ill/Blackout *(F2)*	0%
Sleepy/Drowsy *(F3)*	0%
Vehicle Defect (CL) *(F4)*	0%
Vehicle Defect (CF) *(F5)*	1%
Inattention *(F6)*	30%
Driver's Vision Obscured *(F7)*	1%
Speeding (CL) *(F8)*	4%
Speeding (CF) *(F9)*	1%
Successful Evasive Maneuver *(F10)*	0%
Adverse Environmental Conditions *(AEC)*	21%
Hit & Run *(F11)*	4%
Undetermined	34%
TOTAL:	100%

The top primary crash contributing factor for the LC *other* crash category is inattention. In order to examine the similarities and differences based on crash severity in the priority scheme distributions, a graphical representation of the results is provided in Figure 23.

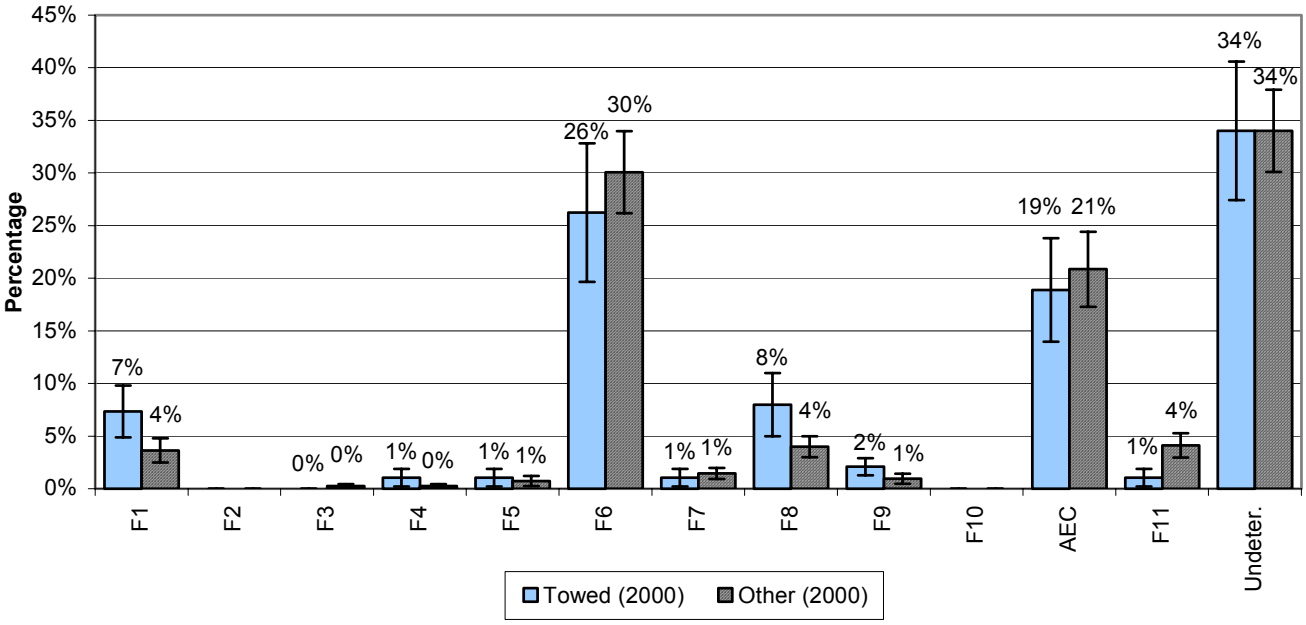


Figure 23. LC Severity Crash Contributing Factors Using the Priority Scheme

As seen in Figure 23, the correlation between the contributing factors for the LC crash type and the crash severity is minimal. Only one factor, hit and run, varied with the crash severity (i.e., the difference between the factors was only statistically significant for hit and run). The percentage of hit and run crashes for the *other* vehicles was larger than for the *towed due to damage* vehicles.

In conclusion, severity was influenced by five of the primary contributing factors for the SVOR crash type. For the RE and LC crash types, crash severity was influenced by fewer primary contributing factors, three for RE and one for LC. One explanation of why severity plays a major role in SVOR crashes is that a large percentage of the SVOR crashes involve alcohol/drugs or speeding. The seriousness of the crash is greatly affected by the existence of one or a combination of the following three factors: alcohol/drugs, speeding resulting in a control loss, and speeding as a contributing factor. A driver's ability to make quick rational decisions while under the influence of alcohol/drugs is significantly impaired.

9. SINGLE VEHICLE OFF-ROADWAY CRASH TYPE – PHASE 3

9.1 DEFINITION OF SCENARIOS

Based on the results of previous studies, the four most prominent single vehicle off-roadway (SVOR) scenarios were chosen for analysis (*6*):

- Traveling Straight and Control Loss
- Traveling Straight and Road Edge Departure
- Negotiating a Curve and Control Loss
- Negotiating a Curve and Road Edge Departure

Table 12 provides the frequency and relative frequency for each of the scenarios based on the 2000 GES. The two most dominant scenarios involved a vehicle traveling straight. The other two scenarios involved a vehicle negotiating a curve. About 65% of the cases occurred while the vehicle was traveling straight; compared to 35% of the cases in which the vehicle was negotiating a curve.

Table 12. Distribution of Crash Scenarios for Target SVOR Crashes

Traveling Straight and Control Loss	Traveling Straight and Road Edge Departure	Negotiating a Curve and Control Loss	Negotiating a Curve and Road Edge Departure	Total
222,000	282,000	165,000	110,000	779,000
29%	36%	21%	14%	100%

The scenarios in Table 12 were defined using the *Movement Prior to Critical Event* and *Critical Event* variables from the 2000 GES database. The variable *Movement Prior to Critical Event* records the vehicle's activity prior to the driver's recognition of the impending critical event. This variable was used to determine whether the vehicle was traveling straight or negotiating a curve. The *Critical Event* variable identifies the action that made the collision possible. Using the *Critical Event* variable, either control loss or road edge departure was able to be determined.

9.2 COMPARISON OF SCENARIOS

Figure 24 provides a comparison of the contributing factors for all four SVOR scenarios based on in-depth examination of the GES PARs. Two of the contributing factors, vehicle defect resulting in a control loss (F4) and speeding resulting in a control loss (F8) were unable to be determined for the SVOR scenarios. These two factors were obtained based on the variable *Critical Event*, which is the same variable that the scenarios are defined from. Therefore, when performing the contributing factor analysis, either 0% or 100% of the cases involved speeding (CL), and none of the cases involved vehicle defect (CL). To rectify the situation, the vehicle defect (CL) and speeding (CL) factors were removed from the SVOR scenario analysis.

Additionally, no cases involving a successful evasive maneuver (F10) were found in any of the scenarios.

Scenarios one and three and scenarios two and four were grouped together in Figure 24 to examine the underlining trend between the contributing factors. Scenarios one and three involve a vehicle losing control, whereas scenarios two and four involve a vehicle departing the roadway. The contributing factors were influenced more by the scenario's *Critical Event* than the recorded *Movement Prior to the Critical Event.* The leading contributing factor for scenarios one and three was speeding as a contributing factor (F9). Inattention (F6) was the leading contributing factor for scenarios two and four, whereas it was the second leading factor for scenarios one and three. Alcohol/drugs (F1) was the second leading contributing factor for scenario two compared to speeding as a contributing factor (F9) for scenario four.

As seen in Figure 24, alcohol/drugs, sleepy/drowsy drivers, and inattentive drivers were found to play a larger role in road edge departure cases than in crashes in which the vehicle lost control. Speeding was more dominant in control loss crashes than in road edge departure crashes. Understandably, adverse environmental conditions were reported more in control loss crashes, probably due to slippery road conditions.

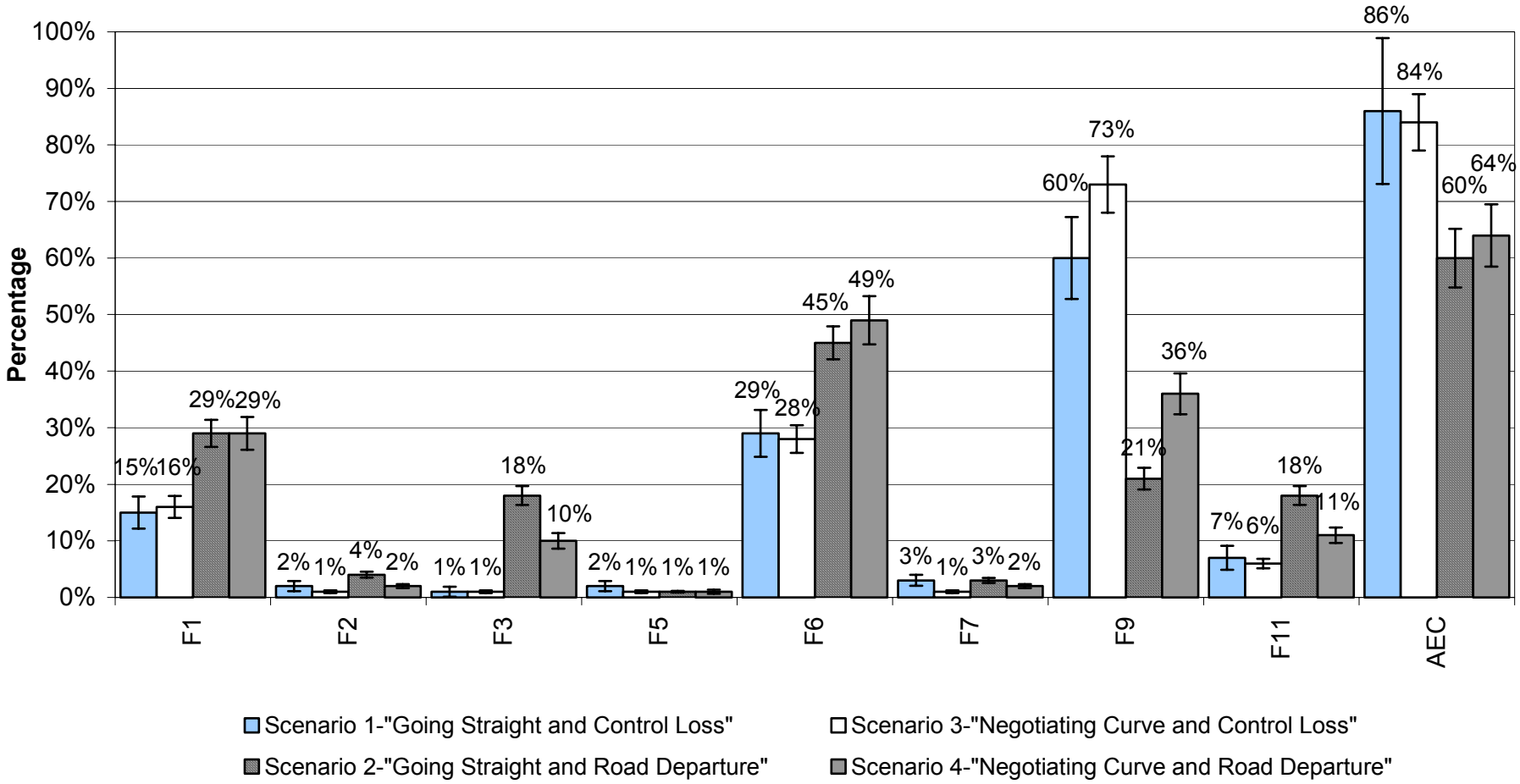


Figure 24. SVOR Comparison of Scenario Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

9.3 PRIORITIZATION OF FACTORS

Primary contributing factors were determined for each of the scenarios based on a ranking of the contributing factors by their degree of influence on a possible collision. The priority scheme distributions for the GES SVOR scenarios are shown in Table 13 and Figure 25.

Table 13. SVOR Scenario Priority Scheme*

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Alcohol/Drugs *(F1)*	14%	27%	15%	27%
Ill/Blackout *(F2)*	2%	3%	1%	2%
Sleepy/Drowsy *(F3)*	1%	13%	1%	9%
Vehicle Defect (CF) *(F5)*	2%	1%	2%	1%
Inattention *(F6)*	11%	22%	12%	24%
Driver's Vision Obscured *(F7)*	1%	1%	1%	2%
Speeding (CF) *(F9)*	42%	6%	46%	11%
Adverse Environmental Conditions *(AEC)*	25%	14%	20%	15%
Hit & Run *(F11)*	0%	3%	0%	0%
Undetermined	2%	10%	2%	9%
TOTAL:	100%	100%	100%	100%

* Based on GES 2000.

A distinct trend exists in the priority scheme between scenarios one and three and scenarios two and four. Scenario coding for the Critical Event variable (i.e., control loss verses road edge departure) was a large influence on the resulting priority scheme distribution. The leading primary crash contributing factor for scenarios one and three was speeding, as expected given the definition of these two scenarios. The second leading primary contributing factors for scenarios one and three was alcohol/drugs. For scenarios two and four, alcohol/drugs was the most dominant factor. The second leading primary contributing factor for scenarios two and four was inattention. All four of the scenarios included the contributing factor alcohol/drugs in the top two primary contributing factors for SVOR crashes with the second factor either speeding as a contributing factor or inattention.

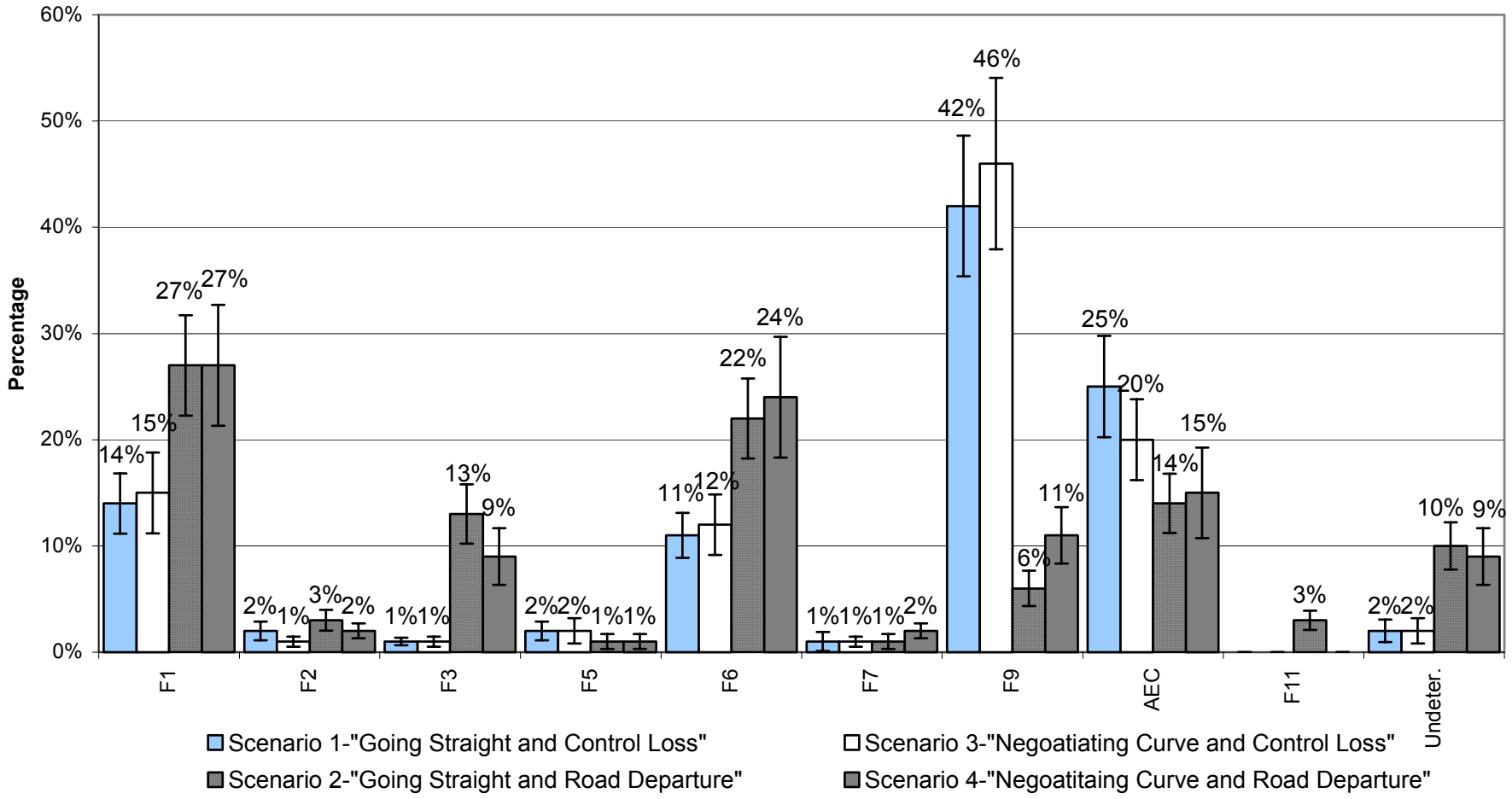


Figure 25. SVOR Scenario Crash Contributing Factors Using the Priority Scheme

10. REAR-END CRASH TYPE – PHASE 3

10.1 DEFINITION OF SCENARIOS

Rear-end (RE) crash scenarios may involve three of more vehicles. However, due to the database restrictions previously discussed in Section 4.1, the analysis was restricted to two-vehicle collisions. Based on previous research, three prominent RE scenarios were chosen for analysis (*6*):

- Lead Vehicle Decelerating (LVD)
- Lead Vehicle Stopped (LVS)
- Lead Vehicle Moving at Lower Constant Speed (LVM)

When defining the scenarios, a certain amount of overlap exists between the LVD and LVS scenarios. Crashes included in the LVS scenario may involve a lead vehicle which decelerated to a stop immediately before the collision. This event occurs most often in cases involving a lead vehicle which is turning or stopping for a traffic control device. For the development of crash countermeasures, it is important to realize that to prevent such a collision, a countermeasure must act while the lead vehicle is decelerating; it would be too late to wait until the vehicle has stopped. Therefore, cases involving a lead vehicle turning or stopping for a traffic control device were included in the LVD scenario. A schematic of the process used to determine the scenarios is shown in Figure 26. The frequency and relative frequency for each scenario is provided in Table 14.

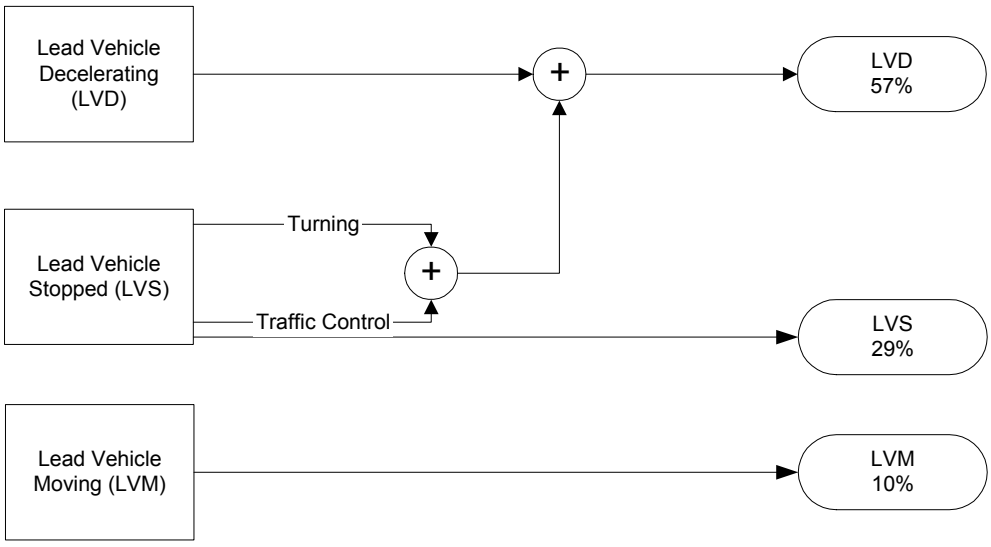


Figure 26. Schematic of RE Scenarios

Table 14. Distribution of Crash Scenarios for RE Crashes (*6*)

Lead Vehicle Decelerating	Lead Vehicle Stopped	Lead Vehicle Moving at Lower Constant Speed	Total (All Scenarios)
864,000	432,000	144,000	1,440,000
60%	30%	10%	100%

The three scenarios were defined from the GES 2000 database using the *Movement Prior to Critical Event* and/or *Critical Event* variables. Each case was examined to see if either the *Movement Prior to Critical Event* or the *Critical Event* variable indicated whether the lead vehicle was decelerating, stopped, or moving at a lower constant speed. In addition to the previous variables, the LVD scenario was further defined using the *Traffic Control Device* variable. The *Traffic Control Device* variable indicates whether or not a traffic control device was present and what type of traffic control (i.e., three-color signal, stop sign).

10.2 COMPARISON OF SCENARIOS

Figure 27 provides a comparison of the contributing factors of the RE scenarios based on an in-depth examination of the GES cases. Error bars based on the GES 2000 estimated sampling error were added to the results to determine if the differences between the factors were statistically significant. Inattention (F6) and speeding as a contributing factor (F9) were the two leading contributing factors for all scenarios.

The variance between the LVM scenario and the other two scenarios was found to be statistically significant for a few of the factors. The largest discrepancy was found in the inattention factor. Fewer cases involving the lead vehicle moving were attributed to inattention than for cases involving the lead vehicle decelerating or stopped in the roadway. Further examination of the LVM scenario revealed that a statistically significant percentage of the LVM cases involved a driver under the influence of alcohol/drugs than for the LVD or LVS scenarios. Furthermore, a statistically significant difference was found between the LVM and the other two scenarios for cases involving hit and run collisions.

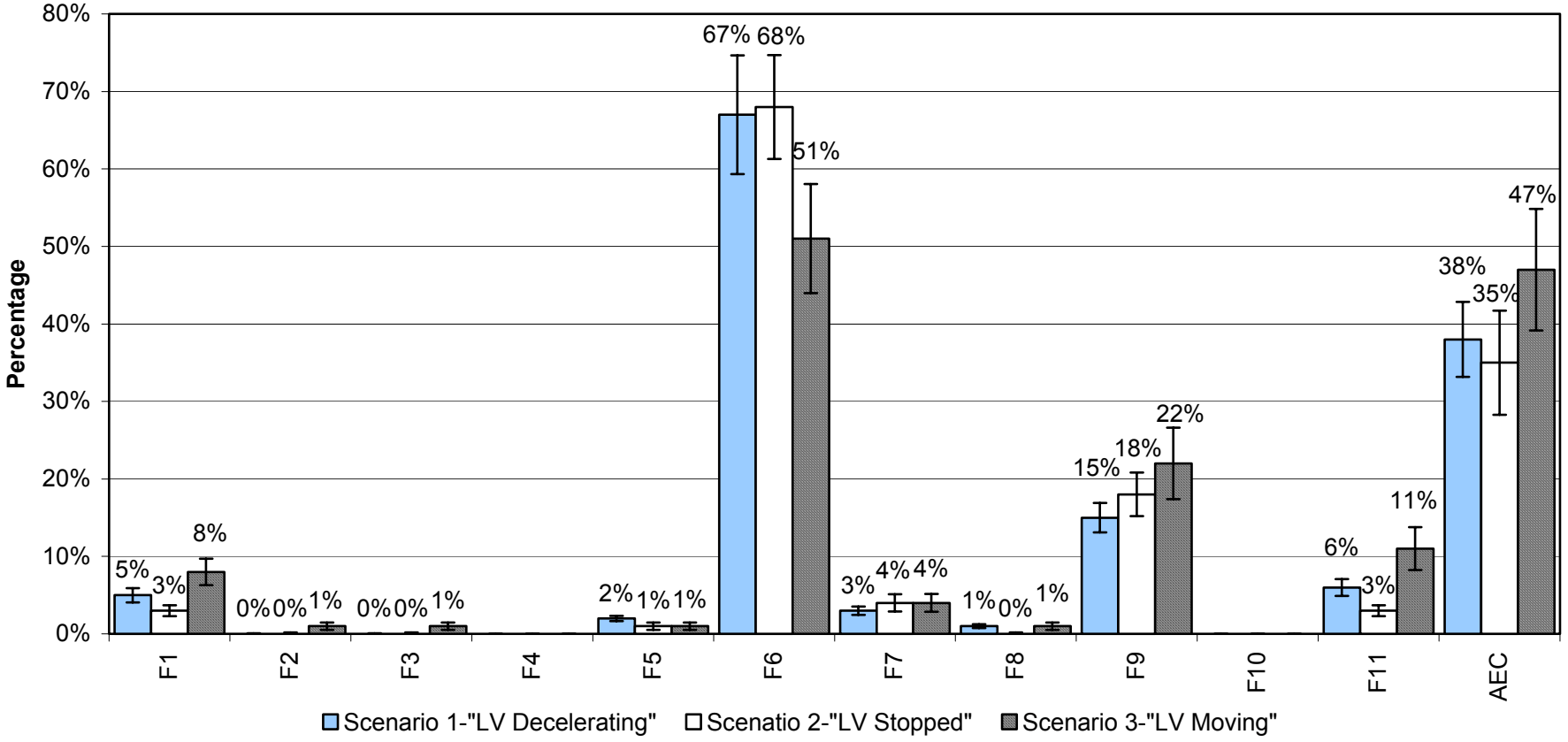


Figure 27. RE Comparison of Scenario Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

10.3 PRIORITIZATION OF FACTORS

Primary crash contributing factors were determined for each RE scenario using the priority scheme as shown in Table 15 and Figure 28.

Table 15. RE Scenario Priority Scheme*

	Scenario 1	Scenario 2	Scenario 3
Alcohol/Drugs *(F1)*	5%	3%	8%
Ill/Blackout *(F2)*	0%	0%	0%
Sleepy/Drowsy *(F3)*	0%	0%	1%
Vehicle Defect (CL) *(F4)*	0%	0%	0%
Vehicle Defect (CF) *(F5)*	2%	1%	1%
Inattention *(F6)*	36%	37%	23%
Driver's Vision Obscured *(F7)*	1%	2%	1%
Speeding (CL) *(F8)*	0%	0%	1%
Speeding (CF) *(F9)*	7%	8%	8%
Successful Evasive Maneuver *(F10)*	0%	0%	0%
Adverse Environmental Conditions *(AEC)*	19%	18%	25%
Hit & Run *(F11)*	1%	0%	2%
Undetermined	29%	31%	30%
TOTAL:	100%	100%	100%

* Based on GES 2000.

Inattention, speeding (CF), and alcohol/drugs are the top three leading primary contributing factors for all three scenarios, respectively. It should be noted that adverse environmental conditions (≥ 18%) were reported in significant number of crashes in each of the three RE crash scenarios.

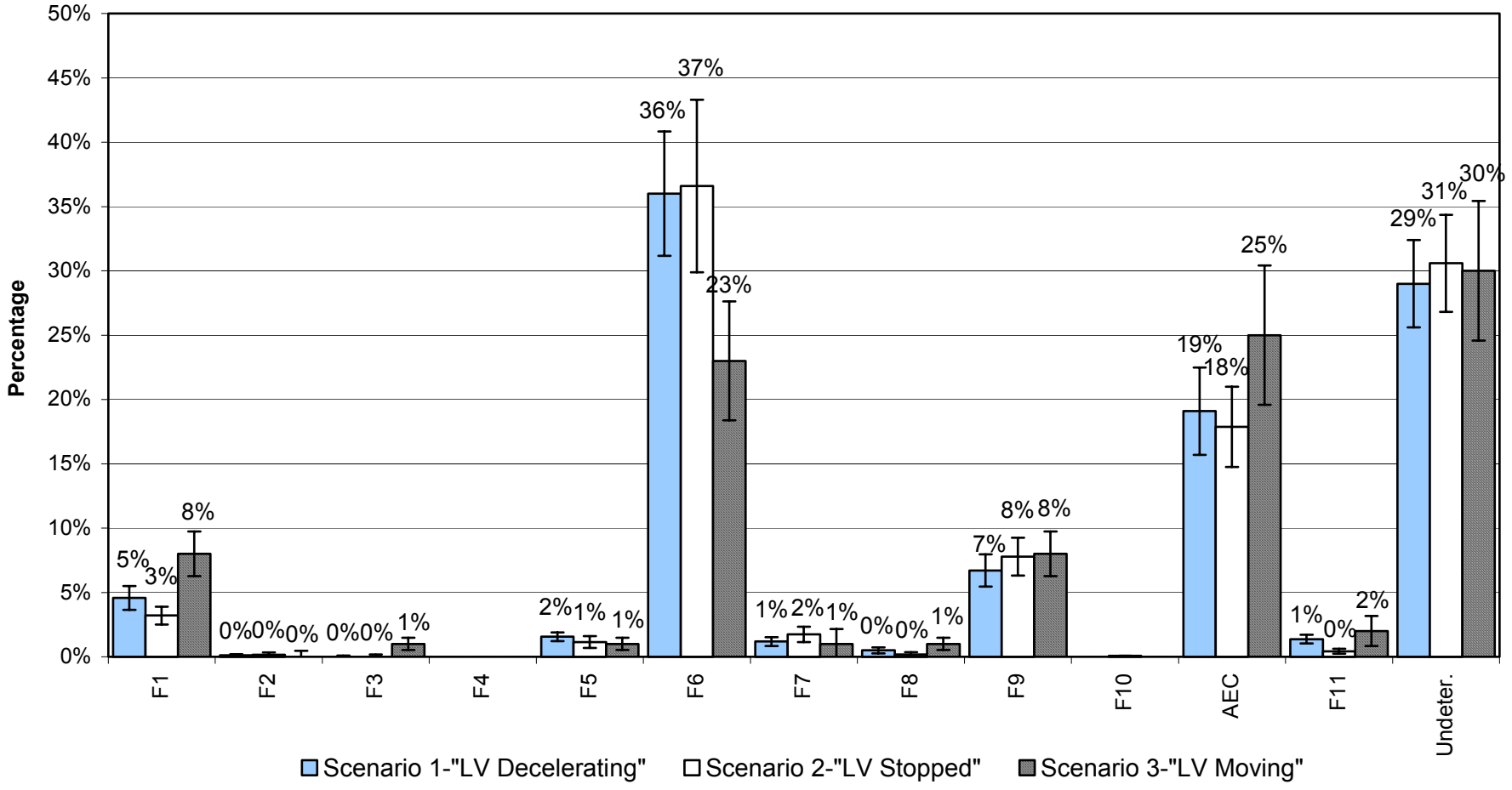


Figure 28. RE Scenario Crash Contributing Factors Using the Priority Scheme

11. LANE CHANGE CRASH TYPE – PHASE 3

11.1 DEFINITION OF SCENARIOS

Contrary to the other crash types that were separated into different scenarios, the lane change (LC) *towed due to damage* and *other* crashes were grouped together to form one lane change scenario. The lane change scenario encompasses all vehicles that perform a lane change maneuver.

11.2 SCENARIO RESULTS

The contributing factors for the LC scenario crashes were determined by an examination of 2,469 *towed due to damage* and 2,001 *other* PARs from the 2000 GES database representing 95,000 and 412,000 PR crashes, respectively. The results were combined and contributing factors were determined for the entire light vehicle crash population as presented in Figure 29.

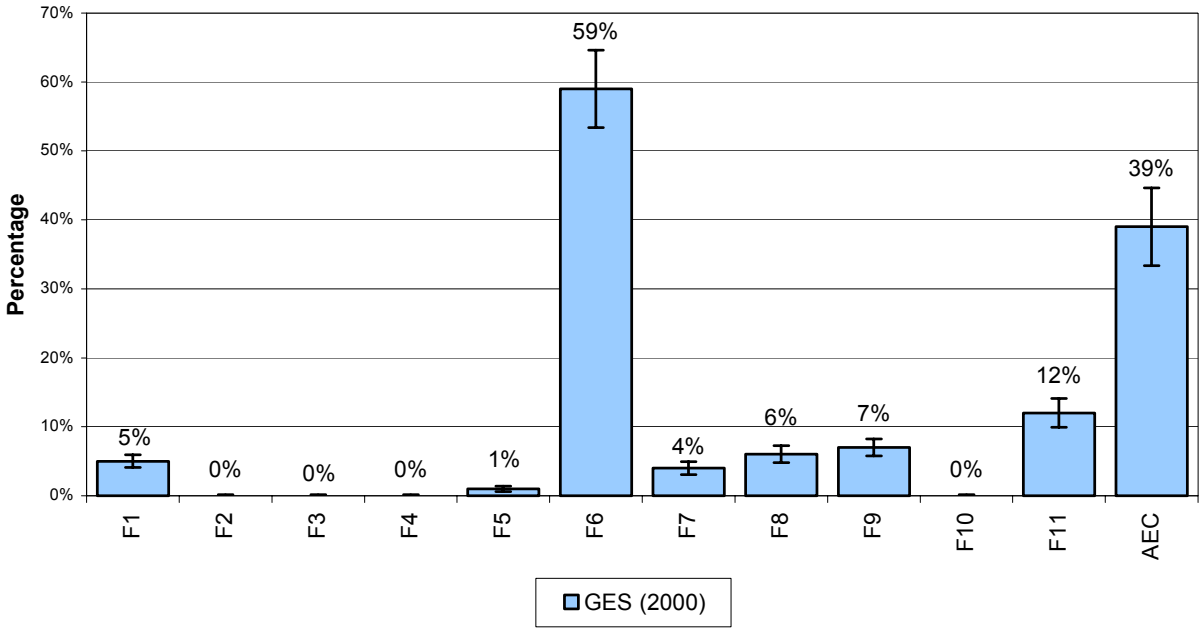


Figure 29. LC Scenario Contributing Factors

Note: The above figure presents values for the contributing factors after the redistribution of unknowns.

The leading crash contributing factor for the LC scenario was driver inattention, accounting for 59% of the collisions. The breakdown of driver inattention is provided in Appendix E. Hit and run was reported in 12% of the crashes. Speed was a contributing factor in 7% of the crashes and resulted in a control loss in an additional 6%. A driver under the influence of alcohol/drugs was reported in 5% of the cases and the driver's vision was obscured in 4%. Vehicle defects

were a contributing factor in 1% of the crashes. Additionally, 39% of the collisions occurred under adverse environmental conditions.

11.3 PRIORITIZATION OF FACTORS

Primary crash contributing factors for the LC scenario were determined through the priority scheme described in Section 2.1.6, as shown in Table 16 and Figure 30.

Table 16. LC Scenario Priority Scheme*

	LC Scenario
Alcohol/Drugs *(F1)*	4%
Ill/Blackout *(F2)*	0%
Sleepy/Drowsy *(F3)*	0%
Vehicle Defect (CL) *(F4)*	0%
Vehicle Defect (CF) *(F5)*	1%
Inattention *(F6)*	29%
Driver's Vision Obscured *(F7)*	2%
Speeding (CL) *(F8)*	5%
Speeding (CF) *(F9)*	1%
Successful Evasive Maneuver *(F10)*	0%
Adverse Environmental Conditions *(AEC)*	20%
Hit & Run *(F11)*	4%
Undetermined	34%
TOTAL:	100%

* Based on GES 2000.

The top primary contributing factor for the LC scenario was driver inattention. Other prevalent contributing factors include speeding resulting in a control loss and alcohol/drugs. As previously discussed, the difference between the primary contributing factors for *towed due to damage* and *other* crash categories was very minor. The only statistically significant difference was in the hit and run. It is very difficult to determine the reasons behind the collision for this factor since one of the vehicles has fled the scene. Since the results of the priority scheme are very similar, it is not necessary to separate the analysis by severity (i.e., *towed due to damage*, *other*). The overall LC scenario may be used instead.

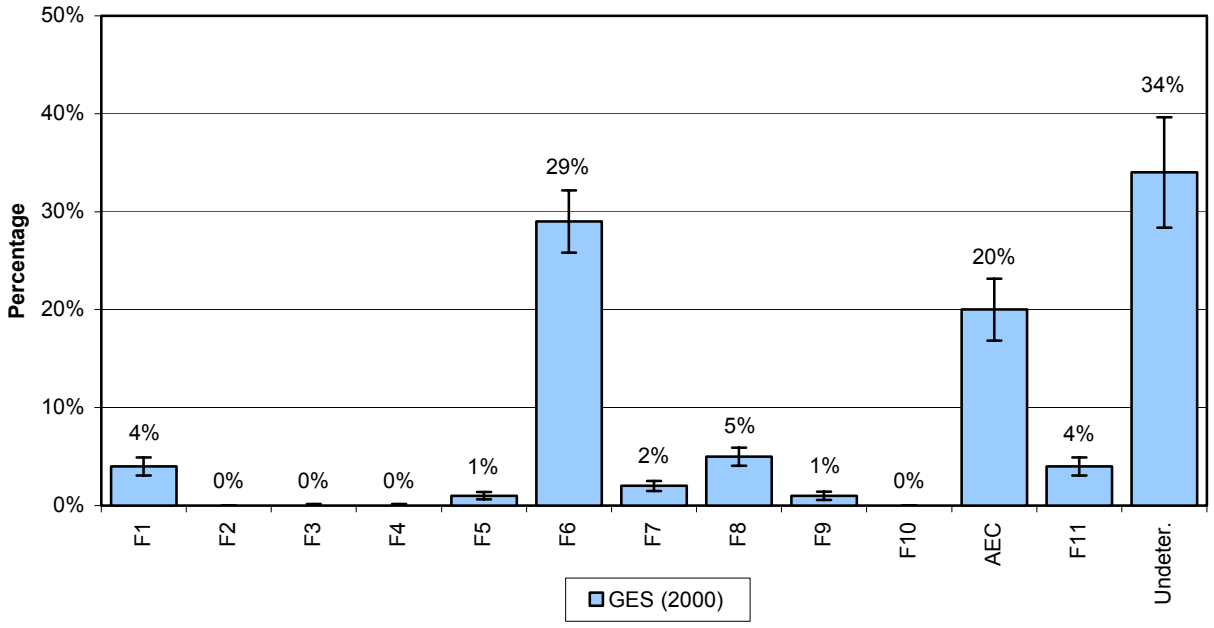


Figure 30. LC Scenario Crash Contributing Factors Using the Priority Scheme

12. DISCUSSION AND CONCLUSION

Crash contributing factors were analyzed for SVOR, RE, and LC light vehicle crashes based on crash data obtained from the 1997-2000 CDS and 2000 GES databases. In response to the U.S. DOT IVI's need for information on the pre-crash events, this research was conducted to determine the crash contributing factors for specific crash types and pre-crash scenarios. In addition, the relationship between the contributing factor distribution and the crash severity was examined. Research was separated into three phases: phase one compared the CDS and GES; phase two addressed crash severity; and phase three examined the contributing factors for given pre-crash scenarios.

12.1 PHASE 1: COMPARE CDS TO GES

The results of the priority scheme for the CDS and GES matched fairly closely. A key finding from phase one is that the GES 2000 data closely resembled or provided more information on driver inattention than the CDS 1997-2000 data for all of the investigated crash types. This finding is contrary to previous studies, which have shown that the GES has many cases coded as unknowns for the contributing factor driver distraction/inattention. Based on a 1996 GES study of RE collisions, distraction was cited as a contributing factor in 1.7%-7.8% of the cases, depending on which scenario was examined (*11*). Conversely, in phase three of the study, the 2000 GES cited inattention in 51%-68% of the cases.

The SVOR distributions of primary contributing factors for the CDS and GES were similar for all factors except speeding (CL). The top three primary contributing factors for the CDS and GES are provided in Table 17.

Table 17. Top Three CDS and GES SVOR Primary Contributing Factors

	CDS[1]	GES[2]
1. Speeding (CL)	21%	27%
2. Alcohol/Drugs	18%	21%
3. Inattention	12%	14%

[1] Based on 1997-2000 data.

[2] Based on 2000 data.

As a result of the analysis, a driver losing control of the vehicle as a result of speeding was a contributing factor in 21% of the CDS cases, compared to 27% of the GES. In support of current research, the GES was found to provide more coded information on speeding than the CDS.

A discrepancy also existed between the two databases for the variable depicting adverse environmental conditions. Adverse environmental conditions were present in 25% of the crashes in the CDS, compared to 11% in the GES. The variance is probably due to the method in which the cases were extracted from the priority scheme. When adverse environmental conditions appeared in conjunction with one of the other contributing factors, that factor was counted in lieu

of the adverse conditions. Therefore, the 14% discrepancy probably reflects the GES attribution of contributing factors to more of the cases than the CDS.

The RE distribution of primary contributing factors was similar for the CDS and GES for all factors except for inattention and alcohol/drugs. The top three primary contributing factors for the CDS and GES RE crashes are shown in Table 18.

Table 18. Top Three CDS and GES RE Primary Contributing Factors

	CDS[1]	GES[2]
1. Inattention	22%	35%
2. Alcohol/Drugs	10%	8%
2(tie). Speeding (CF)		8%
3(tie). Sleepy/Drowsy	1%	
3(tie). Speeding (CL)	1%	
3(tie). Succ. Evasive Maneuver	1%	

[1] Based on 1997-2000 data.

[2] Based on 2000 data.

The 2000 GES provided more information on the actual number of crashes involving an inattentive driver. Based on the phase one analysis, the primary contributing factor in 35% of the crashes in the GES was an inattentive driver, whereas the CDS attributed inattention to only 22% of the collisions. Similar to the SVOR analysis, a discrepancy existed between the two databases for the variable depicting adverse environmental conditions. The explanation behind this discrepancy remained the same; the variance was probably due to the method in which the cases were extracted using the priority scheme.

Similar results were found for the LC analysis. Table 19 provides the top three primary contributing factors for the CDS and GES LC crashes. Similar to the previous two crash types, the GES attributed the primary contributing factor to driver inattention for a larger percentage of collisions than the CDS.

Table 19. Top Three CDS and GES LC Primary Contributing Factors

	CDS[1]	GES[2]
1. Inattention	12%	26%
2. Alcohol/Drugs	6%	7%
3. Speeding (CL)	4%	8%

[1] Based on 1997-2000 data.

[2] Based on 2000 data.

Based on the analysis from the CDS and GES, inattention, alcohol/drugs, and speeding (CL) are the top three primary factors for LC collisions. However, the ranking of these factors varies depending on which database is examined. The second primary contributing factor for the CDS was alcohol/drugs, and speeding (CL) for the GES. The third primary contributing factors were speeding (CL) for the CDS and alcohol/drugs for the GES.

12.2 PHASE 2: EXAMINE ISSUE OF SEVERITY (GES *OTHER* CASES)

Looking at crash severity, the contributing factors for severe and less severe cases were similar for the majority of the three crash types. However, a statistically significant difference was found for alcohol/drug and speeding between the severe and less severe cases. The strong correlation of alcohol/drugs with the crash severity reflects the current trend found in the FARS database, which reports that 40% of all fatal crashes in 2000 involved alcohol. Research has clearly shown that the crash severity increases with higher alcohol involvement rates. The speed that the vehicle is traveling at prior to impact also has a direct correlation to the severity of the crash. As the speed of the vehicle increases, the driver has less time to perform an evasive action and the damage to the vehicle also increases, resulting in higher injury and fatality rates for the occupants.

A large proportion of the contributing factors for the SVOR crash type varied with severity. SVOR crashes are generally more severe than RE and LC. In contrast, only three primary contributing factors for the RE crash type and one for the LC were found to vary with crash severity.

The relative frequency of the following primary contributing factors: alcohol/drugs, sleepy/drowsy drivers, speeding as a contributing factor, successful evasive maneuver, and hit and run crashes varied with the severity of SVOR crashes. SVOR crashes with alcohol/drugs, sleepy/drowsy, or speeding as a primary contributing factor were more likely to be severe crashes. Conversely, SVOR crashes involving successful evasive maneuver or hit and run were more likely to be less severe crashes.

The primary contributing factors for RE and LC crashes had less correlation with the crash severity. For RE crashes, the relative frequency of alcohol/drugs, sleepy/drowsy, and hit and run primary contributing factors varied with crash severity. The severity of the crash increased with alcohol/drug involvement or sleepy/drowsy drivers, and decreased in hit and run cases. For LC crashes, severity affected only the number of hit and run cases. A possible explanation of why

the primary contributing factors for SVOR crashes play a major role in the crash severity versus the minor role in the severity of RE and LC crash contributing factors may be that a large percentage of SVOR crashes involve alcohol/drugs and speeding. The existence of one or a combination of these factors greatly increases the likelihood of a severe collision.

The effectiveness of the priority scheme to assign a primary contributing factor to each crash using existing codes in the GES database was examined. The attribution of a single dominant factor to a crash leads to a distribution of contributing factors for a specific crash type which sums up to a total of 100%. This, in turn, prevents double counting of the crashes that might be avoided with applicable crash avoidance systems. Table 20 presents the results of the priority scheme that was applied to identify such contributing factor distributions for SVOR, RE, and LC crash types, distinguished by whether or not a vehicle was towed from the scene due to damage, using the 2000 GES. The GES clearly provides information about alcohol/drugs, ill/blackout, sleepy/drowsy, vehicle defect (CL), vehicle defect (CF), inattention, vision obscured, speeding (CL), speeding (CF), and successful evasive maneuver to a prior critical event, which convey the factors that might have contributed to the cause of the crash. These 10 factors were known to contribute to 82%, 57%, and 46% respectively of SVOR, RE, and LC *towed due to damage* crashes. Similarly, these factors were reported in 68%, 48%, and 41% respectively of SVOR, RE, and LC *other* crashes. The representation of these factors was larger in *towed due to damage* crashes than in *other* crashes due to higher percentages of reported alcohol/drugs and speeding in *towed due to damage* crashes.

The percentages of adverse environmental conditions in Table 20 refer to the proportions of crashes that occurred under these circumstances and did not involve any of the 10 factors as reported in the GES. If the "unknowns" were negligible in the 10 reported factors, it would then be reasonable to assume that adverse environmental conditions may have played a primary role in the crash. Unfortunately, this assumption may not be accurate due to the high number of "unknowns" coded in some of the GES variables such as those pointing to inattention, ill, drowsy, and obstructed vision. The percentages of "undetermined" factors remain relatively high using the priority scheme, especially for RE and LC crashes. These may be attributed to inattention, ill, drowsy, vehicle defect, obstructed vision, or speeding rather than adverse environmental conditions. Moreover, there could be some other primary factors that might have contributed to the crash which are not included in the GES codes such as "tailgating" and "misjudged gap/velocity" listed in Table 1 (*5,7*). In fact, the GES does not contain any variables that indicate whether or not driver decision errors or erratic actions might have contributed to the crash. Thus, the integrity of the results obtained by the priority-scheme methodology depends largely on the types of codes available in the GES as well as the quality of information reported on the police reports.

The priority scheme was successful in identifying and ranking the most prevalent factors that might have contributed to the crash. Table 20 provides a list of the prioritized factors as well as identifying variables that have undergone an imputation process. The imputation procedure randomly assigns values to the unknowns in the same proportion as the known values for that variable. Speeding, alcohol/drugs, and inattention were the most prevalent factors (in descending order) in SVOR *towed due to damage* crashes, whereas speeding, inattention, and alcohol/drugs respectively were ranked as the most dominant factors in SVOR *other* crashes.

Inattention, speeding, and alcohol or drugs were the most prevalent factors in all RE and LC crashes. Inattention is generally under-represented because it is hard for the police to note on the accident report without any witness statement, and drivers often do not admit to being distracted immediately prior to the crash. Perhaps, an imputation process of the unknowns as conducted on the alcohol/drugs involvement variable would alleviate the coding deficiency of the inattention factor. If such an imputation process were implemented, the priority-scheme methodology would yield better percentage values for the crash primary contributing factors.

Table 20. Distribution of Prioritized Contributing Factors for Selected Crash Types

Prioritized Factors	Crash Types					
	Towed Due to Damage			*Other*		
	SVOR	RE	LC	SVOR	RE	LC
Alcohol/Drugs^	21%	8%	7%	14%	4%	4%
Ill/Blackout	2%	0%	0%	1%	0%	0%
Sleepy/Drowsy	6%	1%	0%	2%	0%	0%
Vehicle Defect (CL)	3%	0%	1%	2%	0%	0%
Vehicle Defect (CF)	2%	2%	1%	1%	1%	1%
Inattention	14%	35%	26%	17%	35%	30%
Vision Obscured	2%	2%	1%	2%	1%	1%
Speeding (CL)	27%	1%	8%	25%	0%	4%
Speeding (CF)	5%	8%	2%	3%	7%	1%
Evasive Maneuver^	0%	0%	0%	1%	0%	0%
AEC^	11%	16%	19%	17%	20%	21%
Hit & Run^	0%	0%	1%	3%	1%	4%
Undetermined	7%	27%	34%	12%	31%	34%
Total	100%	100%	100%	100%	100%	100%

^ = Imputed variables.

It should be noted that this report presents results about contributing factors from coded variables in the CDS and GES. Furthermore, the investigators might have a bias in reporting contributing factors as a function of severity. In more severe crashes, police might look for certain contributing factors, such as alcohol and speed, that are more likely to be associated with higher impact, more severe crashes.

12.3 PHASE 3: EXAMINE CRASH SCENARIOS

Phase three involved a contributing factor analysis for pre-crash scenarios for each crash type. Singling out and analyzing each scenario separately achieved a better understanding of the contributing factors leading to each collision situation. Based on the results of previous studies, four prominent SVOR scenarios and three RE scenarios were selected for analysis. For the case

of the LC crash type, since no prominent scenarios existed, all of the data was combined into one scenario.

Four SVOR scenarios were included in the analysis: Traveling Straight and Control Loss, Traveling Straight and Road Edge Departure, Negotiating a Curve and Control Loss, and Negotiating a Curve and Road Edge Departure. After an initial examination, it was determined that the contributing factors were more influenced by the scenario's *Critical Event* (i.e., control loss versus road edge departure) than the *Movement Prior to the Critical Event*. The top three contributing factors in descending order for the two scenarios involving a control loss are: speeding as a contributing factor, alcohol/drugs, and inattention. For the scenarios involving road edge departure, the top two primary contributing factors are: alcohol/drugs and inattention. Crashes involving a vehicle that loses control generally involved vehicles that were speeding, crashes involving a road edge departure typically involved an inattentive driver.

Three prominent RE scenarios were selected for the analysis: LVD, LVS, and LVM. The crash contributing factors for the LVD and LVS scenarios were very similar. Inattention followed by speeding as a contributing factor were the top two primary contributing factors for both scenarios. The top two factors for the LVM scenario also were inattention and speeding as a contributing factor. Notable findings from the RE scenario analysis also include that alcohol/drugs was a higher contributing factor for the LVM than the LVD and LVS scenarios. RE collisions are more likely to occur in situations involving the LVM when the driver of the striking vehicle is under the influence of alcohol/drugs rather than if the striking vehicle is speeding.

Examining the LC scenario, a very minor variance was found between the scenario priority scheme and the *towed due to damage* and *other* priority schemes. The only statistically significant difference between the priority schemes was in the factor hit and run. Furthermore, it is very difficult to determine contributing factors for hit and run collisions since the vehicle and driver or both have fled the scene. Since the contributing factor distributions for all of the priority schemes are very similar, it is unnecessary to separate the analysis by severity or scenarios.

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(12) National Center for Statistics and Analysis, National Automotive Sampling System *Crashworthiness Data System (CDS) Data Collection, Coding, and Editing Manual 1997*. U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, DC. 1997.

(13) National Center for Statistics and Analysis, National Automotive Sampling System *General Estimates System (GES) Coding and Editing Manual 2000*. U.S. Department of Transportation, National Highway Traffic Safety Administration, Washington, DC. 2000.

APPENDIX A. PREVIOUS CONTRIBUTING FACTOR RESEARCH

Treat, J.R., Tumbas, N.S., McDonald, S.T., Shinar, D., Hume, R.D., Mayer, R.E., Stansifer, R.L., and N.J. Castellan. ***Tri-Level Study of the Causes of Traffic Accidents – Executive Summary*****. DOT HS 805 099, May 1979.**

Completed in 1979, the study provided the National Highway Traffic Safety Administration (NHTSA) with information on the causes of traffic crashes. Two of the main objectives for the research were (1) to identify the factors that influence the sequence of events that result in motor vehicle collisions, and (2) to determine the relative frequency of these factors. In order to provide researchers with insight into the causes of traffic crashes, collision data was collected on three levels, each providing an increasing level of detail. Data collection for Level A consisted of examining police reports and other baseline data. For Level B, skilled technicians conducted on-scene investigations at the time of the crash. For Level C, an in-depth examination was conducted by a multidisciplinary team using the data collected from the on-scene investigations. As a result of the in-depth examination of the data, human factors were found to be the definite cause for 70.7% of the crashes. Environmental factors were determined to be the definite cause in 12.4% of the cases and vehicle factors were identified as the definite cause in 4.5% (*4*). Additionally, drivers were found to be totally non-responsible in approximately 2% of the collisions.

Treat *et al.* analyzed each of the three main crash causal factors (human, environmental, and vehicle factors) and divided and ranked them into categories. The following was the breakout for the human factors (*4*):

- Recognition Errors 41.4%
- Decision Errors 28.6%
- Performance Errors 6.9%
- Critical Non-Performance Errors 1.7%

Ignoring the category groupings and looking strictly at the causes, "improper lookout" was the leading human factor collision cause. Treat *et al.* found that "nearly one-fourth of all the collisions which the Institute for Research in Public Safety (IRPS) investigated resulted when drivers changed lanes, passed, or pulled out from an intersecting alley, street, or driveway without looking carefully enough for oncoming traffic"(*4*). After additional analysis, it was found that approximately half of the drivers cited for "improper lookout" failed to make any surveillance effort at all; the remaining drivers made an effort to look, but failed to see any oncoming vehicles.

Environmental and vehicular factors were the second and third largest categories of crash causal factors, respectively. The environmental factors were ranked as follows (*4*):

- View Obstruction 3.8%
- Slick Roads 3.8%
- Transient Hazards 1.9%
- Design Problems 1.9%
- Control Hindrances 1.2%

The vehicular factors were ranked as follows (*4*):

- Braking System 2.9%
- Tires and Wheels 0.5%
- Body and Doors 0.5%
- Communication Systems 0.2%
- Steering Systems 0.2%

Based on the results obtained, Treat *et al.* found that the leading vehicular collision causes were located within the braking system or involved the tires and the wheels. Specifically, brake failure, inadequate tread depth, and brake imbalances were identified as the three leading causes.

Najm, W., Mironer, M., Koziol, J., Wang, J.S., and R.R. Knipling. *Synthesis Report: Examination of Target Vehicular Crashes and Potential ITS Countermeasures*. DOT HS 808 263, June 1995.

The Indiana Tri-Level Study did not assign causal factors to "specific" crash types. Najm *et al.* presents analysis results of nine target crash types including: (1) rear-end; (2) backing; (3) single vehicle roadway departure; (4) lane change/merge; (5) signalized intersection, straight crossing path; (6) unsignalized intersection, straight crossing path; (7) intersection, left turn across path; (8) reduced visibility; and (9) opposite direction. Each of the target crash types was investigated to determine crash characteristics, crash size, causal factors, and possible ITS collision avoidance systems. The nine target crash types were defined as follows (*5*):

1. Rear-end (RE): The front of the subject vehicle (SV) strikes the rear of a leading principal other vehicle (POV), both traveling in the same lane.

2. Backing (BK): The SV strikes, or is struck by, an obstacle while moving backwards. The obstacle can be another vehicle, an object, animal, or pedestrian.

3. Single Vehicle Roadway Departure (SVRD): The SV leaves the roadway as a first harmful event. This crash type does not include roadway departures resulting from a collision with another vehicle.

4. Lane Change/Merge (LCM): The SV driver attempts to change lanes and strikes, or is struck by, a vehicle in the adjacent lane.

5. Intersection Crossing Path (ICP): Three types of ICP crashes were identified and analyzed:

    i. Signalized Intersection, Straight Crossing Path (SI/SCP): The SV without a right-of-way strikes, or is struck by, a POV with a right-of-way, both traveling through a signalized intersection in straight paths perpendicular to each other.

ii. Unsignalized Intersection, Straight Crossing Path (UI/SCP): The SV without a right-of-way strikes, or is struck by, a POV with a right-of-way, while both are attempting to pass in perpendicular directions straight through an unsignalized intersection (generally controlled by stop signs).

iii. Left Turn Across Path (LTAP): The SV attempts to turn left at an intersection and strikes, or is struck by, a POV traveling in the opposing traffic lanes.

6. Reduced Visibility (RV): This crash circumstance encompasses all crash types occurring in reduced visibility conditions that include non-daylight (dark, dark but lighted, dawn, or dusk) or bad weather (rain, sleet, snow, fog, or smog) conditions.

7. Opposite Direction (OD): The SV collides with a POV traveling in the opposite direction. This crash type results in a frontal impact or a sideswipe.

Crash causal factors were identified for each of the 9 target crash types based on the analysis of 687 cases from the 1991-1993 GES and CDS. Initially, a larger sample of 927 crash cases were going to be analyzed; however, 240 cases were removed from the analysis because they lacked sufficient information to determine one dominant cause. The distribution of crash causal factors, divided by target crash type is shown in Table A1. RE crashes were found to be caused by driver inattention in 56.7% of the crashes. Drivers who looked but failed to see the surrounding vehicles were the leading cause of crashes in the BK, LCM, and UI/SCP crash types. The largest category of SVRD crashes, 20.2%, was caused by bad roadway surface conditions. Drunk drivers were found to be the primary cause of OD crashes. Inattentive drivers were found to be the leading cause in SI/SCP crashes. LTAP drivers who misjudged the gap or the velocity of the entering vehicles resulted in the largest LTAP crash category, 30.0%.

Table A1. Target Crash Causes (*5*)

	RE	BK	LCM	SVRD	OD	SI/SCP	UI/SCP	LTAP
Inattention	56.7%	0.0%	3.8%	15.5%	17.8%	36.4%	22.6%	1.4%
Looked-Did Not See	0.0%	60.8%	61.2%	0.0%	0.0%	0.0%	36.7%	23.2%
Obstructed Vision	0.0%	0.0%	0.0%	0.0%	0.0%	4.3%	14.3%	24.4%
Tailgating/Unsafe Passing	26.5%	0.0%	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%
Misjudged Gap/Velocity	0.4%	0.0%	29.9%	0.0%	5.9%	0.0%	12.2%	30.0%
Excessive Speed	0.0%	26.6%	2.2%	17.8%	0.0%	0.0%	0.0%	0.0%
Tried to Beat Signal/POV	0.0%	0.0%	0.0%	0.0%	0.0%	16.2%	0.0%	11.2%
Failure to Control Vehicle	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Evasive Maneuver	0.0%	0.0%	2.6%	13.7%	18.6%	0.0%	0.0%	0.0%
Violation of Signal/Sign	0.0%	0.0%	0.0%	0.0%	0.0%	23.2%	3.4%	7.4%
Deliberate Unsafe Driving Act	0.0%	0.0%	0.0%	2.2%	0.0%	0.0%	0.0%	0.0%
Miscellaneous	1.1%	0.1%	0.0%	0.0%	1.0%	5.9%	0.0%	1.7%
Drunk	2.1%	3.0%	0.0%	10.1%	31.7%	12.6%	2.7%	0.4%
Asleep	0.0%	1.9%	0.0%	11.8%	0.0%	0.0%	0.0%	0.0%
Ill	9.6%	0.0%	0.0%	3.5%	1.1%	0.0%	0.0%	0.0%
Vehicle Defects	1.2%	5.7%	0.3%	5.3%	4.5%	1.6%	0.0%	0.0%
Bad Roadway Surface Cond.	2.3%	0.0%	0.0%	20.2%	18.3%	0.0%	7.0%	0.0%
Reduced Visibility/Glare	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.1%
TOTAL:	100%	100%	100%	100%	100%	100%	100%	100%

Najm, W., Koopmann, J., Boyle, L., and D. Smith. *Development of Test Scenarios for Off-Roadway Crash Countermeasures Based on Crash Statistics*. DOT HS 809 505, September 2002.

The report analyzes the crash causal factors for off-roadway crashes and presents a set of crash-imminent scenarios to objectively test countermeasure systems for light vehicles. Off-roadway crashes were defined as vehicular crashes in which the first harmful event happened off the travel portion of the roadway. All types of crashes were analyzed, from single vehicle to multi-vehicle collisions. The report targets approximately 992,000 crashes with the critical event characterized by roadway edge departure or control loss, excluding crashes resulting from evasive maneuvers and vehicle control loss due to vehicle failure (*6*). The results of the study provided a basis for future research by the IVI.

Off-roadway crashes were analyzed in order to further the development of IVI concepts as well as to determine functional requirements, performance guidelines and test procedures for crash

avoidance systems. Prior to creating the performance guidelines and test procedures, a through investigation of off-roadway pre-crash scenarios and their physical settings had to be conducted. The 1998 GES database was utilized to statistically define the problem of off-roadway crashes. In order to determine the collision cause for each case, select variables were chosen from the GES that point to possible crash contributing factors including the following: *Hotdeck Imputed Police-reported Alcohol Involvement, Person's Physical Impairment, Driver Distracted By, Speed Related, and Imputed Hit and Run*.

After the involvement of each possible crash contributing factor was determined, a priority scheme was used to narrow down the factors until one dominant contributing factor was present for each crash. The priority scheme analysis was based on a rank of contributing factors in descending order; higher rank represents a higher dominance. The rank of factors used in the analysis was:

1. Alcohol/Drugs
2. Driver Impairment
3. Driver Distraction
4. Speeding
5. Hit and Run

Off-roadway crashes were first separated by roadway type (freeway and non-freeway) and then separately analyzed. The distributions of crash casual factors for off-roadway crashes are shown in Table A2.

Table A2. 1998 GES Off-Roadway Priority Distribution (*6*)

	Freeway	Non-Freeway
Alcohol/Drugs	12.8%	19.7%
Driver Impairment	8.2%	5.2%
Driver Distraction	4.1%	6.2%
Speeding	34.0%	22.6%
Hit & Run	1.0%	8.6%
Other	39.8%	37.8%

Speeding was found to be the most dominant contributing factor in both freeway and non-freeway off-roadway crashes causing 34.0% and 22.6% of the crashes, respectively. Second to speeding, alcohol/drugs were found to be a primary cause in off-roadway crashes. Driver distraction was the primary cause in 4.1% of freeway crashes and 6.2% of non-freeway collisions. The authors go on to note that the GES generally underestimates driver distraction as a contributing factor in collisions since information on distraction is not typically included in police accident reports. It was further mentioned that the CDS typically reports higher rates of inattention than the GES.

Hendricks, D.L., Freedman, M., Zador, P.L., and J.C. Fell. ***The Relative Frequency of Unsafe Driving Acts in Serious Traffic Crashes.*** **DTNH22-94-C-05020, January 2001.**

Hendricks *et al.* revisited the problem of unsafe driving behavior in their 2001 research sponsored by NHTSA. Research was conducted in order to specify driver behaviors and unsafe driving acts (UDAs) that are prevalent in motor vehicle collisions. Furthermore, the situational, driver, and vehicle characteristics related with these driver behaviors were also investigated. The goal of the research was to identify specific problem driver behaviors that cause collisions and to understand the conditions and situations associated with those crashes. In order to reach their goal, four specific objectives were set forth (*7*):

1. Determine specific driver behaviors that lead to crashes as well as the situational, driver, and vehicle characteristics associated with these behaviors.
2. Classify behaviorally caused crashes into crash problem types which contain common sets of characteristics.
3. Develop a ranking of crash problem types based on their relative frequency of occurrence.
4. Describe potential countermeasures for each identified crash problem type.

A total of 723 crashes were investigated between April 1, 1996, and April 30, 1997, from 4 sites: Allegheny County, Pennsylvania; Knox County, Tennessee; Jefferson and Gilpin Counties, Colorado; and Seattle, Washington (*7*). Crashes were randomly selected from the NASS and an in-depth analysis of those crashes was performed. Analysts used an eleven-step approach to obtain and analyze the data for the analysis. Specifically, information was collected on the condition of the vehicle, the crash scene, roadway conditions, and driver behavior. An outline of the 11-step approach used is shown below (*7*):

1. Assess Crash Participant's Statements
2. Examine Physical Evidence
3. Verify Available Data
4. Verify Crash Type
5. Assess Pre-Existing Conditions
6. Assess Critical Event
7. Evaluate Crash Cause
8. Evaluate Driver Behavior (Safe/Unsafe)
9. Specify UDA
10. Determine Internationality
11. Determine Behavior Source of UDA

The crash causes for each case were analyzed and separated into crash categories. Table A3 provides the results of the six most frequent crash categories and the percentage of drivers who fall into each category. The cases were not weighted; therefore the distribution does not represent a national sample.

Table A3. Six Most Frequent Causal Factor Groups (*7*)

Causal Category	% of Drivers
Inattention	22.7%
Vehicle Speed	18.7%
Alcohol Consumption	18.2%
Perceptual Errors[1]	15.1%
Decision Errors[2]	10.1%
Incapacitation[3]	6.4%

[1] Looked, did not see; inadequate gap
[2] Turn/cross with obstructed view; violated red signal; attempted to beat phasing signal, violated stop sign
[3] Asleep/blackout

Hendricks *et al.* found that the leading cause of light vehicle crashes was driver inattention. The second leading crash causal category was vehicle speed. Vehicle speed was defined to encompass cases where the driver was exceeding the speed limit as well as cases where the vehicle was traveling at or below the posted speed, but the speed was inappropriate for the current weather and roadway conditions. The third largest causal category was alcohol consumption. Cases included in this category involved drivers who were over the legal blood alcohol limit or cases in which the driver's alcohol consumption affected their ability to drive safely. Crashes involving perceptual errors included drivers who looked for oncoming vehicles but failed to see them as well as drivers who checked for cross-traffic but either misjudged the gap distance or misjudged the speed of the approaching vehicle. Drivers who performed decision errors either attempted to turn or cross a street with an obstructed view, violated a red signal or stop sign, or attempted to beat the phasing signal. The final category of the six most frequent causal factor groups was incapacitation, which was defined to include drivers who fell asleep, had a seizure or blacked out.

It is important to note that the distribution of the causal factor groups shown in Table A3 is not a representative sample of the national crash population. Twenty-four sites are included in the NASS. Collectively these sites do provide a representative sample; however, Hendricks *et al.'s* research only involved data from four of the NASS sites.

APPENDIX B. GENERALIZED ESTIMATED SAMPLING ERRORS (*9*)

1999 GES ESTIMATES AND STANDARD ERRORS

Crash Estimate (x)	Crash Standard Error (SE)*	Vehicle Estimate (x)	Vehicle Standard Error (SE)**	Person Estimate (x)	Person Standard Error (SE)***
1,000	400	1,000	400	1,000	400
5,000	1,000	5,000	1,000	5,000	1,000
6,000	1,100	10,000	1,500	10,000	1,500
7,000	1,300	20,000	2,400	20,000	2,300
8,000	1,400	30,000	3,200	30,000	3,100
9,000	1,500	40,000	3,900	40,000	3,800
10,000	1,600	50,000	4,600	50,000	4,400
20,000	2,500	60,000	5,300	60,000	5,100
30,000	3,300	70,000	6,000	70,000	5,700
40,000	4,100	80,000	6,700	80,000	6,300
50,000	4,800	90,000	7,300	90,000	6,900
60,000	5,500	100,000	8,000	100,000	7,500
70,000	6,200	200,000	14,200	200,000	13,000
80,000	6,900	300,000	20,200	300,000	18,200
90,000	7,600	400,000	26,100	400,000	23,300
100,000	8,300	500,000	32,000	500,000	28,400
200,000	14,600	600,000	37,800	600,000	33,400
300,000	20,800	700,000	43,700	700,000	38,300
400,000	26,800	800,000	49,600	800,000	43,300
500,000	32,800	900,000	55,500	900,000	48,200
600,000	38,800	1,000,000	61,400	1,000,000	53,200
700,000	47,700	2,000,000	122,100	2,000,000	103,000
800,000	50,700	3,000,000	185,400	3,000,000	154,000
900,000	56,700	4,000,000	251,000	4,000,000	206,200
1,000,000	62,700	5,000,000	318,800	5,000,000	259,600
2,000,000	124,100	6,000,000	388,600	6,000,000	314,100
3,000,000	187,800	7,000,000	460,300	7,000,000	369,600
4,000,000	253,800	8,000,000	533,600	8,000,000	426,200
5,000,000	321,800	9,000,000	608,600	9,000,000	483,700
6,000,000	391,700	10,000,000	685,200	10,000,000	542,100
6,500,000	427,300	11,000,000	763,100	11,000,000	601,400
7,000,000	463,300	12,000,000	842,600	12,000,000	661,500
*$SE=e^{a+b(\ln X)2}$, where a = 4.414534 b = 0.034746		**$SE=e^{a+b(\ln X)2}$, where a = 4.348017 b = 0.034987		***$SE=e^{a+b(\ln X)2}$, where a = 4.452860 b = 0.033682	

2000 GES ESTIMATES AND STANDARD ERRORS

Crash Estimate (x)	Crash Standard Error (SE)*	Vehicle Estimate (x)	Vehicle Standard Error (SE)**	Person Estimate (x)	Person Standard Error (SE)***
1,000	400	1,000	400	1,000	400
5,000	1,000	5,000	1,000	5,000	1,000
6,000	1,100	10,000	1,500	10,000	1,500
7,000	1,200	20,000	2,400	20,000	2,400
8,000	1,300	30,000	3,100	30,000	3,100
9,000	1,400	40,000	3,900	40,000	3,800
10,000	1,500	50,000	4,600	50,000	4,500
20,000	2,400	60,000	5,300	60,000	5,100
30,000	3,200	70,000	5,900	70,000	5,700
40,000	4,000	80,000	6,600	80,000	6,300
50,000	4,700	90,000	7,200	90,000	6,900
60,000	5,400	100,000	7,900	100,000	7,500
70,000	6,100	200,000	14,000	200,000	13,000
80,000	6,800	300,000	19,900	300,000	18,200
90,000	7,500	400,000	25,700	400,000	23,200
100,000	8,200	500,000	31,500	500,000	28,200
200,000	14,600	600,000	37,300	600,000	33,200
300,000	20,800	700,000	43,100	700,000	38,100
400,000	26,900	800,000	48,900	800,000	43,000
500,000	33,000	900,000	54,700	900,000	47,900
600,000	39,100	1,000,000	60,600	1,000,000	52,800
700,000	45,300	2,000,000	120,400	2,000,000	101,800
800,000	51,400	3,000,000	182,800	3,000,000	151,900
900,000	57,600	4,000,000	247,400	4,000,000	203,000
1,000,000	63,800	5,000,000	314,300	5,000,000	255,200
2,000,000	127,300	6,000,000	383,100	6,000,000	308,400
3,000,000	193,900	7,000,000	453,600	7,000,000	362,700
4,000,000	263,100	8,000,000	525,900	8,000,000	417,800
5,000,000	334,800	9,000,000	599,800	9,000,000	473,800
6,000,000	408,700	10,000,000	675,200	10,000,000	530,700
6,500,000	446,400	11,000,000	752,100	11,000,000	588,400
7,000,000	484,600	12,000,000	830,300	12,000,000	646,900
*$SE=e^{a+b(\ln X)2}$, where a = 4.336620 b = 0.035240		**$SE=e^{a+b(\ln X)2}$, where a = 4.335260 b = 0.034980		***$SE=e^{a+b(\ln X)2}$, where a = 4.481530 b = 0.033490	

APPENDIX C. VARIABLE DEFINITIONS

Variable Definitions (*9,12,13*)

CRASHWORTHINESS DATA SYSTEM (CDS)

AC03 "Number of General Vehicle Forms Submitted" (VEHFORMS)

Definition: A General Vehicle Form must be submitted for each in-transport motor vehicle involved in the crash.

AC15 "General Area of Damage" (GADEV?)

Definition: For vehicles which are CDC applicable (e.g., pickups, light vans, and passenger cars) the codes provided under the "CDC Applicable and Other Vehicles" category are used to determine the majority area of vehicle damage.

F = Front
R = Right Side
L = Left Side
B = Back
T = Top
U = Undercarriage
N = Noncollision
9 = Unknown

GV09 "Vehicle Special Use" (VEHUSE)

Definition: Indicates if the vehicle has a special use. Special use means "in use" and not necessarily emergency use. All military vehicles are classified as "4" even if they are police, ambulance, or fire trucks.

0 = No Special Use
1 = Taxi
2 = Vehicle Used as School Bus
3 = Vehicle Used as Other Bus
4 = Military
5 = Police
6 = Ambulance
7 = Fire Truck or Car
8 = Other
9 = Unknown

GV10 "Police-reported Vehicle Disposition" (TOWPAR)

Definition: A "towed" vehicle is defined as a vehicle which is removed from the crash scene other than by means of its own power.

0 = Not Towed Due to Vehicle Damage
1 = Towed Due to Vehicle Damage
9 = Unknown

GV13 "Police-reported Alcohol Presence For Driver" (DRINKING)

Definition: The phrase "alcohol present" means that the driver has consumed an alcoholic beverage. Presence is not an indication that alcohol was in any way a cause of the crash, even though it may have been. Finding open or unopened alcoholic beverages in the vehicle does not constitute presence.

0 = No Alcohol Present
1 = Yes Alcohol Present
7 = Not Reported
8 = No Driver Present
9 = Unknown

GV15 "Police-reported Other Drug Presence For Driver" (DRUGS)

Definition: The phrase "other drug present" includes prescription and "over-the-counter" medications as well as "illicit" substances (e.g., in most cases, marijuana, cocaine, heroin, etc. where usage has not been prescribed by a doctor). Also, "other drug present" means that the driver had ingested an other drug prior to the crash, but it is not an indication that the drug usage was in any way the cause of the crash (or event, even though it may have been). Finding other drugs in the vehicle does not by itself constitute presence.

0 = No Other Drug(s) Present
1 = Yes Other Drug(s) Present
7 = Not Reported
8 = No Driver Present
9 = Unknown

GV25 "Roadway Surface Conditions" (SURCOND)

Definition: This element value is based on the location which best represents the pre-crash environmental data. It is possible for different surface conditions to exist on the same roadway (e.g., intermittent wet and dry sections). The variable was then defined based on the condition that was most representative of the roadway immediately prior to the vehicle's critical pre-crash event.

1 = Dry
2 = Wet

3 = Snow or Slush
4 = Ice
5 = Sand, Dirt, or Oil
8 = Other
9 = Unknown

GV26 "Light Conditions" (LGTCOND)

Definition: The light conditions at the time of the crash, coded based on ambient and artificial sources.

1 = Daylight
2 = Dark
3 = Dark, But Lighted
4 = Dawn
5 = Dusk
9 = Unknown

GV27 "Atmospheric Conditions" (WEATHER)

Definition: The atmospheric condition is coded with respect to the condition at the time of the crash. The element values are oriented toward precipitation, or particle dispersion, which may affect the driver's visual ability or the vehicle's controllability.

0 = No Adverse Atmospheric - Related Driving Conditions
1 = Rain
2 = Sleet/Hail
3 = Snow
4 = Fog
5 = Rain and Fog
6 = Sleet and Fog
7 = Other (Smog, Smoke, Blowing Sand or Dust, etc)
9 = Unknown

GV30 "Driver's Distraction/Inattention To Driving" (DRIVDIST)

Definition: Records the attribute which best describes the driver's attention to driving prior to the driver's realization of an impending critical event or just prior to impact if realization of an impending critical event does not occur. If the driver's vehicle has two critical crash envelopes, the attribute which best describes the driver's attention prior to the first Critical Precrash Event (i.e., prior to realization of the impending danger which the driver successfully avoided) was recorded. If the driver was distracted by a multiple of attributes, the lower numerical attribute was coded. Intoxication was not considered a distraction.

0 = No Driver Present
1 = Attentive or Not Distracted

2 = Looked Did Not See
3 = By Other Occupants
4 = By Moving Object in Vehicle
5 = While Talking or Listening to Cellular Phone
6 = While Dialing Cellular Phone
7 = While Adjusting Climate Controls
8 = While Adjusting Radio, Cassette, CD
9 = While Using Other Device/Control Integral to Vehicle
10 = While Using or Reaching for Device/Object Brought Into Vehicle
11 = Sleepy or Fell Asleep
12 = Distracted By Outside Person, Object, or Event
13 = Eating or Drinking
14 = Smoking Related
97 = Distracted/Inattentive, Details Unknown
98 = Other Distraction
99 = Unknown

GV31 "Pre-Event Movement (Prior to Recognition of Critical Event)" (PREMOVE)

Definition: The attribute which best records the vehicle's activity prior to the driver's realization of an impending critical event or just prior to impact if the driver took no action or had no time to attempt any evasive maneuver was recorded.

0 = No Driver Present
1 = Going Straight
2 = Decelerating in Traffic Lane
3 = Accelerating in Traffic Lane
4 = Starting in Traffic Lane
5 = Stopped in Traffic Lane
6 = Passing or Overtaking Another Vehicle
7 = Disabled or Parked in Travel Lane
8 = Leaving a Parked Position
9 = Entering a Parked Position
10 = Turning Right
11 = Turning Left
12 = Making a U-Turn
13 = Backing Up
14 = Negotiating a Curve
15 = Changing Lanes
16 = Merging
17 = Successful Avoidance Maneuver to a Previous Critical Event
97 = Other
99 = Unknown

GV32 "Critical Precrash Event" (PREEVENT)

Definition: This variable identifies the critical event which made the crash imminent (i.e., something occurred which made the collision possible). A precrash event was coded for each vehicle and identifies the circumstances leading to this vehicle's first impact in the crash.

This Vehicle Loss of Control Due to:
01 = Blow Out or Flat Tire
02 = Stalled Engine
03 = Disabling Vehicle Failure
04 = Non-Disabling Vehicle Problem
05 = Poor Road Conditions
06 = Traveling Too Fast for Conditions
08 = Other Cause of Control Loss
09 = Unknown Cause of Control Loss

This Vehicle Traveling:
10 = Over the Lane Line on the Left Side of Travel Lane
11 = Over the Lane Line on the Right Side of Travel Lane
12 = Off the Edge of the Road on the Left Side
13 = Off the Edge of the Road on the Right Side
14 = End Departure
15 = Turning Left at Intersection
16 = Turning Right at Intersection
17 = Crossing Over (Passing Through) Intersection
18 = This Vehicle Decelerating
19 = Unknown Travel Direction

Other Motor Vehicle In Lane:
50 = Other Vehicle Stopped
51 = Traveling in Same Direction With Lower Steady Speed
52 = Traveling in Same Direction While Decelerating
53 = Traveling in Same Direction With Higher Speed
54 = Traveling in Opposite Direction
55 = In Crossover
56 = Backing
59 = Unknown Travel Direction of the Other Motor Vehicle

Another Vehicle Encroaching Into This Vehicle's Lane:
60 = From Adjacent Lane (Same Direction) – Over Left Lane Line
61 = From Adjacent Lane (Same Direction) – Over Right Lane Line
62 = From Opposite Direction Over Left Lane Line
63 = From Opposite Direction Over Right Lane Line
64 = From Parking Line
65 = From Crossing Street – Turning Into Same Direction
66 = From Crossing Street – Across Path

67 = From Crossing Street – Turning Into Opposite Direction
68 = From Crossing Street – Intended Path Unknown
70 = From Driveway – Turning Into Same Direction
71 = From Driveway – Straight Across Path
72 = From Driveway – Turning Into Opposite Direction
73 = From Driveway – Intended Path Unknown
74 = From Entrance to Limited Access Highway
78 = Encroachment By Other Vehicles – Details Unknown

Pedestrian, Pedalcyclist or Other Non-Motorists:
80 = Pedestrian in Roadway
81 = Pedestrian Approaching Roadway
82 = Pedestrian Unknown Location
83 = Pedalcyclists/Other Non-Motorists in Roadway
84 = Pedalcyclists/Other Non-Motorists Approaching Roadway
85 = Pedalcyclists/Other Non-Motorists Unknown Location

Object or Animal:
87 = Animal in Roadway
88 = Animal Approaching Roadway
89 = Animal Unknown Location
90 = Object in Roadway
91 = Object Approaching Roadway
92 = Object Unknown Location
98 = Other Critical Precrash Event
99 = Unknown

GENERAL ESTIMATES SYSTEM (GES)

Imputation Process:
GES data are obtained either directly from the PAR or by interpreting the information provided in the report through reviewing the crash diagram, the Officer's written statement, or through the combinations of other variables on the PAR. Since the police officer may not have entered all of the information or provide complete information, data may be missing. Two different statistical procedures were performed on the GES data to determine values for the unknown data: univariate imputation and hot-deck imputation. The univariate imputation procedure was developed in SAS to randomly assign values to the unknowns in the same proportions as the known values for that variable. The hot-deck imputations was also performed in SAS and replaces unknown values for one variable using information from other correlated variables. More information on the GES imputation process can be found in the *GES Analytical User's Manual*.

A3 "Number of Vehicles Involved" (VEH_INVL)

Definition: The number of vehicles involved in the crash. This number includes hit phantom vehicles, but does not include phantom vehicles (a vehicle which may have caused the crash but left the scene).

Discussion: Each crash must have at least one in transport motor vehicle involved. The value entered must equal the total number of in transport motor vehicles involved in the crash. Vehicles not in transport are not included in this variable's count.

In order for a vehicle to be considered in transport, the motor vehicle must be either (1) on the roadway or (2) in motion. This includes driverless vehicles.

Hit-and-run crashes may cause some confusion on this variable. The count is increases for each in transport motor vehicle involved in the crash independent of the amount of information collected on the vehicle by the police.

A15I "Univariate Imputed Roadway Surface Condition" (SURCON_I)

Definition: Condition of the road surface at the time of the crash.

1 = Dry
2 = Wet
3 = Snow or Slush
4 = Ice
5 = Sand, Dirt, Oil
8 = Other

Discussion: The variable was coded as "unknown" if no information was contained on the PAR or if the information on the PAR was inadequate for choosing one of the other elements. However, since the imputed variable was used, the cases coded "unknown" were randomly assigned values in the same proportions as the known values for the variable.

A19I "Univariate Imputed Light Condition" (LGTCON_I)

Definition: General light conditions at the time of the crash, taking into consideration the existence of external roadway illumination fixtures.

1 = Daylight
2 = Dark
3 = Dark But Lighted
4 = Dawn
5 = Dusk

Discussion: If the police reports contained more than one coded response for light conditions (e.g., "dark" and "dusk"), then the cases were coded as "unknown." Since the imputed variable was used, the unknowns were randomly assigned values in the same proportions as the known values for the variable.

Furthermore, if both dawn and dusk were marked on the PAR, the time of day was used to either select dawn or dusk.

If the coder was unable to determine if dark or dark but lighted applied, the case was coded as "dark."

A20I "Univariate Imputed Atmospheric Condition" (WEATHR_I)

Definition: General atmospheric conditions at the time of the crash.

1 = No Adverse Conditions
2 = Rain
3 = Sleet
4 = Snow
5 = Fog
6 = Rain and Fog
7 = Sleet and Fog
8 = Other (Smog, Smoke, Blowing Sand/Dust/Snow, Crosswind, Hail)

Discussion: "Unknown" was coded when the police report indicated more than one response for atmospheric conditions. However, since the imputed variable was used, the unknowns were randomly assigned values in the same proportion as the known variables.

D4 "Driver's Vision Obscured By" (VIS_OBSC)

Definition: Identifies visual circumstances that may have contributed to the cause of the crash. If two or more visual obstructions apply, the lowest numerical value is coded.

00 = No Obstruction
01 = Rain, Snow, Smoke, Sand, Dust
02 = Reflected Glare, Bright Sunlight, Headlights
03 = Curve or Hill
04 = Building, Billboard, or Other Design Features (includes Signs, Embankment)
05 = Trees, Crops, Vegetation
06 = Moving Vehicle (including Load)
07 = Parked Vehicle
08 = Splash or Spray of Passing Vehicle
09 = Inadequate Defrost of Defog System
10 = Inadequate Lighting System
11 = Obstruction Interior to Vehicle
12 = Mirrors

13 = Head Restraints
14 = Broken or Improperly Cleaned Windshield
15 = Fog
50 = Hit & Run Vehicle
95 = No Driver Present
96 = Not Reported
97 = Vision Obstructed – No Details
98 = Other Obstruction
99 = Unknown Whether Vision was Obstructed

Discussion: Information on visual obstructions can be located anywhere on the PAR, in the narrative, in the violations section, or in a column entitled "Contributing Factors" or "Driver Action." The variable was coded as "not reported" it there was a specific location on the police report for assessment of vision obstructions but the officer failed to make either a positive or negative assessment. This code was also used if no block exists on the PAR for reporting vision obstructions and not other information was available.

"Unknown" was coded if the PAR indicated that the driver's field of view at the time of the crash was unknown and the driver did not leave the scene. If the driver left the scene, the variable was coded "no driver present."

D7 "Driver Distracted By" (DR_DSTRD)

Definition: Attempts to capture distractions which may have influenced driver performance and contributed to the cause of the crash. The distractions can be both inside the vehicle (internal) and outside the vehicle (external).

00 = Not Distracted
01 = Looked Did Not See
03 = By Other Occupants
04 = By Moving Object in Vehicle
05 = While Talking or Listening to Phone
06 = While Dialing Phone
07 = While Adjusting Climate Control
08 = While Adjusting Radio, Cassette or CD
09 = While Using Other Devices Integral to Vehicle
10 = While Using or Reaching For Other Devices
11 = Sleepy or Fell Asleep
12 = Distracted By Outside Person or Object
13 = Eating or Drinking
14 = Smoking Related
50 = Hit and Run Vehicle
95 = No Driver Present
96 = Not Reported
97 = Inattentive or Lost in Thought

98 = Other Distraction or Inattention
99 = Unknown if Distracted

Discussion: The variable was coded as "not reported" if a specific location on the police report for the assessment of driver distractions existed but the investigating officer failed to make either a positive or negative assessment. Furthermore, the variable was coded as "not reported" if no block exists on the PAR for reporting driver distractions and no other information was available.

The variable was coded as "unknown" if the PAR specifically reported unknown.

The variable was coded as "no driver present" if there was no driver in the vehicle.

D9 "Speed Related" (SPEEDREL)

Definition: This variable indicates whether speed is a contributing factor to the cause of the crash.

0 = No
1 = Yes
8 = No Driver Present
9 = Unknown

Discussion: This variable was coded as "no" if there was no indication on the PAR that the driver's speed was a factor. If the driver's speed was noted as a contributing factor or if a violation was issued for excessive speed, the variable was coded as "yes."

If no driver was present in the vehicle the variable was coded "no driver present."

The variable was coded as "unknown" if the vehicle was a hit and run vehicle and no information was available about its speed.

P11H "Hot-Deck Imputed Police-Reported Alcohol Involvement" (PERALC_H)

Definition: Indicates that the person (drivers of an in-transport motor vehicles and non-motorists only) had consumed an alcoholic beverage. This variable does not indicate that alcohol was a cause of the crash. If a PAR indicates that opened or unopened alcohol bottles were found in the vehicle, then this information does not by itself constitute involvement.

0 = Not Applicable
1 = No (Alcohol Not Involved)
2 = Alcohol Involved

Discussion: "Not applicable" was used for all non-motorists who are passengers. "Alcohol involved" was coded if the police indicate that alcohol presence in the driver via (1) a specific data element on the police report form, (2) the police charge the driver

with DUIL, (3) the police mention in the narrative section of the report that the person had been drinking or (4) the police report has a positive BAC test result (BAC>0.00).

The variable was coded as "unknown" if alcohol involvement was specifically indicated on the PAR as unknown. Since the imputed variable was used, the unknowns were randomly assigned values in the same proportion as the "not applicable," "no," and "alcohol involved" variables.

P17 "Police-Reported Drug Involvement" (PER_DRUG)

Definition: Indicates that the person (drivers of in-transport motor vehicles and non-motorists only) had taken drugs. Involvement is not an indication that drugs were the cause of the crash, even though it may have been. If PAR indicates that drugs were found in the vehicle, than this information does not itself constitute involvement.

0 = Not Applicable
1 = Drugs Not Involved
2 = Drugs Involved
8 = Not Reported
9 = Unknown

Discussion: "Not applicable" was used for all non-motorists who are passengers. "Drugs not involved" was coded in the investigating officer assesses that no other drugs were present in the person.

"Drugs involved" was coded if the police indicate that other drugs were present in the person via (1) a specific data element on the police report form or (2) the police mention in the narrative section of the report that other drugs are present in the person.

The variable was coded as "not reported" if there was a specific location on the police report for assessment of other drugs, but the investigating officer failed to make either a positive or negative assessment.

The variable was coded as "unknown" only if the presence of other drugs was specifically indicated on the PAR as unknown.

P18 "Person's Physical Impairment" (IMPAIRMT)

Definition: Attempts to identify physical impairments for all drivers and non-motorists which may have contributed to the cause of the crash. These impairments can appear anywhere on the PAR – in the narrative section, violation section, or in a column entitled "Contributing Factors" or "Driver Action," etc.

00 = None
01 = Ill, Blackout
02 = Drowsy, Sleepy, Fell Asleep, Fatigued

03 = Requires Cane or Crutches
04 = Paraplegic or Restricted to Wheelchair
05 = Impaired Due to Previous Injury
06 = Deaf
07 = Blind
97 = Physical Impairment – No Details
98 = Other Physical Impairment
99 = Unknown if Physically Impaired

Discussion: The variable was coded as "none" if the PAR indicated that there were no physical impairments for the person or if no physical impairments were reported on the PAR.

"Unknown" was coded if the person's physical condition at the time of the cash was unknown.

V2I "Univariate Imputed Hit and Run" (HITRUN_I)

Definition: Hit and run is coded when a motor vehicle in-transport, or its driver, departs from the scene; therefore, fleeing pedestrians and motor vehicles not in transport are excluded. It does not matter whether the hit and run vehicle was striking or struck.

0 = No, Did Not Leave Scene
1 = Yes, Driver or Car and Driver Left Scene

Discussion: The variable was coded as "no, did not leave scene" if the vehicle did not leave the scene of the crash after the crash occurred. If the PAR indicates that the vehicle fled from the scene, then the variable is coded as "yes, driver or car and driver left scene."

V8 "Special Use" (SPEC_USE)

Definition: Indicates if the vehicle has a special use. Special use means "in use" and not necessarily emergency use. All military vehicles are classified as "4" even if they are police, ambulance, or fire trucks.

00 = No Special Use
01 = Taxi
02 = Vehicle Used as School Bus
03 = Vehicle Used as Other Bus
04 = Military
05 = Police
06 = Ambulance
07 = Fire Truck or Car
10 = Hearse
11 = Farm Equipment

12 = Construction Equipment
99 = Unknown

Discussion: The variable was coded as "unknown" when no information on the vehicle's special use was available (i.e., hit and run vehicles).

V12 "Vehicle Contributing Factors" (FACTOR)

Definition: Indicates which vehicle factors may have contributed to the cause for the crash. Only one "contributing factor" for each vehicle is coded. If a vehicle has multiple "contributing factors" (some of which may not be defects), the lowest numerical value is coded.

00 = None
01 = Tires
02 = Brake System
03 = Steering System – Tie Rod, Kingpin, Ball Joint, etc
04 = Suspension – Springs, Shock Absorbers, McPherson Struts, Control Arms, Etc.
05 = Power Train – Universal Joint, Drive Shaft, Transmission, etc
06 = Exhaust System
07 = Headlights
08 = Signal Lights
09 = Other Lights
10 = Wipers
11 = Wheels
12 = Mirrors
13 = Driver Seating and Control
14 = Body, Doors
15 = Trailer Hitch
50 = Hit and Run Vehicle
97 = Vehicle Contributing Factors – No Details
98 = Other Vehicle Contributing Factors
99 = Unknown if Vehicle has Contributing Factors

Discussion: The variable was coded as "unknown" only if the PAR specifically indicates an unknown defect or unknown contributing factor. If no vehicle defect or contributing factor was indicated by the investigating officer, the variable was coded as "none."

V19 "Manner of Leaving Scene" (TOWED)

Definition: Measures the disposition of the vehicle, or power unit of an articulated combination, at the crash scene.

1 = Driver
2 = Towed Due to Damage

3 = Towed Not Due to Damage
4 = Abandoned
9 = Unknown if Towed

Discussion: The variable was coded as "unknown" if the PAR did not indicate the manner in which the vehicle left the scene of the crash.

V21I "Univariate Imputed Vehicle Maneuver" (MANEUV_I)

Definition: Reports the last action this vehicle's driver engaged in either just prior to the impact or just before the driver's realized the impending danger.

00 = No Driver Present
01 = Going Straight
02 = Decelerating in Traffic Lane
03 = Accelerating in Traffic Lane
04 = Starting in Traffic Lane
05 = Stopping in Traffic Lane
06 = Passing or Overtaking Another Vehicle
07 = Disabled or Parked in Travel Lane
08 = Leaving a Parked Position
09 = Entering a Parked Position
10 = Turning Right
11 = Turning Left
12 = Making U-Turn
13 = Backing Up (other than from a parked position)
14 = Negotiating a Curve
15 = Changing Lanes
16 = Merging
17 = Successful Corrective Action to a previous Critical Event
97 = Other

Discussion: "No driver present" was coded if no driver was present in the vehicle when the collision occurred. The variable was coded as "unknown" when the vehicle's movement prior to its involvement in the crash was unknown. "Unknown" was also coded if the information was inadequate to determine which applicable element applies.

V22 "Vehicle Role" (VEH_ROLE)

Definition: Indicates vehicle role in single or multi-vehicle crashes.

0 = Non-Collision
1 = Striking
2 = Struck
3 = Both
9 = Unknown

Discussion: The variable was coded as "striking" if the vehicle contacted another vehicle, pedestrian, non-motorist or object with its leading end and/or side while in motion. The vehicle was coded as "struck" if it was moving forward, not in rotation, and contacted another vehicle, pedestrian, non-motorist or object with any area of the its exterior other than its front. When the vehicle role was coded, the coding decision was made based on the above stated rules and not necessarily the wording in the narrative.

V26 "Critical Event" (P_CRASH2)

Definition: Indicates the critical 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 the vehicle's first impact in the crash.

00 = Not Applicable/No Collision

This Vehicle Loss of Control Due to:
01 = Blow Out or Flat Tire
02 = Stalled Engine
03 = Disabling Vehicle Failure
04 = Minor Vehicle Failure
05 = Poor Road Conditions
06 = Excessive Speed
08 = Other Cause of Control Loss
09 = Unknown Cause of Control Loss

This Vehicle Traveling:
10 = Over the Lane Line on the Left Side of Travel Lane
11 = Over the Lane Line on the Right Side of Travel Lane
12 = Over Left Edge of Roadway
13 = Over Right Edge of Roadway
14 = End Departure
15 = Turning Left at Intersection
16 = Turning Right at Intersection
17 = Crossing Over (Passing Through) Intersection
18 = Vehicle Decelerating
19 = Unknown Travel Direction

Other Motor Vehicle In Lane:
50 = Other Vehicle Stopped
51 = Traveling in Same Direction With Lower Steady Speed
52 = Traveling in Same Direction While Decelerating
53 = Traveling in Same Direction With Higher Speed
54 = Traveling in Opposite Direction
55 = In Crossover

56 = Backing
59 = Unknown Travel Direction of the Other Motor Vehicle

Another Vehicle Encroaching Into This Vehicle's Lane:
60 = From Adjacent Lane (Same Direction) – Over Left Lane Line
61 = From Adjacent Lane (Same Direction) – Over Right Lane Line
62 = From Opposite Direction Over Left Lane Line
63 = From Opposite Direction Over Right Lane Line
64 = From Parallel/Diagonal Parking Line
65 = Entering Intersection – Turning Into Same Direction
66 = Entering Intersection – Straight Across Path
67 = Entering Intersection – Turning Into Opposite Direction
68 = Entering Intersection – Intended Path Unknown
70 = From Driveway, Alley Access, etc – Turning Into Same Direction
71 = From Driveway, Alley Access, etc – Straight Across Path
72 = From Driveway, Alley Access, etc – Turning Into Opposite Direction
73 = From Driveway, Alley Access, etc – Intended Path Unknown
74 = From Entrance to Limited Access Highway
78 = Encroaching – Details Unknown

Pedestrian, Pedalcyclist, or Other Non-Motorists:
80 = Pedestrian in Roadway
81 = Pedestrian Approaching Roadway
82 = Pedestrian Unknown Location
83 = Pedalcyclists/Other Non-Motorists in Roadway
84 = Pedalcyclists/Other Non-Motorists Approaching Roadway
85 = Pedalcyclists/Other Non-Motorists Unknown Location

Object or Animal:
87 = Animal in Roadway
88 = Animal Approaching Roadway
89 = Animal Unknown Location
90 = Object in Roadway
91 = Object Approaching Roadway
92 = Object Unknown Location

Other
98 = Other Event/Not Applicable/No Collision

Unknown
99 = Unknown Critical Event

Discussion: The variable was coded as "unknown" when the critical event that resulted in the collision was not known.

APPENDIX D. CRASH TYPE AND CODING DEFINITIONS

Crash Type Definitions

SINGLE VEHICLE OFF-ROADWAY (SVOR)

CDS (1997-2000)
GES (2000)

For both NASS/CDS and GES data, vehicles having (ACC_TYPE) codes: 01-12, and 14-16 were selected.

For both NASS/CDS and GES data, light vehicles were determined by body type and vehicle/special use attributes.
(A) NASS/CDS: (BODYTYPE) = 1-22, 28-41, 45-49, and (VEHUSE)=0;
(B) GES: (BDYTYP_H) = 1-22, 28-41, 45-49, and (SPEC_USE)=0.

In addition to the counts/weights resulting from the previous criteria, the GES attribute: "Manner of Leaving Scene" (TOWED) = 2 and the NASS/CDS attribute "Police-reported Vehicle Disposition" (TOWPAR) = 1 were used to further breakout the data. Furthermore the following two attributes: GES data (VEH_INVL) "number of vehicles involved in a crash" and NASS/CDS data (VEHFORMS) "number of vehicles associated with a crash" were set to equal one. By setting these attributes to one, it assures that only one vehicle was involved in the crash.

REAR-END (RE)

CDS (1997-2000)
GES (2000)

For both NASS/CDS and GES data, vehicles having (ACC_TYPE) codes: 20-43 were selected.

For both NASS/CDS and GES data, light vehicles were determined by body type and vehicle/special use attributes.
(A) NASS/CDS: (BODYTYPE) = 1-22, 28-41, 45-49, and (VEHUSE)=0;
(B) GES: (BDYTYP_H) = 1-22, 28-41, 45-49, and (SPEC_USE)=0.

In addition to the counts/weights resulting from the previous criteria, the GES attribute: "Manner of Leaving Scene" (TOWED) = 2 and the NASS/CDS attribute "Police-reported Vehicle Disposition" (TOWPAR) = 1 were used to further breakout the data. Furthermore the following two attributes: GES data (VEH_INVL) "number of vehicles involved in a crash" and NASS/CDS data (VEHFORMS) "number of vehicles associated with a crash" were set to equal two. By setting these attributes to two, it assures that only two vehicle were involved in the crash.

Since there is no attribute in the NASS/CDS that directly indicates whether a vehicle is the striking/struck vehicle in a crash, a methodology was developed which uses the "General Area of

Damage" (GADEV?) attribute to calculate a striking/struck field. Based on the definition of a rear-end crash, the striking vehicle is defined as the vehicle whose front impacts the rear of another vehicle (i.e., the vehicle which has sustained frontal damage). The determination of the striking vehicle becomes more complex when either of the two vehicles sustains damage to more than one general area of the vehicle. The following eight scenarios were used to determined the striking vehicle:

Scenario 1: (GADEV1) = Front
(GADEV2) = Back
Striking Vehicle = Vehicle 1

Scenario 2: (GADEV1) = Front
(GADEV2) = Front and Back
Striking Vehicle = Vehicle 1

Scenario 3: (GADEV1) = Back
(GADEV2) = Front
Striking Vehicle = Vehicle 2

Scenario 4: (GADEV1) = Back
(GADEV2) = Front and Back
Striking Vehicle = Vehicle 2

Scenario 5: (GADEV1) = Front and Back
(GADEV2) = Front
Striking Vehicle = Vehicle 2

Scenario 6: (GADEV1) = Front and Back
(GADEV2) = Back
Striking Vehicle = Vehicle 1

Scenario 7: (GADEV1) = Other/Unknown
(GADEV2) = Front
Striking Vehicle = Vehicle 2

Scenario 8: (GADEV1) = Front
(GADEV2) = Other/Unknown
Striking Vehicle = Vehicle 1

Cases where both vehicles (V1 and V2) were coded as having both front and back damage were discarded since the striking vehicle was unable to be determined.

LANE CHANGE (LC)

CDS (1997-2000)
GES (2000)

For both NASS/CDS and GES data, vehicles having (ACC_TYPE) codes: 44-49 and 70-73 were selected.

For both NASS/CDS and GES data, light vehicles were determined by body type and vehicle/special use attributes.
(A) NASS/CDS: (BODYTYPE) = 1-22, 28-41, 45-49, and (VEHUSE)=0;
(B) GES: (BDYTYP_H) = 1-22, 28-41, 45-49, and (SPEC_USE)=0.

In addition to the counts/weights resulting from the previous criteria, the GES attribute: "Manner of Leaving Scene" (TOWED) = 2 and the NASS/CDS attribute "Police-reported Vehicle Disposition" (TOWPAR) = 1 were used to further breakout the data. Furthermore the following two attributes: GES data (VEH_INVL) "number of vehicles involved in a crash" and NASS/CDS data (VEHFORMS) "number of vehicles associated with a crash" were set to equal two. By setting these attributes to two, it assures that only two vehicle were involved in the crash.

In order to determine the causal factors for the collision, the "guilty" vehicle (i.e., the vehicle which caused the collision) needed to be distinguished. The method for determining the "guilty" vehicle for the CDS and the GES were very similar, the only difference was in the variable names. For the lane change/merge crash type the vehicle which initiated the lane change was defined based on a priority scheme. Each case was put through the following three criteria:

CDS:

1. Vehicle coded with ACC_TYPE 46, 47, 70, or 72
   Yes → Guilty vehicle
   No → Look at Criteria 2

2. General Vehicle Form #31 "Pre-Event Movement (Prior to Recognition of Critical Event)" Codes:
   8 - Leaving a Parked Position
   9 - Entering a Parked Position
   10 - Turning Right
   11 - Turning Left
   12 - Making a U-turn
   15 - Changing Lanes
   16 – Merging

   Yes → Guilty vehicle
   No → Look at Criteria 3

3. General Vehicle Form #32 “Critical Precrash Event” Codes 01-19
   Yes → Guilty vehicle

GES:

1. Vehicle coded with ACC_TYPE 46, 47, 70, or 72
   Yes → Guilty vehicle
   No → Look at Criteria 2

2. Vehicle/Driver File 0V21I “Univariate Imputed Movement Prior to Critical Event” Codes:
   8 - Leaving a Parked Position
   9 - Entering a Parked Position
   10 - Turning Right
   11 - Turning Left
   12 - Making a U-turn
   15 - Changing Lanes
   16 – Merging

   Yes → Guilty vehicle
   No → Look at Criteria 3

3. Vehicle/Driver File V26 “Critical Event” Codes 001-019
   Yes → Guilty vehicle

CDS and GES Contributing Factor Codes

Data Obtained From:

F1-Drugs/Alcohol:

CDS General Vehicle Form: #13-code 1 "Yes Alcohol Present," #15-code 1 "Yes Drugs Present"

GES P17 "Police-Reported Drug Involvement" code 2 "Drugs Involved," P11H "Hot-Deck Imputed Police-Reported Alcohol Involvement"

F2-Ill/Blackout:

GES P18 "Person's Physical Impairment" code 01 "Ill, Blackout"

F3-Sleepy/Drowsy

CDS General Vehicle Form (Precrash Driver Related Data): #30-code 11 "Sleepy or Fell Asleep"

GES P18 "Person's Physical Impairment" code 02 "Drowsy, Sleepy, Fell Asleep, Fatigued"

F4-Vehicle Defect (Control Loss)

CDS General Vehicle Form (Precrash Driver Related Data): #32 "Loss of Control Due to" codes 01-04

GES V26 "Critical Event" codes 001-004

F5-Vehicle Defect (Contributing Factor)

GES V12 "Vehicle Contributing Factors" codes 01-15, 97,98

F6-Inattention

CDS General Vehicle Form (Precrash Driver Related Data): #30 "Driver Distraction/Inattention" codes 02-10, 12-14, 97-98

GES D7 "Driver Distracted By" codes 01-10, 12-14, 97-98

F7-Driver's Vision Obscured By

GES D4 "Driver's Vision Obscured By" codes 01-15, 97, 98

F8-Speeding (Control Loss)

CDS General Vehicle Form (Precrash Driver Related Data): #32 "Loss of Control Due to" codes 05, 06, 08, 09

GES V26 "Critical Event" codes 005, 006, 008, 009

F9-Speeding (Contributing Factor)

GES D9 "Speed Related" code 1 "yes"

F10-Evasive Maneuver

CDS General Vehicle Form (Precrash Driver Related Data): #31 "Pre-Event Movement" code 17 "Successful Avoidance Maneuver"

GES V21I "Univariate Imputed Vehicle Maneuver" code 17 "Successful Corrective Action to a Previous Critical Event"

The first analysis of the data produced a large discrepancy in the *Evasive Maneuver* factor for the GES and CDS. A close examination was conducted d to determine which cases were included in the factor *Evasive Maneuver*. Cases taken from the CDS only involved the successful maneuvers, whereas the GES cases included both the successful and unsuccessful maneuvers. Originally, both successful and unsuccessful maneuvers were to be included in the *Evasive Maneuver* factor, however the CDS does not provide a variable coding the unsuccessful maneuvers. Therefore, the factor was renamed to *Successful Evasive Maneuver* and now depicts only the cases where a successful action occurred. The codes used for the factor *Successful Evasive Maneuver* are:

F11-Hit & Run

GES V2I "Univariate Imputed Hit and Run" code 1 "Yes, Driver or Car and Driver Left Scene"

APPENDIX E. DISTRIBUTION OF DRIVER DISTRACTION

Table E1. Distribution of Driver Distraction for all Phases

	13. Phase 1: Compare CDS to GES						Phase 2: Crash Severity			Phase 3: Scenarios			
	SVOR		RE		LC		SVOR GES *Other*	RE GES *Other*	LC GES *Other*	SVOR			
	CDS[1]	GES[2]	CDS	GES	CDS	GES				Scen.1	Scen.2	Scen.3	Scen.4
Look/Did Not See	1%	1%	8%	4%	23%	11%	2%	2%	14%	1%	1%	0%	1%
Dist By Other Occ.	3%	1%	3%	1%	2%	0%	1%	1%	1%	1%	2%	0%	3%
Dist/Moving Object	2%	0%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	0%
Talk Cell Phone	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	1%	0%	0%
Dial Cell Phone	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Adj. Climate Control	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Adj. Radio/CD	4%	1%	5%	1%	1%	0%	0%	0%	0%	1%	1%	0%	1%
Use Object Integral	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%
Use Object Brought	2%	2%	3%	2%	0%	0%	2%	1%	0%	1%	5%	0%	5%
Dist By Outside	5%	0%	10%	3%	4%	0%	2%	4%	1%	1%	2%	1%	1%
Eating/Drinking	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	1%	0%	0%
Smoking Related	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	1%	0%	1%
Dist Details Unk.	0%	~	1%	~	0%	~	~	~	~	~	~	~	~
Dist/Lost in Thought	~	20%	~	48%	~	35%	25%	53%	44%	17%	25%	23%	30%
Other Distraction	7%	6%	5%	5%	3%	4%	4%	3%	1%	8%	6%	4%	5%

*Distribution rounded to nearest whole percent; therefore discrepancies may exist.
[1]Based on 1997-2000 data.
[2]Based on 2000 data.
~ Factor not found in CDS/GES.
SVOR Scenario 1 = Traveling Straight and Control Loss.
SVOR Scenario 2 = Traveling Straight and Road Edge Departure.
SVOR Scenario 3 = Negotiating a Curve and Control Loss.
SVOR Scenario 4 = Negotiating a Curve and Road Edge Departure.

	Phase 3: Scenarios (cont.)			
	RE			LC
	Scen.1	Scen.2	Scen.3	Scen.
Look/Did Not See	2%	4%	2%	14%
Dist By Other Occ.	1%	2%	1%	1%
Dist/Moving Object	0%	0%	0%	0%
Talk Cell Phone	0%	0%	0%	0%
Dial Cell Phone	0%	0%	0%	0%
Adj. Climate Control	0%	0%	0%	0%
Adj. Radio/CD	1%	1%	0%	0%
Use Object Integral	0%	0%	0%	0%
Use Object Brought	1%	2%	1%	0%
Dist By Outside	3%	4%	1%	1%
Eating/Drinking	0%	0%	0%	0%
Smoking Related	0%	0%	0%	0%
Dist Details Unk.	~	~	~	~
Dist/Lost in Thought	53%	52%	42%	42%
Other Distraction	3%	3%	4%	2%

*Distribution rounded to nearest whole percent; therefore discrepancies may exist.
[1]Based on 1997-2000 data.
[2]Based on 2000 data.
~ Factor not found in CDS/GES.
RE Scenario 1 = Lead Vehicle Stopped.
RE Scenario 2 = Lead Vehicle Decelerating.
RE Scenario 3 = Lead Vehicle Moving.
LC Scenario = Lane Change Maneuver.

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